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Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings

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Assessment of policy instruments for reducing greenhouse gas emissions from buildings

Report for the UNEP-Sustainable Buildings and Construction Initiative

Central European University

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Budapest

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LIST OF ABBREVATIONS

ACEEE	American Council for an Energy Efficient Economy
Adv.	Advanced
AIJ	Activities implemented jointly
Alg	Algeria
Arg	Argentina
AUS	Australia
Aut	Austria
BAU	Business as Usual
B/C	Benefit/Cost (ratio)
Bdg	Building
Be	Belgium
Br	Brazil
Btu	British thermal unit
Cal	California
Can	Canada
CDM	Clean Development Mechanisms
CEE	Central and Eastern Europe
CER	Certified Emission Reduction
CEU	Central European University
CFL	Compact Fluorescent Lamp
CLASP	Collaborative Labelling and Appliance Standard Program
Cn	China
CO_2	Carbon Dioxide
Cr	Costa Rica
CSTB	Centre Scientifique et Technique du Bâtiment
Cz	Czech Republic
De	Germany
DOE	Department of Energy
DSM	Demand-Side Management
ECEEE	European Council for an Energy Efficient Economy
Ecu	Ecuador
EE	Energy Efficiency
EEBC	Energy Efficiency building codes
EEPC	Energy Efficiency Portfolio Standard
Egy	Egypt
EJ	Exajoule: 10^{18} J
El	electricity
En	energy
EPC	Energy Performance Contracting
ESCO	Energy Service Company
ET	Economy in Transition
EU	European Union
Fin	Finland
GB	Great Britain
GHG	Greenhouse Gases
GIS	Green Investment Scheme
Hkg	Hong Kong
Hu	Hungary
ICLEI	Local Governments for Sustainability
ICT	Information and Communication Technologies

IEA	International Energy Agency
IIEC	International Institute for Energy Conservation
IIIEE	International Institute for Industrial Environmental Economics
Ind	India
Inst.	Institutions
Instr.	Instrument
IPCC	Intergovernmental Panel on Climate Change
Irl	Ireland
It	Italy
JI	Joint Implementation
JP	Japan
JRC	Joint Research Center (of the European Commission)
Kt	kilotonne (1000 tonnes)
Kor	Korea (South)
LBNL	Lawrence Berkeley National Laboratory
Mex	Mexico
Mor	Morocco
Mt	Megatonne
MURE	Mesures d'Utilisation Rationnelle de l'Energie (database)
Nb	number
NGO	Non-Governmental Organisation
NL	Netherlands
Nor	Norway
NSW	New South Wales
Nzl	New Zealand
OECD	Organisation for Economic Cooperation and Development
PBF	Public Benefit Fund
PEPS	Promoting an Energy Efficient Public Sector (Initiative)
Phil	Philippines
Pol	Poland
REEEP	Renewable Energy and Energy Efficiency Partnership
Res	Residential sector
Ro	Romania
Soc	Society
SG	Singapore
Sk	Slovakia
SMEs	Small and Medium Enterprises
Svn	Slovenia
Sw	Switzerland
Swe	Sweden
T	tonne/ ton
Ter	Tertiary sector
Tha	Thailand
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USA	United States of America
USD	US Dollar
VA	Voluntary agreement
Yr	Year

FOREWORD

Energy use in buildings has rapidly come into focus as one of the key issues to address in order to meet the climate change challenge. No other individual sector has the same impact in terms of energy use and associated greenhouse gas emissions. No other sector has such a high potential for drastic emission reductions through energy efficiency improvement in buildings. Still, the potential remains largely unrealized because of a number of barriers. It is now well understood that the building sector is not able to pursue energy efficiency in buildings without the support of appropriate government policies. However, most governments at the national and local levels lack experience and knowledge about what policy tools are available and may be effective in their local context.

The Sustainable Buildings and Construction Initiative (www.unepsbci.org) coordinated by the United Nations Environment Programme (UNEP) has therefore engaged the Central European University (CEU) to develop this study and database of lessons learned from various policy tools around the world. CEU has built this database on data they developed for the 4:th assessment report of the Intergovernmental Panel on Climate Change, and then further expanded and refined under this SBCI project. It is our hope and ambition that this study will provide inspiration for governments to formulate policy tools supporting the building sector to realize energy efficiency and greenhouse gas emission reductions worldwide.

UNEP SBCI would like to thank all and everybody contributing to this study and database, and in particular to the lead authors at CEU; Sonja Koeppel and Diana Ürge-Vorsatz.

Niclas Svenningsen
SBCI Manager
Paris September 2007

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1. Introduction

1.1. Background

Climate change is recognised as one of the main barriers to sustainable development. The recent alarming findings of the Intergovernmental Panel on Climate Change (IPCC 2007) indicate that this process is progressing even more rapidly than expected. While climate change is caused and accelerated by greenhouse gas (GHG) emissions from all energy end-use sectors such as transport, industry, buildings, agriculture, energy and waste management (UNFCCC 1999), the buildings sector[1] contributes about a third of all energy-related CO2 emissions worldwide (Price *et al.* 2006). Research conducted for the Intergovernmental Panel on Climate Change (IPCC 2007) estimated that around 30% of the baseline CO2 emissions in buildings projected for 2020 could be mitigated (avoided) in a cost-effective way globally, i.e. at no or even negative costs, if various technological options were introduced, such as more efficient heating systems or appliances. Thus, tapping this potential in the buildings sector alone will contribute considerably to solving the global climate change problem. Moreover, realizing these potentials will also bring numerous co-benefits such as decreased air-pollution, better health and reduced mortality, improved social welfare and energy security, and others.

Although these large potentials that can be captured at a net benefit for society have been known for long, many of these energy efficiency possibilities have not been realized. This is due to certain characteristics of markets, technologies, and end-users which inhibit rational, energy-saving choices in the purchase and use of appliances as well as during the life-cycle of a building. Therefore, policies which aim to overcome these barriers to application of energy efficiency technologies are very important for GHG mitigation in buildings.

There are three major ways to reduce GHG emissions: reducing energy use, replacing fossil fuels with renewables and increasing energy efficiency. Policy instruments are available for all of them. This report places the major focus on policy instruments which aim to improve energy efficiency or reduce energy use and thereby reduce GHG emissions since these have been shows to be among the cheapest and most important options to reduce GHG emissions from buildings (IPCC 2007).

Realizing the potential described above as well as the need for policies to overcome the barriers in question, more and more countries are enacting policies to improve energy efficiency in buildings. The first minimum energy efficiency standards for appliances were set in Poland and France in the 1960s, followed by other countries (della Cava *et al*. 2001). However, these standards were often poorly implemented, and therefore did not have significant effects. The first building energy efficiency codes were set in the 70s in response to the oil crisis (Deringer *et al* 2004). Since then, the variety of instruments applied has grown considerably, from regulatory and voluntary instruments in the initial phase towards the use of financial incentives and economic instruments (IEA 2005b). Since the 1990s, with the increasing awareness on climate change, more and more

[1] The buildings sector is defined here as encompassing the construction and management of residential and commercial, but not industrial buildings.

developing countries have introduced appliance standards, building codes and labelling policies (Deringer *et al*. 2004). However, numerous countries, especially developing countries, have still not enacted or are just introducing policies for the buildings sector.

The list of policy measures enacted to improve energy efficiency in buildings includes regulatory instruments such as building codes (energy efficiency standards for buildings); economic instruments such as cooperative procurement; fiscal measures such as energy taxes and subsidies; and voluntary/informative instruments such as voluntary labelling of appliances. For various reasons, the effectiveness of these policy measures in terms of reaching their goals varies significantly depending on countries, situations and policy instruments chosen. For example, building codes have reduced energy consumption of new dwellings in the USA by about 30%, but are often not effective in developing countries (Deringer *et al* 2004). Appliance standards for refrigerators were very successful in Thailand in contrast to those for air conditioning in the same country (Phuket and Prijyanonda 2001). Rebates for energy efficient products have been effective in Denmark, but very cost-ineffective in the Netherlands. In general, little understanding exists of the impact of the various policy instruments and especially the reasons for this impact. In addition, policy-makers often face the question: which type of instrument should we introduce to achieve a certain policy goal? In order to assist decision-makers in this choice, this report addresses a few fundamental questions related to the comparative assessment of policy instruments applied in the building sector to improve energy efficiency, or reduce CO2 emissions.

1.2. Aims of this report

This report therefore aims at assessing and comparing the most important policy instruments for achieving energy efficiency improvements and GHG emission reductions in buildings according to their emission reduction effectiveness, cost-effectiveness and lessons learned.

The following questions are answered:

1. **Which instruments can achieve high energy savings and GHG emission reductions?**
2. **Which are especially cost-effective?**
3. **Which factors enable or enhance the effectiveness of these policies?**

Currently, only a few comprehensive comparative assessments of policy instruments for promoting energy efficiency in the buildings sector are available. The existing studies mostly compare only a small number of instruments (Lee/Yik 2004, Geller 2006) or do not specifically focus on the buildings sector (WEC 2001/WEC 2004). Especially, systematic comprehensive and quantitative comparisons of all the most important policy instruments for energy efficiency improvements in buildings in terms of their effectiveness and cost-efficiency are scarce. Furthermore, policies in developing countries are rarely analysed comprehensively. This research was started in March 2006 as a contribution to the Chapter entitled “Mitigation options in residential and commercial buildings” of the 4th Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) (2007) (Working Group III on mitigation). The research was extended to a wider range of countries for as well as funded by the United Nations Environment Programme’s Sustainable Buildings and Construction Initiative (UNEP-SBCI)[2] in 2007.

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[2] This initiative is a partnership between UNEP and worldwide leading companies as well as other organizations to support and promote sustainable solutions in the buildings and construction sector aimed at improving the sustainability in the construction sector. It aims at providing a common platform for the

The following objectives are pursued with this report:

1. Compare the most important policy instruments and identify the most effective and cost-effective ones in terms of energy savings and GHG emission reductions achieved.
2. Highlight best-practice examples of implementation of such policy instruments.
3. Analyze the success factors of these policy instruments.
4. Investigate which policy instruments and packages of policy instruments can best overcome certain barriers.
5. Analyze the special situation of developing countries in regard to feasibility/ implementation/success factors of such policy instruments.

In order to answer these questions the effects of implemented policy instruments have to be compared. Therefore, the following assessment is based on the collection and comparative analysis of over 80 existing evaluation studies or review articles of policy instruments implemented in countries all over the world. The research focused on ex-post studies, but in a few rare cases ex-ante studies were also used when ex-post studies were not available. While the ideal research would perform an original primary evaluation of these instruments on an equal footing, this is presently not possible because the necessary detailed and uniformly collected data are not available about the performance of these instruments. In addition, it would still be very difficult to carry out the attribution of the impacts to the different policies without a profound understanding of the policy and economic environments in which these policies have been enacted. Therefore the authors of this report believe that presently the most appropriate method for such analysis is to collect and assess primary policy instrument evaluations, preferably those that are carried out with a detailed understanding and knowledge of the instrument as well as the policy and economic environments. However, such a method also has its caveats because the different evaluations used different methods. The limitations that follow from these differences are described in later sections.

Although an attempt was made to cover as many countries as possible, the number of case studies is limited due to non-availability of either policy measures or their evaluations, especially in developing countries such as in Africa and Latin America which have not introduced many policy measures for buildings yet. Other limitations of the research include the difficulty of comparing existing evaluations which use partly different methods, and the problem that policy measures are usually combined into policy packages which makes separate evaluation of the effects of a single instrument difficult. However, since we relied on existing and completed studies evaluating the individual instruments, the attribution of impacts to the instruments have been carried out by the authors of these source reports, and thus this report does not deal with impact attribution.

The most important case studies from the database are presented in a table including all policy instruments, usually referred to as “the policy table” (see table 30). After briefly outlining the barriers to energy efficiency the methods for the assessment of policy instruments to overcome these will be presented. In the following chapter, the policy instruments are first analysed separately with a summary table[3] at the end of each policy measure’s discussion, summarizing the major results on effectiveness, cost-effectiveness, barriers and remedies, advantages and success factors of the instrument. Chapter 5 includes

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stakeholders, establishing baselines, developing tools and strategies, and implementing them through case studies.

[3] The country name abbreviations are to be found under table 30 and in the list of abbreviations. Where no information was available, the respective column was deleted.

the overall comparative analysis of all policy instruments followed by recommendations on how to effectively combine them into policy packages and a special section on developing countries before the summary and recommendations.

2. Barriers to energy efficiency improvements in buildings

Many studies and articles on policy measures discuss barriers to energy efficiency either to illustrate the need for policy measures or to explain why policy tools are not as successful as expected (for example Deringer *et al.* 2004, Westling *et al*. 2003, Vine 2005). The number of barriers is enormous - according to some estimates higher in the buildings sector than in any other sector (IPCC 2007).

2.1. Economic/financial barriers

Purchasing more efficient equipment usually involves higher first costs which many consumers do not want to spend and which low-income consumers cannot afford because they have limited capital (Carbon Trust 2005). This is one of the most important barriers for energy efficiency in buildings as well as in other sectors in developing countries and often cannot be solved internally. In developed countries, on the other hand, consumers often don't want to pay higher up-front costs because they either don't know or don't believe that energy efficiency investments usually pay back in a few years or even months.

2.2. Hidden costs and benefits

In addition to the higher up-front costs, there are hidden costs and benefits for the end-user not captured directly in financial flows, such as transaction costs associated with securing the energy efficient solution and risks associated with the replacement technology (Westling, 2003; Vine, 2005). Transaction costs are often high due to the fragmented structure of the buildings sector with many small owners and agents. New technologies might not be compatible with existing sockets for example (Carbon Trust 2005). On the other hand, indirect benefits of improved energy efficiency, such as reduced air pollution and thereby improved health are often neglected as well.

2.3. Market failures

Market failures prevent the consistent translation of specific energy-efficient investments into energy saving benefits (Carbon Trust 2005). Misplaced incentives are a major barrier in the buildings sector as building tenants pay the energy bill and are therefore possibly interested in reducing it, but have no control over the system, whereas building owners are not interested in energy efficiency improvements. Similarly, utilities have no direct interest in measures reducing their clients' energy use. In the public sector, budget constraints are a major barrier preventing energy efficiency investments (Urge-Vorsatz, Koeppel et al. 2007).

2.4. Behavioural and organizational constraints

Behavioural characteristics of individuals and organizational characteristics of companies hinder energy efficiency technologies and practices. Small but easy opportunities for energy conservation are often ignored and changing behaviour or lifestyle is very difficult. (Shove 2003; Chappells and Shove, 2005). A lack of awareness and information on the opportunities and low costs of energy savings are a related problem, even more in developing than in developed countries. In developed countries, perhaps the most important hurdle towards improving energy-efficiency is the small share and thus limited importance of, energy expenditures in the disposable income or financial turnover of affluent households and businesses, which results in limited attention given to this issue among other priorities. This phenomenon can be described as “bounded rationality” according to Simon (1960), who argues that human beings act and decide only partly on a rational basis. In developing countries, energy expenditure represents a much larger share of the disposable income, but subsidies often lower the energy price artificially, which does not provide an incentive for energy saving behaviour. Actually, energy subsidies are frequently considered as one of the most important barriers for energy efficiency in developing countries (Alam 1998).

2.5. Political and structural barriers

Political and structural barriers mainly occur in developing countries and include problems such as lack of government interest in energy efficiency, insufficient enforcement of policies due to inadequate enforcement structures and institutions, lack of qualified personnel, and corruption (Deringer *et al* 2004).

2.6. Information barriers

Lack of information about the possibilities, techniques and potentials of energy efficiency solutions is a major barrier in developing countries and therefore mentioned as a separate barrier category here (Evander *et al*. 2004, Deringer *et al*. 2004). Very often, provision of energy services or provision of access to the national grid is considered a priority without recognizing the advantages of always combining these with considerations of energy efficiency in order to reduce the electricity required. Even in Germany and most European as well as other developed countries many architects don’t know and don’t learn about how to construct energy efficient houses during their studies.

2.7. Overview of all barriers

Table 1 includes an overview of barriers in all countries together with possible remedies. The numerous barriers presented explain why energy efficiency improvements usually require special impetus through governmental action.

Barrier categories	Definition	Examples	Countries*	Possible remedies*	References
Economic/ financial barriers	Ratio of investment cost to value of energy savings	Higher up-front costs for more efficient equipment Lack of access to financing Energy subsidies Lack of internalization of environmental, health, and other external costs	Most countries Especially developing, but also developed countries	Fiscal and economic instruments such as tax rebates, Kyoto Flexibility Mechanisms, sub-sidized loans, regulatory instru-ments. Or increase energy price, remove energy price subsidies	Deringer *et al* 2004 Carbon Trust 2005, IPCC 2007
Hidden costs/ benefits	Cost or risks (real or perceived) that are not captured directly in financial flows	Costs and risks due to potential incompatibilities, performance risks, transaction costs etc. Poor power quality, particularly in some developing countries	All countries	Appliance standards, building codes (to overcome high transaction costs), EPC/ ESCOs, public leadership programs	Carbon Trust 2005, IPCC 2007
Market failures	Market structures and constraints that prevent a consistent trade-off between specific ee invest-ment and energy saving benefits	Limitations of the typical building design process Fragmented market structure Landlord/tenant split and misplaced incentives Administrative and regulatory barriers (e.g. in the incorporation of distributed generation technologies) Imperfect information Unavailability of energy efficiency equipment locally	All countries	Fiscal instruments and incentives Product standards Regulatory-normative Regulatory-informative Economic instruments Technology transfer, mechanisms	Carbon Trust 2005, IPCC 2007
Behaviou-ral and organizatio nal barriers	Behavioural charac-teristics of indivi-duals and companies that hinder energy efficiency technolo-gies and practices	Tendency to ignore small energy saving opportunities Organizational failures (e.g. internal split incentives) Non-payment and electricity theft Tradition, behaviour and lifestyle, Corruption Transition in energy expertise: Loss of traditional knowledge and non-suitability of Western techniques	Developed countries Developing countries	Support, information and voluntary action: Voluntary agreements Information and training programs	Carbon Trust 2005, Deringer *et al* 2004, IPCC 2007
Information barriers*	Lack of information provided on energy saving potentials	Lacking awareness of consumers, building managers, construction companies, politicians	Especially develop-ping, but also deve-loped countries	Awareness raising campaigns, Training of building profession-nals, regulatory-informative	Carbon Trust 2005, Yao *et al*. 2005, Evander *et al*. 2004
Political and structural barriers*	Structural characteristics of the political, economic, energy system which make energy efficien-cy investment diffi-cult	Process of drafting local legislation is slow Gaps between regions at different economic level Insufficient enforcement of standards Lack of detailed guidelines, tools and experts Lack of incentives for EE investments Lack of governance leadership/ interest Lack of equipment testing/ certification Inadequate energy service levels	Most developing (and some developed) countries	Enhance implementation of standards Incentive policy encouraging ee building design, Enhance international cooperation and technology transfer, Public leadership programs	Yao *et al*. 2005 Deringer *et al* 2004

Table 1: Major barriers to energy efficiency (ee) in the buildings sector

Source: based on Carbon Trust (2005) and IPCC (2007- forthcoming), * these categories and columns were added

3. Methods used for assessing policy instruments

3.1. Definition and classification of policy instruments

Today, more than 30 policy instruments are in use, including for example appliance standards, public leadership programs, pricing schemes and many more. 20 frequently used instruments of these are analysed in detail in this report (see table 2).

Table 2: Policy instruments chosen for the study and their definitions

Policy instrument	Definition
Appliance standards	Define a minimum energy efficiency level for a particular product class such as refrigerators, to be fulfilled by the producer (Birner et al. 2002)
Building codes	Address the energy use of an entire building or building systems such as heating or air conditioning (Birner and Martinot 2002)
Procurement regulations	Provisions for energy efficiency in the public procurement process.
Energy efficiency obligations and quotas	Requirement for example for electricity and gas suppliers to achieve targets for the promotion of improvements in energy efficiency for instance in households (Lees 2006)
Mandatory labelling program	.Mandatory provision of information to end users about the energy-using performance of products such as electrical appliances and equipment, and even buildings (Crossley et al. 2000)
Mandatory audit programs	Mandatory audit and energy management in commercial, industrial or private building, sometimes subsidized by government
Utility demand-side management (DSM)	Planning, implementing, and monitoring activities of energy efficiency programs among/by utilities
Energy performance contracting	A contractor, typically an Energy Service Company (ESCO), guarantees certain energy savings for a location over a specified period; implements the appropriate energy efficiency improvements, and is paid from the actual energy cost reductions achieved through the energy savings (EFA 2002)
Cooperative procurement	Private sector buyers who procure large quantities of energy-using appliances and equipment work together to define their requirements, invite proposals from manufacturers and suppliers, evaluate the results, and actually buy the products, all in order to achieve a certain efficiency improvement in products equal or even superior to world best practice (Crossley et al. 2000)
Energy efficiency certificate schemes	Tradable certificates for energy savings (often referred to as “white certificates”)
Kyoto flexibility mechanisms	Joint Implementation (JI) and Clean Development Mechanisms (CDM)
Taxation (on CO_2 or household fuels)	Imposed by government at some point in the energy supply chain. The effect is to increase the final price that end-users pay for each unit of energy purchased from their energy supplier, although the tax may be levied at any point in the supply chain (Crossley et al. 2000)
Tax exemptions/ reductions	Used to provide signals promoting investment in energy efficiency to end use customers (Crossley et al. 2000)
Public benefit charges	Raising funds from the operation of the electricity or energy market, which can be directed into DSM/ energy efficiency activities (Crossley et al. 2000)
Capital subsidies grants, subsidised loans	Financial support for the purchase of energy efficient appliances or buildings
Voluntary certification and labelling	Provision of information to end users about the energy-using performance of products such as electrical appliances and equipment, and even buildings. Voluntary for producer (Crossley et al. 2000)
Voluntary and negotiated agreements	Involve a formal quantified agreement between a responsible government body and a business or organisation which states that the business or organisation will carry out specified actions to increase the efficiency of its energy use (Crossley et al. 2000)
Public leadership programs	Energy efficiency programs in public administrations, demonstration projects to show private sector which savings and technologies are possible
Awareness raising,	Policy instruments designed by government agencies with the intention to

Policy instrument	Definition
education, information campaigns	change individual behaviour, attitudes, values, or knowledge (Weiss & Tschirhart 1994)
Detailed billing and disclosure programs	Display detailed information related to the energy consumption to the user either on bill and/ or directly on appliance or meter

The policy instruments are classified into the following categories. (UNFCCC 1999, IEA 2005b).

- *regulatory and control mechanisms*: "laws and implementation regulations that require certain devices, practices or system designs to improve energy efficiency" (IEA 2005b). Following the MURE[4] methodology, these tools were further sub-divided into *regulatory- normative* for standards and *regulatory-informative* when the end-user is just informed, but not obliged to follow the energy efficiency advice (e.g. labelling).
- *economic/ market-based instruments* are usually based on market mechanisms and contain elements of voluntary action or participation, although often initiated/promoted by regulatory incentives.
- *fiscal instruments and incentives* usually correct energy prices either by a Pigouvian tax aimed at reducing energy consumption or by financial support if first-cost related barriers are to be addressed.
- *support, information and voluntary action.* These instruments aim at persuading consumers to change their behaviour by providing information and examples of successful implementation (IEA 2005b).

The policy instruments were divided into the different categories as shown in table 3.

Table 3: Classification of policy instruments chosen for assessment in the study

Control and regulatory instruments		**Economic and market-based instruments**	**Fiscal instru-ments and incentives**	**Support, information and voluntary action**
Normative: −Appliance stan-dards −Building codes −Procure-ment regu-lations −Energy efficiency obligations and quotas	**Informative:** − Mandatory audits − Utility demand-side management programs − Mandatory labelling and certi-fication programs	− Energy performance contracting − Cooperative procurement − Energy efficiency certificate schemes − Kyoto flexibility mechanisms	−Taxation −Tax exemptions / reductions −Public benefit charges −Capital subsidies, grants, sub-sidized loans	− Voluntary certification and labelling − Voluntary and negotiated agreements − Public leader-ship programs − Awareness rai-sing, education, infor-mation campaigns − Detailed billing and disclosure programs

Sources: Adapted from Crossley et al. (1999), Crossley et al. (2000), EFA (2002), Vine et al. (2003), and Wuppertal Institute (2002), Verbruggen et al, 2003, Grubb (1991), and IEA (1997).

[4] The MURE- database is an electronic database which includes descriptions and mostly short assessments of over 300 policy measures divided by sectors implemented in the different EU member states (MURE 2007).

3.2. Evaluation of policy instruments through case studies

The assessment of policy instruments is based on various sources. A strong effort was made to collect the limited number of other existing comparative assessments (publications, reports) and especially to identify as many individual policy evaluations for concrete policy applications from as many countries as possible. National communications to the UNFCCC as well as several policy instrument databases, mainly the MURE database which comprises, describes and assesses policy measures for energy efficiency in EU-countries, were also used. However, this method was revealed as insufficient especially for developing countries as many of them have not yet enacted policy instruments for energy efficiency improvements in buildings or just recently introduced them so that by and large, no evaluations have yet been conducted. Therefore, energy efficiency policies in 12 countries were analysed in detail by external researchers, mostly nationals of the respective countries. In addition, more than 50 government officials, research institutes, Non-Governmental Organizations and other energy experts in 36 countries were contacted via email and phone in order to ask for evaluation studies. Around 30 of them answered and gave important information. In some cases, relevant information was then requested in different ways such as by conducting interviews or sending questionnaires.

In general, ex-post[5] evaluations, where available, were preferred to *ex-ante* assessments, since the latter often project different savings than the actual ones found in *ex-post* reviews (Geller and Attali 2005). In total, over 80 studies, review articles and other relevant publications were identified from approximately 52 countries, covering each inhabited continent (see fig. 1).

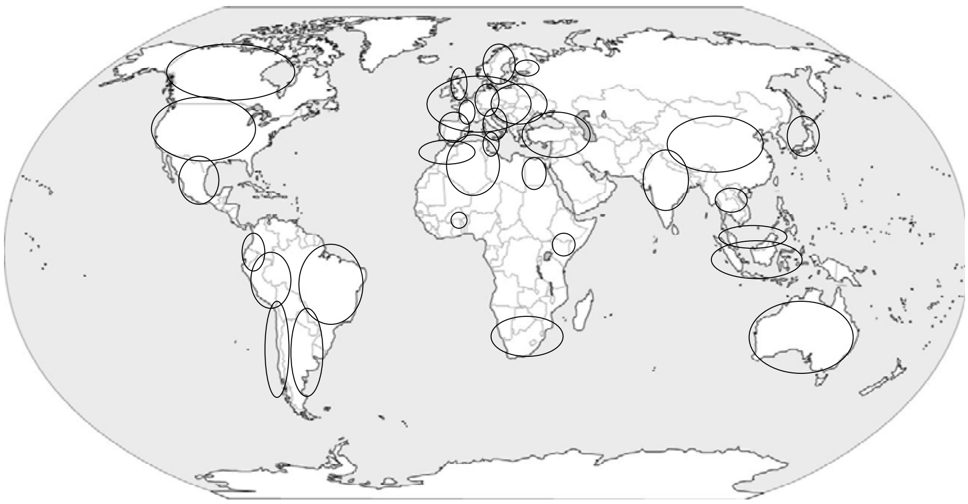


Fig. 1: Countries covered in this report

[5] Ex-ante assessments are predictions made before the implementation of a policy instrument whereas ex-post assessments evaluate policy instruments after or during their implementation.

3.3. Criteria for assessing the policy instruments

Effectiveness, i.e. whether the policy instrument achieves its goal, the improvement of energy efficiency and reduction of GHG emissions, seems to be the most important criterion for evaluating policies or programs. In this report, effectiveness is defined not as general environmental effectiveness, but specifically as success in reducing GHG-emissions.

Cost-effectiveness of CO_2 reduction, in terms of USD/tCO_2 saved is another important criterion when policy-makers decide about which policy instruments to apply. Cost-effectiveness can be analyzed from different perspectives such as societal, individual (participants) or the program administrator's perspective (IEA 2005b). For this study, total societal costs were considered (i.e. from the policy-making perspective) and recalculated into USD with the base year 2000 where possible (see section 3.4.2).

Success factors: Policy instruments can vary significantly in their effectiveness in different countries. Building codes are for example often successful in developed countries, but less successful in developing countries due to insufficient enforcement (Deringer *et al*. 2004). For this reason, it is important to identify key factors determining the effectiveness of the instrument as well as barriers which can explain failure of the same instruments in other locations. For example, if an instrument triggered (mostly in combination with others) market transformation, this can be considered as an important success factor. Market transformation is defined as "the reduction in market barriers due to a market intervention, as evidenced by a set of market effects that lasts after the intervention has been withdrawn, reduced or changed" (Eto *et al*.1996 cited in Vine and Sathaye 1999).

3.4. Methods used for the evaluation according to the criteria

The identified case studies and information about them for the above mentioned criteria were collected in a database including the 20 policy instruments.

3.4.1. Effectiveness

Qualitative assessment of effectiveness

Each policy instrument's effectiveness in the buildings sector is analyzed in a qualitative and quantitative way. Where possible, the amount of energy or CO_2 saved as a result of the policy was extracted from the evaluation studies or otherwise determined. Based on all cases, policy instruments were then assigned qualitative grades "High", "Medium" and "Low" for their performance in reducing energy use and GHG emissions. Although such grades should be ideally assigned in a systematic way based on numerical limits of emission reductions (such as % of baseline reduced), this was impossible due to the absence of baselines for most of the quantitative data, which were mostly given in absolute terms[6]. Second, even in relative terms, the numerical values of emission reductions cannot be compared without precaution as their temporal and spatial scale as well as the total emission coverage of the case studies differs. Some case studies describe policies covering

[6] In the MURE database, policies are evaluated as follows: Low is given for 0-0.1% reduction of total energy use in the sector, medium for 0.1-0.5% and high for >0.5%. This was not possible in our case due to lack of baselines MURE 2007.

the whole sector while others focus only on sub-sectors or smaller territorial units such as states in the USA or cities.
Due to these limitations, the grades were not assigned based only on the emission reduction data, but also on experts' judgment. More than 20 experts in the field of building energy efficiency policies were asked, such as most of the authors of the chapter on mitigation in buildings in the fourth IPCC assessment report. This method leads to results which take into account the overall applicability and potential of the instrument relative to the overall energy consumption in the affected end-use category.

Quantitative data on effectiveness
As the data on effectiveness were given in different units by the studies, recalculations had to be performed to increase the comparability of the data. Since the study aimed at assessing emission reduction effectiveness, data given in terms of energy units saved had to be recalculated into t CO_2 saved using emission factors (indicating how much CO_2 is emitted through energy production) taken from the literature. As the types of energy end-use were unknown in most cases, general country-specific emissions factors were used, mainly relying on UNEP 2000. However, due to the limited availability and reliability of these data for several countries, original units in energy were kept for some studies.

3.4.2. Cost-effectiveness

Qualitative data
Like effectiveness, cost-effectiveness is evaluated in a quantitative and a qualitative way. Cost-effectiveness is viewed from a societal perspective. The qualitative grades are based again on the quantitative figures as well as on the following indicative ranges in table 4:

Table 4: Ranges as basis for qualitative grades for cost-effectiveness

Grades for cost-effectiveness	**High**	**Medium**	**Low**
Cost of GHG reductions in $/t$CO_2$	< 0	0-25USD/t CO_2eq	>25USD/tCO_2eq
benefit - cost ratio (B/C)	>1	0.8<B/C<1	< 0.8

However, as many evaluation studies did not include any cost-effectiveness data at all and the number of studies for some instruments was very low this method was considered insufficient and therefore complemented by expert review.

Recalculation of quantitative data on cost-effectiveness
Data given in energy units had to be converted into USD/tCO2 saved using country-specific emission factors from the literature. All financial values were deflated to the base year 2000 (where possible). Furthermore, the given data were corrected for the benefit of avoided costs due to reduced energy consumption. Cost-effectiveness data often take into account only investment and capital costs as well as implementation costs of energy efficiency retrofits. However, considering cost-effectiveness from a societal perspective requires including the financial benefits (i.e. avoided costs) of saved energy due to several reasons: first, not taking into account these benefits misinterprets the cost-effectiveness of instruments. This is confirmed by the literature: internationally recognized scholars explain the necessity of this recalculation (for example Koomey and Krause 1989, Koomey *et al*. 1990, Atkinson *et al*. 1991) since the financial benefits of saving energy have to be taken into account. Secondly, some of the evaluation studies used such as Australian GHG office (2000) had already performed this recalculation; therefore, it was necessary to use the same method also for other data in order to ensure the comparability of all data. For these reasons, the avoided costs of saved energy were taken into account by subtracting the

country-specific energy price from the cost of saved energy before dividing by the emission factor. Thus, not only the investment or capital costs and the implementation costs of the various policies, but also the direct economic benefits (yielding from energy savings) were taken into account.

3.4.3. Factors for success

The last category of criteria explaining the reasons for the success or failure of policy instruments is rather qualitative. Where available this information was extracted from the literature and the consulted evaluation studies of policy instruments' implementation. However, as many policy instruments have either not yet been evaluated or their evaluations do not cover such issues, a limited number of qualitative interviews were performed with experts and/ or policy-makers carried out not only by the authors of this report, but also by researchers in the respective countries. For this purpose, a questionnaire was developed which constituted a guideline for the conversation.

3.5. Limitations of the study

As stated in the introduction, the aim of this study was a comparative assessment of numerous policy instruments using **existing** ex-post evaluation studies. Therefore, no original primary evaluation was carried out. Thus, the limitations are determined by those given by the literature used.

Finding evaluation studies was difficult because they either do not exist, are not publicly available or exist only in the national language for which translation has not been available. In order to overcome the language barrier, a large number of contributors were hired for the research in this report in the source countries in order to read and summarise the key information in reports written in not accessible languages as well as to conduct interviews. Although an effort was made to identify original evaluation studies, this was occasionally not possible. Therefore, secondary sources reporting on the results of existing, but not available or understandable evaluation studies sometimes had to be used.

Unfortunately, many studies do not detail the methodology of the evaluation and most of them use different methodologies for calculating effectiveness and cost-effectiveness. Cost-effectiveness can include transaction costs and administration costs. For example, some case studies include the benefits of saved energy while others do not. Wherever possible the applied methodologies were identified and harmonized using the methods described above in order to finally have comparable societal costs for all case studies.

In addition, the comparability of the effectiveness of instruments is limited since they are based on diverging baselines, some of which are not even known. Relative emission reduction figures (in percent) would be more helpful to compare the instruments, but are only rarely available. Secondly, many policy instruments especially in developing countries, but also in many developed countries, have not been evaluated at all due to the recentness of their introduction, to limited financial resources, and other factors. In many countries, ex-ante evaluations are much more frequent than ex-post evaluations. Since the former are often more optimistic than the latter, or occasionally more pessimistic, as many ex-post studies as possible were included. However, sometimes only ex-ante studies were available which are clearly marked as such. Finally, even if evaluation studies are available, they sometimes do not include quantitative data, especially not on cost-effectiveness. For this reason, quantitative information on some policy instruments is limited so that some results require further research.

However, the most important caveat is that policy measures are not enacted in a policy vacuum, but as part of complex policy architectures. This can generate synergistic effects increasing the overall effectiveness, or can compromise effectiveness, but makes it difficult to separate the impacts due to the specific policy instrument in question. However, as this study is based on existing policy evaluations, this separation was performed by the original studies and thus this research has not dealt with the attribution of policy impacts.

4. Assessment of individual policy instruments

The evaluation of the majority of instruments includes case studies that achieved significant energy and CO_2 savings. However, the amount and costs per tonne of CO_2 saved diverge greatly and all instruments are subject to numerous success conditions.

4.1. Regulatory and control instruments

Control and regulatory instruments are probably the most commonly used instrument category for energy efficiency improvements in the buildings sector. They can be defined as institutional rules which aim to directly influence the environmental performance of polluters by regulating processes and products used, by prohibiting or limiting the discharge of certain pollutants, and/or restricting activities to certain periods or areas. (OECD 1989). Following the methodology of the MURE database, this category was further sub-divided into *regulatory-normative* and *regulatory-informative* instruments since some of the instruments such as building codes prescribe a certain standard for producers whereas others, such as mandatory labelling, stipulate just the provision of information to the user, who may decide not to follow the energy efficiency advice.

Numerous case studies have shown that standards and obligations are usually effective in the building sector if applied well. However, their effectiveness can be hampered by poor enforcement, which is a major obstacle to real effectiveness in several countries (Lee and Yik 2004, Ürge-Vorsatz *et al* 2003), as well as the rebound effect[7]. In order to remain effective, control and regulatory instruments have to be monitored, evaluated and *updated* or *revised regularly* in accordance with technological developments and market trends. In addition, regulatory instruments are much more applicable and easy to enforce in new than in existing buildings (EURIMA 2006). In the latter category, compliance is especially difficult to enforce as building owners often don't need to notify the authorities in case of small renovation works. Finally, low-income households need to be specifically addressed as they cannot afford many of the energy retrofits.

4.1.1. Regulatory-normative instruments:

4.1.1.1. Appliance standards

Appliance standards are among the oldest and most commonly used instruments for increasing energy efficiency of appliances used in commercial and residential buildings. The first effective standards were set in the 70s in California (della Cava *et al*. 2001). Today, most developed and more and more developing countries have enacted appliance standards for certain products. Products subject to standards cover all end-uses and fuel types, although typically there is a focus on appliances, ICT, lighting, heating and cooling equipment. For instance, the Top Runner Program in Japan, requiring that all new products must meet by a specified date the efficiency level of the most efficient product at the time the standard was set (Geller *et al*, 2006, Mirasgedis, pers. comm.), resulted in energy efficiency improvements of over 50% for some products. Total energy savings are expected to reach 0.35 EJ (Exajoule) by 2010, which is significant compared to the total annual household consumption of around 2 EJ (Geller *et al*. 2006). The US was one of the first countries introducing *appliance standards.* These resulted in a decrease in the total

[7] The rebound effect refers to the phenomenon that when consumers purchase a more energy-efficient product, they tend to use it more or purchase a larger capacity product, therefore cancelling part of the energy savings through the technical efficiency.

national annual electricity demand by 2.5% in 2000 compared to the projected demand (Geller *et al*. 2001) and are projected to reach a total reduction of 6.5% of the baseline in 2010 and 7.8% in 2020. CO_2 emissions were reduced by 108 Mt in the period 1990 to 1997 (Mc Mahon *et al*. 2000).

Box 1: Appliance standards in China

Appliance standards have enabled significant energy and CO2 savings also in developing countries. In China, the first standards were set in 1989. Today, the country has one of the most comprehensive standards and labelling programs in developing countries (Lin 2002), combining minimum energy efficiency standards, a voluntary endorsement label and a planned energy information label. According to Lin, existing standards and labels in China for the most common appliances will probably reduce residential electricity consumption by 33.5 TWh annually, or by approximately 9% of the forecasted residential electricity in 2010 (Lin 2002). Such a saving would also result in a CO2 emissions reduction of 11.3 million tons of carbon in China. From a cumulative point of view this corresponds to electricity saving of 164 TWh, equivalent to a reduction of China's CO2 emissions by 56 million tons of carbon.

Appliance standards are cost-effective from a theoretical point of view, as setting standards reduces transaction costs for consumers and producers. This is confirmed in numerous countries: for 2020, "costs" for appliance standards evaluated by the studies range between **-65$/t$CO_2$** (i.e. a *net benefit* of USD 65/tCO2, instead of a net cost) in the USA, projected for 2020, and **-190$/t$CO_2$** in the EU (IEA 2005, Schlomann *et al.* 2001, Gillingham *et al.* 2004, Energy Charter Secretariat 2002, WEC 2004, Australian Greenhouse Office 2005, IEA 2003a); which certainly makes them one of the most cost-effective instruments in the arena of mitigation policies. However, for 2010, the costs are still expected to be above zero in Europe (IEA 2003a). Standards do not provide incentives for innovation beyond the target. For this reason, they need to be periodically updated, which is a prerequisite for achieving continuous and significant GHG emissions reductions and to be communicated clearly to the manufacturers. Another option is to combine them with mandatory labelling which provides incentives for further innovation. Furthermore, to be effective, standards require continuous testing of products as well as effective control of imported goods in order to make sure that they correspond to the standards. This implies the requirement to train customs officers in this area. Brands need to be protected, which is not the case in for example Kenya, where standards can therefore not be effectively applied (Klinckenberg, pers. comm.). Finally, a major barrier is that the energy efficiency gains are sometimes offset by the purchase of new additional energy-consuming equipment so that the overall energy consumption is not reduced. To prevent this effect, information programs are important. Table 5 summarizes the information on appliance standards.

Table 5: Summary table for appliance standards[8]

Emission reduction examples	Cost-effec-tiveness examples	Barriers	Remedies	Advantages	Factors for success
Jp: 31 M tCO_2 in 2010 Cn: 250 Mt CO2 in 10 yrs US: 1990-1997: 108 Mt CO2eq, in 2000: 65Mt CO2 = 2.5% of electricity use	US: -65$/tCO2 in 2020 EU: -194$/t CO2 in 2020	- No incentives for innovation -Rebound effect - Problem of enforcement	- Combination with infor-mative instruments	- Less trans-action costs - Control relati-vely easy as limited number of manufac-turers - Can change market	- Regular update - Clear commu-nication - Provide quality testing - use "Top Runner" approach

[8] Country name abbreviations can be found under table 30 as well as in the list of abbreviations.

4.1.1.2. Building codes

Building codes, standards which address the energy use of an entire building or building systems such as heating or air conditioning (Birner and Martinot 2002), are one of the most frequently used instruments for energy efficiency improvements in buildings and can play an important role in improving energy efficiency in buildings (OECD 2003). While building energy efficiency codes exist in almost all developed countries more and more developing countries such as Thailand are currently introducing such legislation. The latter are often introducing voluntary standards first.

There are two types of building codes: On the one hand prescriptive codes that set separate performance levels for major envelope and equipment components, such as minimum thermal resistance of walls, are used more frequently, possibly due to their easier enforcement (for instance Australian Greenhouse Office 2000, Mirasgedis, pers. comm.). On the other hand, overall performance-based codes, prescribing only an annual energy consumption level or energy cost budget, usually provide more incentives for innovation (Gann *et al.* 1998), but require better trained building officials and inspectors (Hui 2002).

However, the effectiveness of building codes varies significantly from country to country, mainly due to difficulties and resulting differences in compliance and enforcement. As can be seen on table 6, building codes in the US are estimated to have reduced energy use by 15-16% of the baseline in 2000 (0.57 EJ) (Nadel, 2004). According to estimates, new dwellings in the EU built today use on average 60% less energy compared to the building stock built before the first oil shock (WEC 2004). On the other hand, only 40% of new buildings comply with building codes in the UK (Deringer *et al*. 2004) and this figure is as low as 20% in the Netherlands as authorities are often reluctant to enforce the standards on private owners (EURIMA 2006). Another problem is that, as most building codes policies mainly concern new buildings, the impact of this policy tool becomes apparent only after a significant amount of time (IEA 2005b). At least in developed countries, old buildings make up the largest part of the buildings stock, and the rate of turnover is rather low. Therefore, focusing building codes only on new buildings, as does the new EU Energy Performance of Buildings Directive, has only limited effects. One possibility is to require energy efficiency considerations be taken into account when renovation works are undertaken anyway (EURIMA 2006). Germany is one of the few countries which have enacted regulations for existing buildings: when more than 20% of the building area is affected by the renovation, rules for new construction need to be followed.

Especially in developing countries, building codes are often ineffective or much less effective than predicted. Deringer *et al* (2004) argue that while building energy efficiency codes exist in a number of developing countries, but they are often only on paper due to insufficient implementation and enforcement, corruption and other problems. In China, enforcement of building standards is high in major cities (above 80%), but much lower in smaller cities and rural areas (Huang 2007). Furthermore, one study found that although 70% of all new buildings complied with the standard on paper, this number was reduced to about 30% in reality (Deringer *et al.*2004). Building codes in developing countries are usually promoted by and developed with support from international donor agencies, but if this support does not cover the implementation period, prospects are rather negative. Furthermore, similar to most other regulatory measures, building codes have to be regularly upgraded to remain effective, as technologies improve and costs of energy-efficient features and equipment decline. Another possibility to stimulate compliance is to combine building codes with incentives: The German minister for environment has proposed that tenants could be allowed to pay less rent if the landlord does not ensure a certain level of energy use. Many developing countries actually introduce building codes first on a voluntary basis in order to raise awareness among professionals, who often don't know about energy efficiency. In Lebanon, new buildings complying with the building codes are allowed a larger floor space in construction, which provides incentives for compliance.

Table 6: Summary Table for building codes

Emission reduction examples	**Cost-effectiveness examples**	**Barriers**	**Remedies**	**Advantages**	**Factors for success**
Cn: 1% of total electricity in Hkg saved	NL: from -189\$/tCO_2 to -5\$/tCO_2 for end-users, 46-109\$/ tCO_2 for society	- Lack of compliance - Rebound effect	Better enforcement through inspection Combination with incentives	-Lowers transaction costs - very effective	- Regular update of standards - Adaptation to local context - Training/Capacity building - Demonstration programs
UK: 7% less energy use in housing					
US: 15-16% of baseline, 79.6 $MtCO_2$ in 2000					
EU: up to 60% for new buildings, 35-45 MtCO s					

Table 7 summarizes the major barriers and possible remedies for building codes in developing countries. (The barriers refer to the barrier table (1) while building code implementation activities or accompanying measures/instruments are considered as remedies.) According to the table, demonstration programs and market transformation programs can overcome most barriers.

Table 7: Barriers and possible remedies for energy efficiency building codes (EEBC)

		Potential for Overcoming Barriers (H=High, M=Medium, 0= no impact on barriers)								
EEBC Implementation Activities		**Barriers**								
		Strong first cost bias	Access to building financing	Lack of long-term donor commitment	Lack of Government Champion	Lack of efficient products	Lack of testing & certification	Limited local energy expertise	Lack of awareness and tools	Potential Abuses
1	Promulgation	H	0	H	H	0	0	0	0	H
2	Compliance Process	0	0	H	0	0	0	0	H	0
3	EEBC Administration and Enforcement Structure	H	0	H	0	M	M	0	H	0
4	Training and Capacity Building	0	0	H	0	0	0	H	H	0
5	Outreach and Public Information Programs	0	0	H	H	0	0	M	H	H
6	Estimate Energy savings and cost effectiveness	0	0	H	M	M	0	M	H	M
7	Market Transformation Programs	H	H	H	0	H	M	H	H	0
8	Multiple Demonstration Buildings	H	M	M	M	H	M	H	H	M

Source: Deringer *et al*. 2004

4.1.1.3. Procurement regulations

Procurement regulations with provisions for energy efficiency are mainly used in the public sector and are considered to be one of the most effective instruments due to the large share of the public sector in many countries. The US Federal government for example is the largest energy consumer in the world (FEMP 2007). However, the effectiveness of procurement regulations depends on whether energy efficiency specifications are ambitious, regularly upgraded and built into the procurement legislation (Borg *et al*. 2003; Harris *et al*. 2005; Van Wie McGrory *et al*. 2006). Appropriate combination with other policy instruments is important, for instance with training of employees.

Germany, France and Italy have introduced environmental and energy efficiency concerns into public procurement regulations while the UK procurement law even requires life-cycle cost-assessment (Borg *et al*. 2006). Only Italy has mandatory energy efficiency public procurement regulations for the buildings sector, while other countries apply voluntary agreements or issue guidelines. However, compliance is low in Italy so that energy consumption in the public sector continues to rise. The USA with its Federal Energy Management Program (FEMP) has one of the most stringent legislative frameworks for procurement: federal agencies are required by the Energy Policy Act of 2005 and Executive Order 13123 to purchase ENERGY STAR-qualified or FEMP designated products as well as to purchase products using less power in the standby mode (FEMP 2007). Savings are expected to reach 4.32 MtCO2 in 2010.

Table 8: Summary table for procurement regulations

Emission reduction examples	**Cost-effectiveness examples**	**Advantages**	**Factors for success**
Mex: 4 cities saved 3.3 ktCO_2 eq. in 1 year Cn: 3.6Mt CO_2 expected EU: 20-44Mt CO_2 potential US:9-31Mt CO_2 in 2010	Mex: $1 Million in purchases saves $726,000/ year EU: <21$ /tCO_2	Appreciated way to spend tax-payers money	− Ambitious energy efficiency specification and regular updates − Mandatory programs are better − Immediate need is positive (energy shortage, high energy prices) − High-level political commitment − Energy efficient labelling and testing − Beginning with simple measures − Supporting legal framework and reliance on other policy instruments i.e. labelling

Several developing countries, including Mexico, China, Thailand, South Africa and Ghana, have introduced various measures for energy efficiency improvements in the public sector, some of them public procurement regulations such as in Korea (Van Wie McGrory *et al* 2002). China has elaborated an energy efficiency procurement law, modelled after the US Federal Energy Management Program and supported by the PEPS program. As it was only introduced in 2004, no evaluations are available yet, but savings are expected to reach 4.65 TWh or 3.6 MtCO2 in year 10 of the program (Van Wie McGrory *et al* 2006). In Mexico, however, the attempt to introduce a comprehensive federal program failed due to budget pressures and staff turnover. Instead, public procurement legislation was introduced at the city level. After one year, 5000 MWh or 3300 tCO2 had been saved in four municipalities and replication was planned for other cities. In both cases, the success can be explained by the immediate need for action due to high energy prices (Mexico) and energy shortage (China), the supportive legal framework, and the existence of other policy measures such as labelling. Another important success factor is the strategy of program designers to focus on a few products and simple measures first. However, the example of Mexico also shows that the same program designs cannot be applied everywhere, but adaptation to the local situation is necessary.

4.1.1.4. Energy efficiency obligations (EEOs) and quotas

Energy efficiency obligations (EEOs) can be defined as a legal obligation for electricity and gas suppliers to save energy in their customer's premises (Lees 2006). The suppliers fulfil this obligation using measures such as insulation, cogeneration, improved heat pumps. In 2007, this instrument was enacted in the UK, Flanders, Denmark, Italy, France and Ireland. However, the design varies significantly, for example regarding who sets the target, the discount rate and the level of the target. Energy efficiency obligations are usually effective, but especially cost-effective: in the UK, the Energy Efficiency Commitment's (EEC) net societal costs were negative at -139 $/tC02 saved during the first EEC period from 2002-2005 (Lees 2006), and those of the energy efficiency obligation in Flanders as low as -60 to -216 $/tCO2 (UK government 2006, Sorell 2003, Lees 2006, Collys 2005, Bertoldi and Rezessy 2006). The savings due to the UK EEC exceeded expectations by about 20%. Other advantages of an Energy efficiency obligation include its cheap administration and relative simplicity, that it can be designed to avoid regressive social impacts and that it need not count as government expenditure (Lees 2006). Furthermore, the EEC in the UK has triggered a market transformation for cold appliances, wet appliances and condensing boilers.

If the government decides on the target and the discount rate the effectiveness of EEOs can be maximized because of the social and environmental implications of these decisions (Lees 2007). For example, by allocating part of the energy saving target to low income consumers, fuel poverty can be reduced. In addition, it is necessary to address the problem of free-riders, i.e. those who would have introduced the energy efficiency retrofits anyway, for example by increasing the target. It is therefore necessary to know the previous sales of Energy efficiency measures. Energy efficiency obligations have not yet been used in developing countries, however, one expert (Lees 2007) proposes linking EEOs with CDM or carbon offsetting. EEOs would help developing countries to tackle the energy problem from the demand- side and not as usual the supply-side. However, administration, monitoring and verification of the energy companies have to be ensured, adapted to the local circumstances. Although EEOs usually lead to increases in energy price of 1 to 2% they can bring financial benefits to consumers and commerce in the medium term.

Table 9: Summary table for Energy Efficiency Obligations (EEOs)

Emission reduction examples	**Cost-effectiveness examples**	**Barri-ers**	**Reme-dies**	**Advantages**	**Factors for success**
UK: 2.16 $MtCO_2$ /yr	Flanders: -60 to -216 $/tCO2 UK: -139 $/tC02	Re-bound effect	Combina tion with informa-tion and incen-tives	cheap administration, relatively simple need not count as govern-ment expenditure can trigger market trans-formation can be designed to avoid regressive social impacts	- Regular updates - New energy efficiency measures - government decides on target

4.1.2. Regulatory-informative instruments:

4.1.1.5. Mandatory certification and labelling

Mandatory certification and labelling programs are defined as the mandatory provision of information to end users about the energy-using performance of products such as electrical appliances and equipment, and even buildings. Labelling programs are used in many countries all over the world, also in numerous developing countries such as China, Brazil and South Africa (CLASP 2007). They are considered one of the most effective and cost-effective policy tools which can also achieve the desired market transformation. Combination with other policy instruments such as financial incentives or voluntary agreements can enhance their effectiveness. Labelling is also often combined with appliance standards. Voluntary labelling can be considered an informative instrument and is therefore treated in the corresponding section (see 4.4.1), but is often less effective (Birner and Martinot 2002) as only the most effective products might be labelled.

In Australia, energy use of many appliances such as freezers and dishwashers was reduced by approximately 4% annually from 1993 to 2005 through mandatory labelling which was achieved at a negative cost of 30$/tCO2 (WEC 2004, OPET network 2004, Holt/Harrington 2003). In the future, from 2005 to 2012, GHG emission reduction due to tighter labelling standards in Australia is expected to reach a total of 81 MtCO2 e.q., with costs between -135$/tCO2 and -23 $/tCO2, depending on the discount rate applied (IEA 2003, Australian Greenhouse Office 2005). However, the rebound effect and lack of compliance can significantly hamper the effectiveness of the instrument, even in developed countries. On the other hand, although a survey found that compliance with the labelling obligations for kitchen equipment was low, especially in retail shops and for built-in appliances in Germany, the instrument was considered relatively effective as the share of A-labelled appliances had risen to up to 50% (Schlomann *et al*. 2001). Table 10 displays further success factors.
Mandatory labelling and certification is increasingly used not only for appliances, but also for whole buildings. The new Energy Performance of Buildings Directive in the EU requires the obligatory energy certification of new and existing buildings (building pass) as well as prominent display of this certification and other relevant information in public buildings (Geissler *et al*. 2006). Several EU countries had national certification programs already prior to the EU directive, but building certification is usually much more expensive than appliance labelling since calculations have to be performed for every house individually.

Table 10: Summary table for mandatory certification and labelling

Emission reduction examples	Cost-effectiven. examples	Barriers	Remedies	Advantages	Factors for success
Dk: 3.568 MtCO2 Aus: 81 MtCO2 2000-2015	Aus: -30$/tCO2	- Rebound effect - Lack of compliance	- Combination with other instruments - Stakeholder involvem. in supervisory systems	- very effective and cost-effective - can lead to market transformation	− Information and training − Use by major economic agents as marketing tool − Use as basis for reporting and specifying performance − Open-ended labelling, regular revision and updates

4.1.1.6. Mandatory audit programs

Mandatory audit programs bring diverse results, but combination with other instruments such as financial incentives enhances their effectiveness (WEC 2004). Mandatory energy audits for industrial and large commercial consumers are one of the most common policy instruments in many European and other countries (WEC 2004), but, residential buildings are rarely included in audit programs. These programs have the advantage that a large number of customers can be reached in a short time and the measure thereby can quickly lead to urgent energy savings, e.g in the case of energy shortages (Eichhammer 2007). Conducting energy audits in public buildings as well as the training and certification of auditors is also a frequent policy instrument in developing countries which are introducing energy efficiency policies, such as India.

However, mandatory audit programs require qualified auditors and energy managers which necessitates a certification process. The success of audits depends on the implementation and financing of the proposed retrofits. In developed countries, many of the proposed measures (from 50% in the US to 80% in New Zealand) are installed after the audit, with payback times of frequently less than 3 years. Financing of audits and the follow-up measures can be another problem: Mandatory audits are often partially or completely financed by the authorities. In the US, 100 000 homes are upgraded (weatherized) annually as a result of auditing with financial support from the government, which reduces their fuel consumption by approximately 21% (Gillingham *et al*. 2006). Audits and their follow-up can also be performed by ESCOs, but, ESCOs are not always content with subsidized audit programs as the quality of the audits is often low (Urge-Vorsatz *et al*. 2007).

Mandatory audits are used by a number of developing countries such as Thailand or Korea. In Korea, auditing around 20 public and other commercial buildings annually saved 296 tCO2 (1417 MWh) annually (IEA 2005 c). Audits for certain energy consumers are also mandatory for example in Tunisia, India, Taiwan, Romania, Algeria, Australia, Bulgaria and the Czech Republic (Eichhammer 2007). Unfortunately, if the audit is subsidized, but not the implementation of the suggested improvements, the rate of implementation is frequently low, for instance below 20% in Lebanon. This rate is much higher, i.e. around 60-70% in Tunisia, where a fund is available to support part of the energy efficiency improvements (Mourtada, pers. comm., Kawther-Lihidheb, pers. comm.). In addition, subsidized or mandatory audits require capacity-building of consultants who perform the audits. Lack of monitoring of the audit’s quality as well as its follow-up is a major reason for the limited success of this measure in Egypt.

Table 11: Summary table for mandatory audit programs

Emission reduction examples	Cost-effectiven exampl	Barriers/ Problems	Remedies	Advantages	Factors for success
Kor: 296 t CO2 yearly US Wheaterization Programme: 22-30% savings	US Weatherisation program BC-ratio: 2.4	- No requirement to implement advice of audit -insufficient staff - complex and expensive to administer	Regular audit require-ment	Can be positive for ESCOs	- Correct implementation and financing - Combination with fin. Incentives - High energy price - Capacity-building

However, there are also disadvantages of mandatory audits as table 11 shows: Denmark abolished the audit requirement after several years as it was too complex from an administrative point of view and too expensive (Eichhammer 2007). Detailed energy audits, especially in industry, are relatively costly. Often, the information from audits is collected in a central government body, but follow-up is difficult due to understaffing at the agency. Capacity-building of all involved actors, including officials, is therefore a prerequisite for the success of this measure.

4.1.1.7. Utility demand-side management programs

Utility demand-side management (DSM) programs can be defined as planning, implementing, and monitoring activities of energy efficiency programs among/by utilities. Table 12 displays possible measures in DSM programs and table 13 examples of effectiveness and cost-effectiveness of these. DSM programs are often effective, conserving, for example, 36.7 Mt of CO_2 in 2000 at a negative cost of -35$/tCO2 saved in the USA (Gillingham *et al*. 2004). Costs for DSM programs in Europe are about 0.02 c$/ kWh. Their effectiveness is usually higher in the commercial than in the residential sector (IEA, 2005; Kushler *et al* 2004). However, the success of DSM programs depends on deliberate project design, adapted to the local situation and market as well as other factors displayed in table 12. In the UK for example, distributing compact fluorescent lamps (CFLs) free of charge has discouraged purchase of these energy-efficient products in the marketplace which led to a reduction of CFLs in retail stores, seriously undermining the long-term sustainability of the measure (Boardman 2005 cited in Geller and Attali 2005).

Table 12: Different types of DSM programs

Households	**Industry, trade and services**
Counselling of individual consumers	
Individual advice and counselling	Individual advice and counselling – energy assessment
Conversion of electrical heating	Advice regarding new installations
Appraisal of electrical heating	Energy management and auditing
Advice of heat pump installations	
General information	
Activities changing energy behaviour	Meetings about energy topics
Education of school children	Show and display rooms
Lending out of meters and low-energy bulbs	Informative electricity bills
Show and display rooms	
Articles, advertisement, magazines	
PC-program about energy use and saving	
Informative electricity bills	
Technical campaigns	
Street lighting	
Standby	
Technology procurement	

Source: Hein Nybroe 2001

DSM programs have been initiated by utilities, for example in the USA in the 1990s, in order to cope with increasing energy demand and avoid constructing new power plants or to keep customers. Due to the restructuring and liberalization of electricity markets, started in the mid-1990s especially in the EU, utilities significantly reduced the number of their voluntary DSM programs as they feared losing competitiveness. However, the liberalization of electricity markets has also provided opportunities for new policy initiatives in this area (Palmer, 1999; Eyre 1998) especially due to accompanying policy measures. In fact, DSM programs are more and more boosted by regulatory incentives or mandatory charges on electricity prices (public benefit charges, see below). For instance, in the US many state restructuring laws and federal restructuring bills also include a mechanism for funding DSM initiatives (for instance through an electricity surcharge, often referred to as the public benefit charge or by imposing a spending target). Public benefit charges are also enacted in some EU countries while other EU member states have introduced energy efficiency obligations or trading schemes whose concept is similar to DSM. Denmark has even introduced mandatory DSM provisions.

DSM programs have also been introduced in some developing countries. Jamaica ran a DSM program between 1994 and 1999 which included 7 energy efficiency programs, public information, and institutional capacity building as well as assessment of energy saving potentials of 4 projects (MITEC 2007). US$12.5 million was invested into the project by a consortium of funding agencies. In spite of numerous barriers such as insufficient support by the government, low energy prices and unfavourable investment climate caused by an unfavourable macroeconomic situation, the project was successful and exceeded the expectations (Evander *et al*. 2004). Phase 1 of the project supplied 100 households at no cost with energy efficient technologies, which reduced annual energy use by 58 021 kWh. 32,000 households have been reached through the residential program (phase 2) which provided energy saving devices at discounted prices resulting in total annual energy savings of 5,347 MWh (Evander *et al*. 2004). The Large Commercial Retrofit Program completed energy audits for 15 facilities. However, as the announced funding for the implementation of the proposed measures could not be provided, only 5 facilities realized the saving potential using their own funds. Estimated savings amount to 3 GWh (MITEC 2007).

Thailand also has a successful DSM program replacing chillers in buildings (Evander et al 2004) combined with labelling. The energy efficient fluorescent lamp project (thin tube project) and the labelling project for refrigerators and air-conditioners are considered very successful. The DSM office tries to promote market transformation by stimulating local manufacturers, importers and distributors to consider the production and import of more efficient appliances and by encouraging consumers to actually buy these new products (Brulez et al 1998). Thailand is in general often considered a model for other developing countries as it succeeded in making energy efficiency a national priority through its energy conservation law and accompanying measures (Brulez, pers. comm.). Market transformation started and foreign investors became interested in the energy efficiency market.

Table 13: Summary table for utility demand-side management programs

Emission reduction examples	Cost-effective-ness exple	Barriers	Reme-dies	Advantages	Factors for success
US:36.7Mt CO_2 in 2002 Jamaica:4.9% less el use = 10.8 ktCO2 Dk: 0.8 MtCO2	US: -35$/ tCO2 EU: -255 $/tCO2	Restruc-turing of electri-city market	Manda-tory charges on elec-tricity prices	-Involvement of industry - More effective for commercial sector	- Combination with regulatory incentives - Adaptation to local needs & market research - Clear objectives - Focus on skills and pilot programs first - Strong leadership

4.1.3. Comparison of regulatory instruments

Regulatory instruments are used in most countries with legislation on energy efficiency in buildings, but often in combination with other instruments. Figure 2 shows for example how widespread standards and labelling are already today; figure 3 refers to building codes. Main problems are the lack of enforcement and the rebound effect, but on the other hand, most of these policy instruments achieve high savings at low costs, often at negative costs to society. They can overcome many of the numerous barriers, in the buildings sector such as information barriers, market failures and financial/economic barriers as well as hidden costs (see table 1). For example, regulatory instruments help to reduce transaction costs, one of the major problems in this sector, by simply imposing standards which eliminate the need for information-searching.

Comparing different regulatory instruments is difficult, especially as many of them are usually used together since they concern partly different end-uses or target groups, for example appliance standards for appliances, building codes for buildings and procurement regulations for the public sector. The available case studies indicate that appliance standards are often easier to enforce than building codes because the industry is more concentrated and the products are standardized, while the building industry has many diverse trades and the products (buildings) are custom-built (Huang, pers. comm.). However, if correctly enforced, building codes can achieve enormous savings as well. According to the MURE database, regulatory –normative instruments such as building codes and appliance standards are more effective than regulatory- informative instruments such as mandatory labelling or audits because the latter are not binding (MURE 2007).

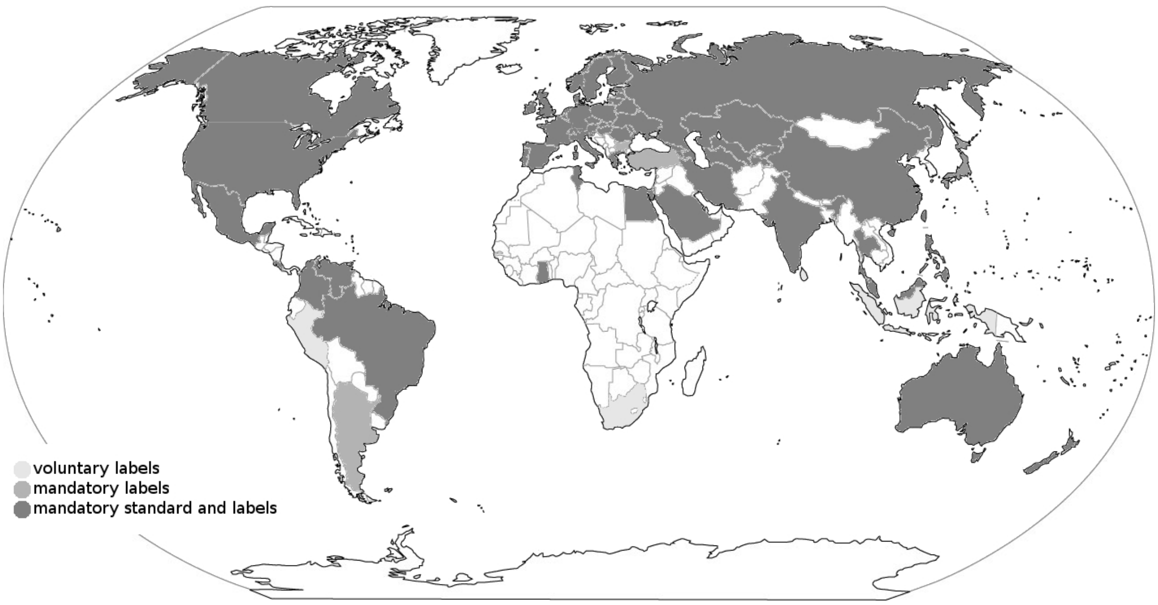


Fig. 2: Standards and labels in different countries as of Sept. 2004
Source: CLASP 2007

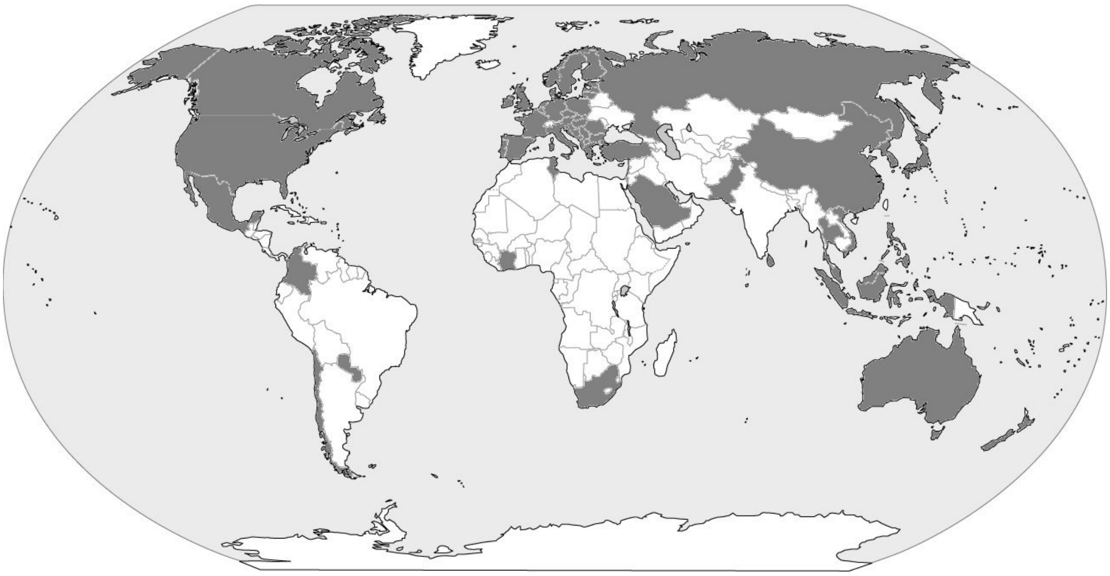


Fig. 3: Building codes implemented all over the world in 2005
Source: UNEP 2007, the Deringer group 2005

4.2. Economic and market-based instruments

Economic instruments for energy efficiency improvements are based on market mechanisms and usually contain elements of voluntary action or participation, which are often initiated or promoted by regulatory incentives. As most economic or market-based instruments, except for performance contracting, are rather new in the buildings sector and have been implemented only recently, mostly in developed countries, ex-post evaluations with universal lessons are only rarely available. The instruments analyzed in this report differ considerably in their form, aim and emission reduction effectiveness.

4.2.1. Energy performance contracting/ ESCO support

Energy performance contracting (EPC) means that a contractor, typically an energy service company (ESCO), guarantees certain energy savings for a location over a specified period; implements the appropriate energy efficiency improvements; and is paid from the estimated energy cost reductions achieved through the energy savings (EFA 2002). EPC and ESCOs are therefore not real policy instruments, but rather vehicles or agents for implementing and financing energy efficiency projects. However, various policy measures exist which can support the development of ESCOs, some of which are among the 20 instruments analyzed in this report (see table 14).

The success of EPC and ESCOs varies significantly from country to country. The mechanism has been working effectively in some countries such as Germany, the US and Hungary, while there are few or no ESCOs in other countries such as Denmark, the Netherlands and most developing countries. In the US, the first and most successful country in terms of energy performance contracting, 3.2 Mt CO_2 is estimated to have been saved through this mechanism (ECCP 2003, OPET network 2004, Singer 2002, WEC 2004). During the last decade, ESCOs have been created in a number of developing countries, often supported by international programs run by GEF, UNDP, the World Bank, UNEP or funding support schemes by the respective governments. Today, ESCOs are considered successful in several developing countries such as China and Brazil, and less so in some other countries such as India (Urge-Vorsatz, Koeppel *et al*. 2007).

EPC is becoming increasingly popular since no public spending or market intervention is needed to capture the cost-effective energy-efficiency potential (although they can be helpful in certain cases to kick-start the ESCO market) and competitiveness can be improved. However, a certain number of conditions must be fulfilled for an effective ESCO industry such as a mature financial sector willing to lend for energy efficiency projects, unsubsidised energy prices and supportive legal, financial and business environments. As these are not present in many countries, the EPC market has not reached its potential, even in countries considered as successful in terms of EPC. Furthermore, the activity of ESCOs varies considerably according to the sector: in many countries, especially developed countries, the public sector is the most important sector for ESCOs and even the driver for the ESCO market (Urge Vorsatz, Koeppel *et al*. 2007). ESCO activity in the residential and commercial sectors is much rarer due to a number of barriers such as split incentives, small project size and high transaction costs.

When international organisations are implementing ESCO support projects in developing countries it is important that local issues be taken into account, that energy conservation technologies and suppliers are carefully chosen and that ESCO staff are supported in implementing the first projects as they are usually relatively complex (Evander et al. 2004). Barriers to EPC and possible solutions are presented in table 14.

Table 14: Barriers to EPC in different sectors and possible solutions

Barrier	Sector	Reasons	Country	Possible solutions
Insufficient levels of information and awareness of EPC and its opportunities	All	Potential clients and many financial institutions are unfamiliar with the principles of EPC	All countries	Information and demonstration programs, train financial facilities, model contracts, en. agencies
High perceived technical and business risk by clients	All and banks	Fear of losing jobs, fear about trade secrets, not understanding/ trusting payback scheme of EE, end-use EE projects often non-asset based, collateral hard to get	All countries, e.g. Germany	Information and demonstration programs, accreditation system, standarddization of contract procedures
Lack of confidence and trust in ESCOs	All	Customers are suspicious of the "win-win" solution, don't believe in success of saving measures	All	Accreditation system, standardization of contract procedures, M&V protocols
Banks are not willing to lend for EPC	All	Conservative lending practices and limited experience with EE project financing, Asset-based lending practices versus cash-flow based financing suitable for EE projects, Not aware about EPC or considered as too risky (credit risk)	Mainly countries with still conservative banking system	Demonstration projects, training, grants, concessionnal loans, credit facilities, guarantee schemes provided by the state or IFI, technical assistance, guarantee facilities
ESCOs are not interested in small projects	Esp. Res. sector	Transaction costs high (i.e. profit is too low and risky)	most countries	Guarantee fund, pooling, combination with state support schemes
Principal/agent problem: investor different from beneficiary of savings	Res. hospitals, schools	Split incentives between landlord and tenant, municipal or institutional budget units, etc.	All	Enabling public procurement legislation, progressive rental and leasing contract arrangements
Financing problem for ESCOs	All	Especially small new ESCOs have insufficient internal funds and do not get access to grants	Mainly developping countries	Guarantee fund if high perceived risk, loan schemes, preferential loan schemes
Unfavorable procurement rules	Public	Rules/ procedures difficult to understand, focusing on initial least cost rather than life-cycle, no green procurement	Germany Hungary, India	Change in procurement law/policy
High transaction costs relative to profit	Mainly residential		Many countries	Bundling of buildings/ similar projects programmatic CDM
Low level of data collection, no base-line data available	All	High transaction costs and long preparation time	Developing countries	Systematic collection of consumption data
Inadequate energy service levels	Residential, public	Comfort standards not met prior to intervention	Developing countries	Combination of EPC with other renovation efforts
Unfavorable tax regimes	All	VAT on investments/ equipment higher than on energy prices	DE	Changes in the tax regimes
Shortage of qualified staff and equipment for ESCOs	All	Insufficient high quality education, highly qualified young people move abroad	Developing countries	Education programs, training, ESCO association

List of abbreviations: DE- Germany, CN- China, HU- Hungary, IFI- international financial institution, IN- India, ind- industrial, IT- Italy, PL- Poland, res- residential, SE- Sweden, SME- small and medium enterprise, TE- countries in transition

Source: Urge-Vorsatz, Koeppel *et al* 2007

4.2.2. Cooperative/ technology procurement

Cooperative procurement or technology procurement is a voluntary tool whereby customers from the private or public sector who procure large quantities of energy-using appliances and equipment cooperate in order to influence the market by creating demand for more efficient products. They define their requirements together, invite proposals from manufacturers and suppliers, evaluate the results, and buy the products collectively. Their requirements include energy efficiency specifications which correspond to, or even exceed in certain cases, world best practice instead of only first-cost considerations as usual (EFA 2002). Technology procurement, when used as a market transformation tool for energy efficiency, can be described as a project to aggregate demand for energy-efficient products aimed at encouraging innovation and the introduction of new, more energy-efficient technologies (ten Cate *et al*. 1998). The goal is the commercial availability of new technologies for all buyers, not just the initial group, and ultimately the sustained market acceptance of efficient new products.

Cooperative procurement has been shown to lead to varying results (Van Wie McGrory, pers. comm.) as table 15 and 16 show. For example, 24 US utilities, supported by the US EPA, initiated together the *Super Efficient Refrigerator Program* by launching a competition for a refrigerator 30-50% more efficient than the 1993 standards. The competition, won by *Whirlpool,* led to cumulative energy savings of 192 750 MWh (96 ktCO2) (IIEC 1996).

Table 15: Examples of technology or cooperative procurement

Product	**Project Sponsors**	**Buyers Groups**	**Description**	**Results**
Apartment-sized refrigerators	NY Power Authority, CEE, DOE	NY City Hou-sing Authority NYCHA	NYCHA as lead buyer	Purchase of 100,000 units, 30% efficient gain over conventional; low first cost
Clothes Washers and dryers	NUTEK	Social housing agencies	Efficient, quit equipment for shared laundry rooms	50% more energy-efficient, reduced water and noise levels.
Computers, Printers	White House Executive Order	U.S. federal government	Require federal purchases to specify ENERGY STAR criteria	High market penetration of qualified products; current focus on enabling power mgt.
LED traffic lights	City of Stockholm	Swedish National Road Administration	Purchase of 3-color LED light sets, 85% energy reduction and longer lifetimes.	Demonstrating feasibility and cost saving of 3-light units.
Super-Efficient Refrigerator Project (SERP)	Utilities, ACEEE, EPA, DOE	N/A	Rebate to manufacturers for 25% efficiency impro-vement vs. federal standards	Demonstrated technical potential for greater efficiency

Source: ten Cate *et al*. 1998

Some developing countries are using technology procurement or bulk procurement, i.e. public procurement of energy saving equipment in large amounts, and can thereby achieve or at least trigger a market transformation. India has for example a program to purchase 1 million CFLs while South Africa has distributed CFLs for free in order to solve the energy shortage (Glynn, pers. comm.).

However, as buyers and sellers are often sceptical on whether the proposed energy efficiency improvement can be achieved, strong interaction and positive long-term relationships are important (ten Cate *et al.*1998). Pointing out the co-benefits of this measure such as expected positive public relations effects for the producer and, for example, noise reduction through better products for the consumers can increase the effectiveness of the instrument. The selection of appropriate products with high potential for energy savings and market acceptance is important. The preparatory work for the technical procurement needs to be well executed and the coordinating organisation be well recognised and actively work to gain trust throughout the process (Savola, pers.comm.) However, cooperative procurement requires considerable funding. In China many manufacturers lost interest, due to high technology risks and because they faced strong competition from old cheaper products (Evander et al. 2004). Therefore, funds for addressing demand-side barriers are needed.

Table 16: Summary table for cooperative procurement

Emission reduction examples	Cost-ef-fectiven examp	Barriers	Remedies	Factors for success
US: 192 750 MWh = 96 ktCO2	US: - 118 $/ tCO2 saved	-Scepticism from buyers & sellers -Technical Incompati-bilities -Lack of funding	- Strong interaction btw. buyers and sellers - Secure sufficient Funding	Long-term market commitment and buyer-relationship, active engagement
				Positive publicity for winner
				Combination with other benefits for consumers such as noise reduction
				Combination with standards or labelling
				Choice of right products with technical and market potential

4.2.3. Energy efficiency certificate/white certificate schemes

Energy efficiency certificate schemes, i.e. tradable certificates for energy savings, often called “white certificates”, are a new policy measure, which has been applied in Italy since 2005, in New South Wales (Australia) since 2003 and since July 2006 in France. They consist of a savings obligation which can be fulfilled through trading with savings certificates. White certificates can be defined as certificates issued by independent certifying bodies confirming the claims of market actors for savings of energy, as a consequence of energy end- use efficiency measures (Bertoldi and Rezessy 2006 cited in Capozza 2006). The savings obligations in Flanders and the British Energy Efficiency Commitment are also often considered as certificate schemes due to their energy efficiency obligation element, but as they do not officially include certificate trading in the strict sense[9] (Bertoldi/Rezessy 2006) they have been analysed under “energy efficiency obligation” in the regulatory instruments section above. The scheme in New South Wales (NSW) (Australia) is not a real white certificate scheme in the strict sense as it is part of the NSW Greenhouse Gas Abatement Scheme (Bertoldi and Rezessy 2006). Certificates can be awarded for carbon sequestration projects, demand-side abatement, low emission electricity generation or industrial projects reducing GHG emissions.

The first evaluations of the Italian scheme indicate that expectations have been exceeded, but only during the first year: instead of the expected 1744.5 GWh or 732ktCO2 savings 3 256 GWh or 1.3 MtCO2 were saved. However, this is also due to the high number of “early actions”, since projects and savings undertaken since 2001 could be

[9] The UK EEC scheme could also be potentially discussed in this category since measures and obligations of savings can be traded among obliged parties with the approval of the regulator. Horizontal trade between suppliers does however not take place, in contrast to vertical trade which has been common with suppliers contracting out to project developers most of their measures.

included in the application (Pavan, pers. comm.). Most of these projects were in the domestic sector (34%). However, some problems start to appear. The criteria of assignment of white certificates foreseen by the Italian Decrees and the reference markets' structure – especially in the natural gas sector – show that by May 2007 the 22% of the national objective defined by the same Decrees cannot be assigned and, consequently, cannot be translated into effective energy savings. In terms of absolute value, this gap is expected to grow in proportion to the increase of national energy savings objectives foreseen for the next years (Fioretto, pers. comm.).

Due to the newness of the instrument, experience on cost-effectiveness is not available yet. Costs are estimated to be 0.013 $/kWh in France (Capozza 2006). However, transaction costs might be high and advanced institutional structures are necessary. Countries which have already a trading scheme for renewable energy therefore seem to be better suited to introduce this new instrument. For the same reason, it is not suitable for developing countries. Table 17 summarizes the results for white certificate schemes.

Table 17: Summary table for energy efficiency/white certificate schemes

Emission reduction examples	Cost-effec-tiveness	Barriers	Remedies	Advantages	Factors for success
I: 1.3 MtCO2 in 2006 (3 256 GWh), 3.64 Mt CO2 eq by 2009	Fr: 0.013 $ /kWh expec-ted	Transaction costs can be high	Existing green certificates scheme are helpful	- Benefits for employment - Flexibility for cost-effective compliance	- Adv. institutional structures needed. - Appropriate setting of baseline - Good Measure-ment &verification
		High insti-tutional costs	Certain degree of self-regulation		

Source: Bertoldi and Rezessy 2006

4.2.4. Kyoto Flexibility Mechanisms

The effectiveness and use of the Kyoto Flexibility Mechanisms, i.e. Joint Implementation (JI) and Clean Development Mechanisms (CDM) in the buildings sector are much lower than expected (Novikova et al 2006). They were designed as cost-effective instruments for delivering financing, know-how, sustainability benefits as well as capacity building for GHG mitigation projects in developing countries and economies in transition, also in the buildings sector. Since buildings possess significant, perhaps even the highest cost-effective potential for carbon savings compared to other sectors (see Chapter 6 of IPCC 2007), the mechanisms were expected to deliver major GHG savings in buildings during the pilot phase "Activities Implemented Jointly" (AIJ) and the 1st Kyoto commitment period, 2008-2012.

However, during the pilot phase there were only 10 demand-side projects in economies in transition compared to over 50 supply-side energy projects (Evans 2001). The majority of the former, 5 projects, were in the buildings sector, but their costs varied between 122 and 238 USD/tCO2 gross. Reasons for the low number of demand-side energy projects included the disconnect between emission reductions and end user's energy savings and the higher costs for demand-side energy efficiency projects, since the revenue from energy savings is difficult for an external carbon investor to capture (Evans 2001). Probably the most important barrier is the high transaction costs for demand-side projects, which tend to be small and fragmented, especially in the buildings sector.

These reasons also explain the very low share of projects on energy efficiency in buildings among all CDM projects today (see table 18): in April 2007, only 5 out of 683 projects registered by the CDM Executive Board were linked to the buildings sector (UNFCCC 2007). Although the CDM-market is developing dynamically, the prospects for projects in the buildings sector are rather negative due to the currently very complicated pre-registration and approval-procedure and the lack of a methodology adapted to the buildings sector, due to the uncertainty about the post-2012 regime, and to the high transaction costs (Novikova *et al*. 2006).

Table 18: Registered CDM projects in the buildings sector in 2007

No.	Registration	Title	Host Country	CERs (tonnes of CO2eq./year
1	2005-08-27	Kuyasa low-cost urban housing energy upgrade project, Khayelitsha	South Africa	6,580
2	2006-01-20	Moldova Biomass Heating in Rural Communities	Moldova	17,888
3	2006-01-29	Moldova Energy Conservation and GHG Emission Reduction	Moldova	11,567
4	2006-02-26	CDM Solar Cooker Project Aceh 1	Indonesia	3,500
5	2006-11-18	Improvement in Energy Consumption of a Hotel	India	2,987

Source: Novikova *et al*. 2006, UNFCCC 2007

Table 19: Summary table for Kyoto Flexibility Mechanisms

Emission reduction examples	Cost-effectiveness examples	Barriers	Remedies	Advantages	Factors for success
CEE: 220 K tCO_2 in 2000	63 $/$tCO_2$	High transac-tion costs	Develop new methodo-logy	It is the only international cooperation instrument directed at developing countries	- Project bundling - Information & awareness cam-paigns - Link to program-matic CDM/ GIS
Estonia: 3.8-4.6 kt CO2 (3 projects)	Estonia: 41-57$ /tCO2				
Latvia: 830-1430 tCO2	Latvia: - 10$/ $tCO2_2$				

Possible suggestions for improvement of the current situation include the rapid development of a simplified methodology and procedures specifically for buildings, the establishment of a facility providing project bundling, information and awareness campaigns as well as a link to programmatic CDM or green investment schemes (GIS) (Novikova *et al*. 2006) (see table 19). Monitoring systems enabling the annual evaluation of buildings' energy performance improvement would also be helpful (UNEP 2007).

4.2.5. Comparison of economic instruments

The four economic instruments presented in this section, energy performance contracting, cooperative procurement, energy efficiency certificate schemes and Kyoto flexibility mechanisms are very diverse. They can be applied simultaneously in one country as they target different end-users: energy performance contracting is a financing mechanism, cooperative procurement is used voluntarily by large buyers or groups of buyers in the public or private sector and the Kyoto flexibility mechanisms is the only international cooperation instrument specifically directed at developing countries. However, due to the newness of two of the instruments, Kyoto mechanisms and white certificates, their effectiveness is still uncertain and limited. This might be due to problems with their current design such as a missing methodology for Kyoto mechanisms adapted to the buildings sector. For the same reason, ex-post evaluations are still rare and especially the cost-effectiveness of the instruments remains uncertain. However, there is a significant potential for energy and cost savings through these instruments in the future.

4.3. *Fiscal instruments and incentives*

Fiscal instruments and incentives can be defined as policy tools which influence energy prices either by imposing a Pigouvian tax[10] aimed at reducing energy consumption or by financial support if first-cost related barriers are addressed. Environmental economists often consider fiscal instruments and especially taxes to be the best instruments, as they can give a uniform signal to the whole economy and equalise compliance costs. However, the assessment shows that fiscal instruments vary widely in their effectiveness and cost-effectiveness.

4.3.1. Energy or carbon taxes

Taxes are increasingly implemented, either as CO2-tax or as energy tax (ECS 2001). Examples of CO2 taxes include Denmark, Finland, Norway, the Netherlands and Sweden. In Denmark, Finland and Poland, the tax depends on the carbon content of the fuel, in Germany and Norway on the energy use.

Taxes have a number of advantages: they can reinforce the impact of other instruments such as standards and subsidies, or make energy efficiency investments more profitable. Indeed, tax exemptions are often granted for companies which conclude voluntary agreements or do audits as in the UK, Denmark, Netherlands (ECS 2002). Lowe (2000) points out that energy or carbon taxes, in contrast to regulatory instruments, directly affect the whole building lifecycle, i.e. construction, operation, renovation, demolition as well as the performance of in-building energy systems. Taxes are often considered as very cost-effective in the environmental economics literature. However, the Norwegian energy tax was evaluated as not cost-effective due to the variation in tax rates and the numerous exemptions (ECS 2002).

The effectiveness of energy taxes, especially in the residential and commercial sector, is very much contested (Lowe 2000, Crossley et al. 2000, Schaefer *et al.* 2000). Although environmental taxes are increasingly used in developed countries due to their assumed economic efficiency, quantitative data, especially on cost-effectiveness for the buildings sector, are very rare. These instruments are less frequently used in developing countries where energy prices are subsidized rather than taxed. Energy taxes can take many forms and can reduce GHG emissions in two ways: Taxes always increase the end-user price which is supposed to reduce the demand and therefore associated GHG emissions. Secondly, governments can reinvest tax revenues into energy efficiency improvements. However, both effects depend on the tax design and local conditions.

The first effect mainly depends on the price elasticity of the demand as well as on the level and design of the tax. The elasticity is determined by the proportion of energy expenditures in disposable income (i.e. the relationship between energy prices, consumption and income), and the availability of substitution options. Probably due to the non-immediate availability of substitution options (for example, tenants cannot change their heating system, which accounts for around half of overall residential energy use in European countries) the price elasticity of the demand in the buildings sector has so far been rather low, which limits the effectiveness of the tax (Bernstein and Griffin, 2005). Many studies have found price elasticities between 0 and -0.4 meaning that a 1% price

[10] A Pigouvian tax is a tax levied in order to correct negative externalities of a market activity such as environmental pollution due to industrial activities.

increase leads to a reduction in consumption of 0 to 4 % (Schaefer *et al*. 2000). For example, according to IPCC (2007) in the UK, long-run price elasticity for the household sector is very low with -0.19 (Eyre, 1998), in the Netherlands -0.25 (Jeeninga and Boots, 2001), and in Texas -0.08 (Bernstein and Griffin, 2005). The tax in Norway has not significantly influenced households' choices (ECS 2002). In Denmark, however, taxes decreased the energy consumption of the residential sector by 15% from 1977 to 1991. In Sweden, the energy tax was also relatively effective since it reduced consumption in the residential sector between 1991-2001 by 5% (Brink and Erlandsson, 2004).

Even in developing countries, price elasticities for residential energy are rather low: de Vita (2006) found an average price elasticity for the residential sector of -0.135 which is below the elasticity of most other sectors. In some countries, elasticities are higher for example in Indonesia (-0.57 in the period 1973-1990), and in Pakistan -0.33 (De Vita *et al*., 2006). These low elasticities explain the moderate effectiveness of taxes in reducing emissions. However, the effectiveness of taxes increases if they are levied as upstream as possible in the supply chain (Lowe 2005). Furthermore, their effects are often more significant in the long term (Schaefer *et al*. 2000), since long-run price elasticities are higher. Finally, taxes can also reduce emissions if the government invests the tax revenues into energy efficiency improvements. This can take the form of mandatory DSM measures, subsidy schemes, green funds and other mechanisms. These impacts are discussed and evaluated under the relevant other instruments in this report.

According to Crossley (2000) taxes do not specifically address barriers to energy efficiency and can have social and political impact. However, they can be effective if targeted to achieve specific policy goals or when the revenues are used to fund energy efficiency improvements. Table 20 summarizes the findings on taxes.

Table 20: Summary table for energy and carbon taxes

<table>
<tr><th>Emission reduction examples</th><th>Cost-effectiveness</th><th>Barriers</th><th>Remedies</th><th>Advantages</th><th>Factors for success</th></tr>
<tr><td>Dk: 1977-1991 with subsidies 15% CO2 reduction</td><td rowspan="3">No data</td><td rowspan="3">Low elasticity of demand in many countries</td><td rowspan="3">Higher rates of taxes and longer period</td><td rowspan="3">- Can reinforce other instruments such as VAs
- Affects whole building life-cycle
- Revenues can be used for energy efficiency improvements</td><td rowspan="3">- Levy tax as upstream as possible in supply chain</td></tr>
<tr><td>De: 0.9 % less en use in households</td></tr>
<tr><td>Swe: 5% from 1991-2001</td></tr>
</table>

4.3.2. Tax exemptions and reductions

Tax exemptions are granted in the form of income tax credits as in France or VAT exemptions, for example for CFLs in Germany (ECS 2001). Tax exemptions and tax reductions, if properly structured, can be more effective than taxes. They are very important for stimulating the introduction and initial sales of energy efficiency technologies and very efficient new homes and commercial buildings (Quinlan *et al* 2001, Geller and Attali 2005).

However, depending on the design, results of tax exemptions differ widely (Mirasgedis, pers. comm.): in the USA, the Energy Tax Act of 1978, which induced a 15%

tax credit up to a maximum of $300 for residential conservation and renewable energy measures, was not evaluated as effective: the adoption of energy efficiency measures did not increase due to the small size of the credits and the fact that credits applied to already commercialized technologies. Therefore, tax credits must be sufficiently high. On the other hand, the new tax credits in the US, intended to support the commercialization and market development of advanced energy efficiency measures (for instance highly-efficient new homes, appliances of very high efficiency) are expected to result in significant energy and economic savings and emissions reductions (Quinlan *et al.*, 2001).

To be effective, tax exemptions should meet the following criteria (Quinlan *et al*. 2001): they should be adopted for advanced technologies where first-cost is a major barrier, pay for results according to performance criteria, be sufficiently high and not phase out too early. In addition, they should be flexible concerning who receives the credit, and complement other policy instruments. However, free-riders can be a major barrier to the effectiveness of this mechanism as seen on table 21.

Although tax exemptions have a very high potential, the current tax system in many countries does not provide incentives for reduction of energy consumption (EEB Forum in Brussels 2007). For example, electricity and other forms of energy are often taxed with reduced VAT-rates (ECS 2001). On the other hand, energy efficiency retrofits such as improved insulation are often taxed the full VAT rate. This contradiction has existed in most EU-countries for many years, and although the European Council had proposed to enact a EU guideline this has not happened so far.

In the industrial sector, reductions on or exemptions on profit taxes are given to environmentally friendly activities such as district heating in Germany. Such tax credits could also be used to support ESCOs, especially in developing countries (ECS 2001).

Table 21: Summary table for tax exemptions

Emission reduction examples	Cost-effectiven. examples	Barriers	Remedies	Advantages	Factors for success
US: 88 $MtCO_2$ in 2006 FR: 1Mt CO2 in 2002	US: B/C ratio com-mercial buildings: 5.4, New homes: 1.6	- Free-rider effect - Small size of credits - Application to old techno-logies	- Sufficiently high level - No early phase-out - Apply them to new technologies	Effective for advanced technologies with high first-cost	- Pay for results according to performance criteria - Flexibility who receives credit - Combination with other instruments

4.3.3. Public benefits charges

Public benefits charges are a new mechanism defined as raising funds from the operation of the energy market, which can then be directed into DSM and energy efficiency activities (Crossley et al. 2000). They therefore resemble a specific form of energy tax whose revenues are typically invested partially or completely into energy-efficiency.

Public benefits charges are currently applied in numerous US states as well as in some European countries. In Brazil, all distribution utilities are required to spend at least one percent of their revenues on energy efficiency improvements, while at least one-quarter of this amount (representing approximately $50 million per year) has to be spent on end-use efficiency projects. Table 22 gives a summary on public benefits charges.

Public benefit charges can be cost-effective and an appropriate mechanism to raise funds for energy efficiency measures and possibly to accelerate market transformation, but their effectiveness in terms of the total amount of GHG saved is moderate: studies for the US found that 0.4% of all electricity sold was saved, at a negative cost which was probably due to limited demand elasticity (Western Regional Air Partnership 2000, Kushler *et al* 2004).

Table 22 Summary table for public benefit charges

Emission reduction examples	**Cost-effectiveness examples**	**Barriers**	**Remedies**	**Advantages**	**Factors for success**
US: 0.1-0.8% of total electricity sales saved /yr, average 0.4%, 1.3 $ktCO_2$ in 12 states NL: 7.4TWh in 1996, 2.5 Mt CO2	US: From -53$/$tCO_2$ to - 17$/$tCO_2$	- Misuse of funds by government - Unexperienced program administration - Year-to-year decision- making	- Independent administration of funds to avoid misuse for budget filling - Multi-year programs	- Good mechanism to raise funds for energy efficiency	- involvement of all stakeholders - regular evaluation/ monitoring and program changes -team approach with utilities - good communication - simple and clear program design

Source: Kushler *et al* 2004

4.3.4. Capital subsidies, grants, subsidized loans, rebates

Capital subsidies, grants, subsidized loans and rebates are one of the most frequently used instruments for increasing energy efficiency in buildings - the majority of the instruments in the MURE database fall under this category (MURE 2007). Subsidies are very common in the residential sector in order to overcome the major barrier of high first costs (ECS 201). They are used to finance better insulation such as roof insulation in the UK, more efficient equipment such as refrigerators in Germany, CFLs or energy audits as in France. Subsidized loans are used for example in Austria to support ESCOs.

Subsidies and grants are often effective, but usually less cost-effective from a societal point of view. However, the German and Slovenian subsidy schemes have been very effective. Subsidies can be important to facilitate the introduction of new technologies and enable especially poor households to engage in energy efficiency investments. For this reason, they are especially useful in developing countries where financial limitations constitute one of the major barriers for energy efficiency improvements. Subsidies are one component of the relatively successful energy conservation law in Thailand (Brulez, pers. comm.), combined with mandatory energy audits, awareness raising and training as well as demonstration projects. In Brazil, the PROCEL program which provides grants to state and local utilities, state agencies, private companies, universities, and research institutes resulted in cumulative savings of 5.3 TWh (169 ktCO2) per year at a benefit-cost ratio of 12:1 from 1986 to 1998 (WEC 2004).

In contrast to developing countries where subsidies are often needed as an incentive, in developed countries, the effectiveness and cost-effectiveness of subsidies and grants depends on the design of the instrument. In the MURE database, grants and subsidies achieve a high number of *high* or *medium* ratings for effectiveness (MURE 2007). Generally, the risk of free-riders is high and can significantly reduce the effectiveness of subsidies and grants. Kemp (1995) concludes for example that the subsidies for double glazing in the Netherlands did not affect the adoption of this new technology, but rather provided “windfall gains” to the beneficiaries as half of the participants were free-riders.

Limiting subsidies either to a short period of time to facilitate market introduction of new technologies or to a specific target group in need enhances the effectiveness of the instrument (Jeeninga and Uyterlinde 2001). Subsidising appliances with an already high penetration rate is expensive. In the Netherlands, for example, rebates for energy efficient clothes dryers did not lead to any CO2 reduction due to the limited availability of A-labelled clothes dryers. For cold appliances such as fridges, the cost-effectiveness of the rebate program is estimated at 300 Euro/tCO2 and for dishwashers at 165 Euro/tCO2. One reason for this is the rapid increase in residential electricity consumption in the Netherlands over the last decade which limits the impact of fiscal incentives. Other sources such as Joosen *et al*. 2004 have calculated slightly lower, but still relatively high costs of Dutch subsidy programs for society: 41-105 \$/tCO_2 (Energy Charter Secretariat 2002, Martin and Carsalade 1998, Schaefer *et al*. 2000, Geller *et al* 2006, Joosen *et al* 2004). Further barriers limiting the effectiveness of subsidies and rebates include also the lack of awareness of the existence of such financial incentives and inappropriate bureaucracy.

On the other hand, results of the rebate program in Denmark indicate a high cost-effectiveness of –20\$/ tCO2 (Karbo 2001). This might be explained by the limited duration of the rebate program, and its combination with a large government campaign supported by retailers, manufacturers and utilities. Table 23 includes some more barriers and remedies.

Table 23: Summary table for subsidies

Emission reduction examples	**Cost-effectiveness examples**	**Barriers**	**Remedies**	**Advantages**	**Factors for success**
Svn: up to 24% energy savings BR: 169ktCO2 UK: 6.48MtCO2/ yr, 100.8 MtCO2 in total	Br: B/C ratio: 12:1 Dk: – 20\$/ tCO2 NL: 41-105 USD/t CO2 saved	Risk of free-riders	Limit period of time	Good mechanism if first cost is major barrier	- Don’t use it if penetration rate is already high - Limit to short period of time & specific target group
		Lack of awareness	Information provision		
		Rebound effect	Combination with information campaigns		
		Bureaucratic procedures	Simplification of procedures		

4.3.5. Comparison of fiscal instruments

According to the presented case studies the effectiveness of fiscal instruments varies considerably and depends strongly on the design of the instrument. The effectiveness of taxes depends, for instance, on the level of taxes or on the use of the tax revenue by the government. Tax exemptions are usually more effective and seem to be one of the most neglected, yet very useful instruments. Subsidies, grants, loans and rebates can be effective if designed well, and are especially needed in developing countries where lack of financing constitutes a major barrier. In these countries, tax exemptions are not enough. Fiscal instruments can help overcome the barriers under the categories financial costs vs benefit and market failures (see table 1). In addition, fiscal incentives need to be high enough to attract attention.

4.4. Support, information and voluntary action

The last category "*support, information and voluntary action*" regroups a number of very different policy measures whose effectiveness depends among other things on appropriate combination with other policy instruments.

4.4.1. Voluntary certification and labelling programs

Voluntary certification and labelling programs are rather used for appliances than for buildings and can be effective as well as cost-effective if designed well and updated regularly. Combination with other policy instruments such as fiscal incentives and regulation enhances their effectiveness. The US Energy Star Program is one of the most well known and successful voluntary labelling programs with expected cumulative savings of 833 Mt CO_2eq by 2010 (Gillingham *et al* 2006).

Voluntary labelling programs are frequently used in developing countries, but with varying success. Thailand is often seen as a success story since it implemented energy efficiency standards for air-conditioning and refrigerators as part of a DSM program. However, although similar labelling programs were introduced for refrigerators and AC systems (Phuket and Prijyanonda 2001), significant energy savings were achieved only in the first case. This can be explained by differences in the market structure: because in the case of air-conditioning the number of manufacturers was very high, in contrast to the situation for refrigerators, serious enforcement problems occurred. The air-conditioning market would have needed stricter enforcement and stronger market intervention strategies (Phuket and Prijyanonda 2001). For this reason, labelling programs must be adapted to the product market and the market transformation strategy (see table 24).

Voluntary labelling programs have also been introduced in several Latin American countries such as Venezuela, Peru and Colombia (Lutz *et al* 2003). They are often transformed into mandatory labelling programs after a few years. Problems in the Andean region include low commitment of the government, insufficient testing mechanisms, lack of funding and the need to establish more testing centres to test the performance of appliances before labelling. A major problem of voluntary labelling is that inefficient appliances are often not labelled or the label is removed. This problem can only be avoided by mandatory labelling (see section 4.1.1.5).

The Chinese experience with voluntary labelling has shown several success factors for this mechanism (Lin 2002, Lin 2000): maintaining the quality of the label is crucial. The Chinese label was relatively effective because a year on more than 50% of all refrigerators were meeting the standards. However, the standards were not updated for several years after that. Regular updates are important to ensure the long-term success of the market transformation. Secondly, it is very important that consumers know, understand and recognize the label. Therefore, the label has to be tested among the consumers and, if necessary, it must be adjusted. In addition, communication between authorities responsible for the label and manufacturers is crucial: for example, Chinese manufacturers complained about the long testing procedures for products which are problematic for them for competitiveness reasons. Some manufacturers even abstain from getting their products certified for fear of competition. Finally, capacity-building, for example among sales-persons, is important to ensure the success of the label.

Table 24: Summary table for voluntary labelling

Emission reduction examples	Cost-effectiven. examples	Barriers	Remedies	Advan-tages	Factors for success
Br: 169.6 K tCO_2 in 1998, US: 13.2 MtCO2 in 2004, 884 $MtCO_{2eq.}$ in total by 2012, Tha: 192 tCO_2	US: 0.01-0.06 $/ kWh Br: 20 $ Million saved	Only labelling of eefficient models	Mandatory labelling	Good strategy if mandatory labels are not possible	- Adaptation to local market - Low number of manufacturers is better
		Insufficient testing mechanisms	More testing centers		
			accepting that saved energy costs may be invested into better access to energy services		

4.4.2. Voluntary and negotiated agreements

The effectiveness of **voluntary agreements** is very much disputed in the buildings sector as well as in other sectors as, for instance, Bertoldi and Rezessy (2007) show. This is due to the fact that voluntary agreements are often concluded by companies in order to avoid regulatory measures (Price 2005). Voluntary agreements involve a formal agreement between a responsible government body and a business or organisation which states that the business or organisation will carry out specified actions to increase the efficiency of its product's energy use. In the buildings sector, they are used rather for appliances than for buildings and can be effective when regulatory instruments are difficult to enact or enforce and when their design meets certain conditions (Chapters 6 and 13, IPCC 2007).

Completely voluntary programs are less effective, but combination with other instruments such as public leadership programs and especially with a threat of regulation (Geller *et al.* 2006, Cotrell 2004) significantly enhances the effectiveness. The success of the Energy Star program in the US, for example, can be explained by the public procurement regulations requiring the purchase of Energy Star appliances. On the other hand, the majority of those voluntary agreements in Europe included in the MURE database are not effective (MURE 2007).

One advantage of the mechanism is that voluntary agreements are usually decided and implemented faster and negotiated agreements offer an opportunity for collective decision-making (see table 25). In theory, negotiated agreements give more flexibility to companies and are therefore more cost-effective than command-and-control measures. However, if not well designed, voluntary agreements may fail to involve all stakeholders and therefore cannot guarantee that abatement costs are shared, resulting in a situation where marginal abatement costs are not equated. Voluntary agreements are more successful if those manufacturers accounting for most of the equipment are included, quantified saving targets are defined at the outset, and effective monitoring schemes are established (IPCC 2007). Furthermore, setting realistic targets and sufficient government support enhance the effectiveness (Price 2005). In general, voluntary agreements are usually more effective when good relationships exist between program implementer and supplier (Evander et al. 2004).

The Greenlight program of the European Commission, a voluntary program where private and public organizations commit to adopting energy-efficient lighting measures, has led to energy savings of 100 GWh per year which corresponds to 50 ktCO2 (Bertoldi *et al*. 2005) in the 300 buildings which adhere to the program. The results of the Climate Change Agreements in the UK have even exceeded initial expectations: by 2002, savings amounted to 16.4 MtCO2, which is more than triple the estimated amount (Leigh 2005). One success factor of the program is that concluding such an agreement exempts the company from paying the Climate Change levy. In the US the national inventory of Greenhouse gas emissions and voluntary agreements, mandated by section 1605b of the 1992 Energy Policy Act, is estimated to have reduced emissions by 66 MtCO2eq. (Gillingham et al 2006).

Experience with voluntary agreements in developing countries is still rather scarce. Transferring the US experience with voluntary agreements to China has proved rather difficult as Chinese companies are not used to such approaches and supporting policies were not in place or uncertain (Price, Worrell et al. 2003). India and Chile also have some negotiated agreements for energy efficiency, but most of them are in the industrial sector (Price 2005).

Table 25: Summary table voluntary agreements

Emission reduction examples	**Barriers/ Prob-lems**	**Reme-dies**	**Advantages**	**Factors for success**
US: 66 Mt CO2eq in 2000 UK: 14.4 MtCO2 in 2004	Results often below expecta-tions	Combine with threat of regu-lation	- Faster decision and implementation - More flexible for companies and more cost-effective to them - positive for beginning	- Inclusion of most important manufacturers - clear targets - effective monitoring - involve all stakeholders

4.4.3. Public leadership programs

Government and the public sector are often the largest energy consumer in a country. In the USA, the government accounts for one fifth to one sixth of the total economy (Harris *et al*. 2004). Public leadership programs, i.e. energy efficiency programs in public administrations, therefore have a huge potential: on the one hand they can significantly reduce energy consumption and thereby costs in the public sector; on the other hand, they can demonstrate new technologies and thereby provide an incentive to the private sector to follow the example of the public sector (Harris *et al* 2004). They also demonstrate to taxpayers that government revenues are spent in a useful way.

Public leadership programs are usually effective and cost-efficient. In Germany, for example, 25% of energy was saved in the public sector in a 15-year period (Borg *et al*. 2003; Harris *et al*. 2005; Van Wie McGrory *et al*. 2006, OPET network 2004, EFA 2002). Mandatory public leadership programs are more effective than voluntary ones (Van Wie McGrory 2006, personal communication). In the US, for example, federal agencies are obliged by executive orders from the President to reduce their energy use by 35% by 2010 compared to 1990 levels. This has led to energy savings of 4.8 GWh annually (2.3 ktCO2) and to cost savings of $5.2 billion (US DOE 2006) which finally resulted in a market transformation. The US example also shows that public leadership programs can be an important driver for the ESCO industry: public buildings are the most important clients of the US ESCO industry, which is the most successful ESCO industry worldwide.

There are positive experiences with public leadership programs in developed as well as developing countries (see table 26). In Brazil, 140 GWh are saved yearly, the government agency PROCEL provides funding for retrofits in government buildings (Van

Wie Mc Grory 2002). Public leadership programs exist also in Colombia, Ghana, Costa Rica, Ecuador, Dominican Republic, Malaysia, Peru, Philippines, Russia and Argentina. In Thailand, government buildings are required to appoint an energy manager, assess energy saving opportunities and adopt a savings program using best available technologies. In the EU, energy saving potentials through public leadership programs are projected to reach 12 billion Euro (Borg *et al*. 2006).

Table 26: Various public leadership programs in developing countries

PROGRAM CATEGORIES	PROGRAM EXAMPLES
Policies and Targets Energy saving goals; tracking and reporting progress Government organisation (lead responsibility for energy savings, interagency committees etc.) Budget policies (e.g. life-cycle costing, separate budget line for energy, energy cost saving shared with agencies)	Argentina (reporting) Dominican Republic (goals) Ecuador (goals) Mexico (saving goals and reporting requirements) Philippines (GEMP goals)
Energy-Saving Capital Projects Energy audits Retrofit projects: lighting, HVAC, building envelope, controls Financing: third-party (ESCO) funding, loan funds, leasing Efficiency standards/guidelines for new buildings Design assistance, software tools, architect training New technology demonstrations, showcase facilities Public services – efficient systems and equipment (water supply and Treatment, street lighting, LED traffic signals)	Brazil (low-interest loans to retrofit public buildings) Colombia and Argentina (street lighting) Mexico (Web-based lighting audits, “100 Public Buildings” and APF) Russia (pilot audits and retrofits)
Facilities Operation and Maintenance Building system commissioning: pre-occupancy + continuous Energy metering/monitoring, benchmarking, operator feedback Facility manager training and certification Operator incentives and recognition (awards) Employee information and outreach campaigns O&M for government vehicles; promote ridesharing and transit	Dominican Republic Mexico (building O&M, operator training, ‘Ports of Attention’ for outreach + technical assistance) Thailand (mandatory measures in public buildings)
Purchasing energy-efficient products Specify efficient building equipment, office equipment, motors, lighting, appliances, etc. Efficient and alternative fuel vehicles for government fleets Green power purchasing	Korea Philippines (GEMP)

Source: Van Wie McGrory *et al*. 2002

However, mandatory regulations for new public buildings such as the Energy Policy Act of 1992 in the United States are much more effective than voluntary leadership programs and can even trigger a market transformation. Other success factors for public sector leadership programs include the importance to clearly state and communicate as well as monitor the program (Van Wie McGrory 2002). Adequate funding and staff resources are necessary as well as a combination of technical investments with non-technical measures such as training of staff. Involving on-site building managers as well as high-level experts from the beginning contributes to the success of the measure.

Table 27: Summary table for public leadership programs

Emission reduction examples	Cost-effectiveness examples	Barriers	Remedies	Advantages	Factors for success
De: 25% less CO2 in public sector in 15 years US: 2.3 ktCO2/year Br: 4.48 ktCO2/ year Ghana:14% less CO_2 Mex:169 ktCO2 /yr (13% of baseline)	US DOE estimates \$4 savings for every \$1 invested, EU: 13.5 billion \$ savings by 2020 Br:-125 \$/t CO_2	Budgetary constraints	-Energy Performance Contracting – mandatory programs	-Taxpayers' money spent in useful way -Driver for ESCO-industry	- Clearly state, communicate and monitor - Adequate funding and staff - Involve building managers and experts

If public leadership programs are mandatory, enforcement is important: in Ecuador, for example, public buildings above 1000 kWh yearly consumption are required to have a building energy management committee as well as an Energy Saving Program. However, the program is considered unsuccessful due to low enforcement.

4.4.4. Awareness raising, education and information campaigns

Public information campaigns can be described as policy instruments designed by government agencies with the intention to change individual behaviours, attitudes, values, or knowledge (Weiss and Tschirhart (1994) cited in Bender *et al*. 2004). Program types include "energy tips" and counselling, consumption feedback, elementary school programs, and mass media motivational campaigns. The effect of such campaigns is contested and difficult to measure since they are often part of policy packages. Furthermore, they are particularly difficult to define because the baseline depends on behavioral assumptions and long- and short-term effects conflate (Moezzi, pers. comm.).

Information programs can usually increase the effectiveness and the long-term impact of most other policy instruments, especially by reducing the rebound effect which is a particular problem for all regulatory and control policy measures. For instance, complementing appliance standards by raising awareness can promote long-term behavioural changes, and prevent or limit, for example, the rebound effect (Bender *et al*. 2004; Dias *et al*. 2004, Darby 2006; IEA 2005; Lutzenhiser 1993; Ueno *et al*. 2006, Energy Saving Trust 2005).

Information campaigns are usually more effective for the residential than the commercial sector and are often relatively cost-effective. For instance, in Brazil, the cost-effectiveness of information programs exceeded those of most other policy instruments, with negative costs of -66\$/tCO_2 (Dias *et al*. 2004). In order to be effective, public information campaigns have to be adapted to the audience, deliver a credible and understandable message, which influences audience beliefs, and finally create a social context that leads to the desired outcome (see table 28, Weiss & Tschirhart 1994). Unfortunately, there is often too little correspondence between advice offered and what consumers want to know or what is correct in their situation (Moezzi, pers. comm.).

Table 28: Summary table for information and awareness raising programs

Emission reduction examples	Cost-effectiveness examples	Barriers	Remedies	Advantages	Factors for success
Cal: 6.7% energy use reduction UK: 10.4 ktCO_2 per year Br: 6.5-12.2 MtCO2/yr with labelling	Br: -66$/t$CO_2$ UK: 8$/t$CO_2$ (for all programs of Energy Trust)	Too little correspondence between consumers and message	Better research on consumers	Can reinforce long-term effect of other measures	- Deliver credible and understandable message - Adaptation to audience

The *Flex your power* campaign was started by the governor in California after the Energy crisis in 2001 in order to reduce peak demand and enable energy savings. 949 million USD were spent on regular media advertisements, provision of toolkits to teachers, voluntary partnerships with businesses, special events with manufacturers and retail stores. (Bender *et al* 2004). The program exceeded all expectations, with a reduction of 8.9 % for peak demand and 6.7 % for energy consumption. Information programs are especially important in developing countries where lack of information has been identified as major barrier for energy efficiency and renewable energy investments (Evander *et al*. 2004).

4.4.5. Detailed billing and disclosure programs

Finally, detailed billing and disclosure programs describe the display of detailed information related to energy consumption to the user either on the bill and/ or directly on the appliance or meter. They can usually save up to 10 % of energy consumption (Darby 2000) and are mostly cost-effective (Crossley *et al* 2000, Darby 2000, Roberts/Baker 2003, Energywatch 2005, WEC 2004, Smart Metering Working Group 2002). However, the effectiveness depends on the exact type and design of the program: usually, displaying energy use on appliances is more effective than more frequent bills.

Darby (2000) reviews 38 different detailed billing and disclosure programs. In her sample, the highest savings of about 20% were achieved by using a table-top interactive cost- and power- display unit, a smartcard meter for prepayment of electricity and an indicator showing the cumulative cost of operating an electric cooker. Barriers which hamper the purchase and use of smart meters include imperfect information, financial problems and first-cost consideration instead of long-term thinking as well as regulatory barriers, uncertainty about return on investment and uncertainty about the duration of residence (Smart Metering Working Group 2002). Therefore, regular evaluation is a condition for success of this policy instrument and the effectiveness can be enhanced through combination with other instruments (see table 29).

Table 29: Summary table for detailed billing and disclosure programs

Emission reduction examples	Barriers	Remedies	Advantages	Factors for success
Max. 20% savings, usually 10 UK: 3% Nor: 8-10 %	- Imperfect information - First-cost bias - Uncertainty about rate of return on investment and about duration at house	- Information programs - free meters (DSM programs)	Can change behavior	– Regular evaluation – Combination with other mechanisms – Comparability with other households

4.4.6. Comparison of support, information and voluntary action instruments

Although instruments in this category might be considered rather “soft” they can still achieve significant savings and successfully complement other instruments. However, they are usually less effective than regulatory and control measures. They are also often used at the outset of a country’s political engagement in energy efficiency policies either by the public sector or outside it.

In general, the impact of instruments under this category is difficult to measure due to the frequent combination with other instruments. Public sector leadership programs seem to be the most effective instrument in this category. Voluntary labelling and agreements can be effective under certain conditions. Informational instruments can be effective in combination with suitable other instruments. Finally, instruments classified here can certainly help to overcome a number of the presented barriers (see table 1), especially the information barrier, but also contribute to solving, for example, the political/ structural barriers.

5. Overall comparison of the policy instruments

As demonstrated in previous sections, many of the instruments analysed can achieve high savings at low and many even at negative costs when their design meets certain conditions and when they are adapted to the local situation. If these conditions are not fulfilled, all instruments may fail to reach the expected savings or perform poorly. This statement is well exemplified by the MURE database: several instruments included in this database have a very different impact in different countries – high in some cases and low in others. This is likely to be due to differences in policy tool design and implementation, to the local context such as income levels and energy prices as well as due to interactions with other instruments already in place in the country.

The comparative assessment of policy instruments presented in Table 30 reveals significant differences between the instruments, especially concerning their cost-effectiveness. The societal costs of policy tools in the sample varied widely: figures ranged between - 214 $/tCO2 (i.e. a significant net benefit to society) and 109 $/tCO2. The maximum absolute emission reduction achieved by a policy tool amounted to 88 MtCO2[11] which corresponds to 7.5% of total CO2 emissions in the buildings sector per year, reached by tax exemptions (investment tax credits) in the USA. Overall, appliance standards, building codes, labelling, utility DSM programs and tax exemptions achieved the highest savings in the sample.

When comparing the four different categories of measures, the collected case studies indicate that regulatory and control measures are probably the most effective as well as the most cost-effective category, at least in developed countries. They all achieved ratings of *high* or *medium* (see table 30) according to both criteria. Measures which can be designed both as voluntary and as mandatory, such as labelling or energy efficient public procurement policies, have been revealed as more effective when they are mandatory. These findings are confirmed in the MURE database: Legislative normative instruments are the only category where the number of *high* ratings for effectiveness clearly exceeds the number of those measures rated as *medium* or *low*[12]. The MURE database also shows that normative legislative instruments, i.e. mandatory minimum standards for buildings or appliances, are more effective than informative legislative instruments such as labelling or mandatory audits. However, enforcement problems can seriously undermine the effectiveness of these instruments, especially in developing countries.

[11] In an ideal case, relative figures should be compared, i.e. percentages of the baseline. However, unfortunately, in many cases only absolute emission reduction figures are available and baseline data are missing.

[12] However, as pointed out before, the methodology used for impact assessment in the MURE database differs slightly from the methodology used in this study and is partly based on estimates.

Table 30: Comparative assessment of all policy instruments

Policy instrument	Country/ regions exples	Effe ctive ness	Energy or emission reductions for selected best practices	Cost-effecti veness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits	References
Control and regulatory mechanisms- normative instruments							
Appliance standards	EU, US, JP, AUS, Br, Cn	High	Jp: 31 M tCO_2 in 2010; Cn: 250 Mt CO2 in 10 yrs US: 1990-1997: 108 Mt CO2eq, in 2000: 65MtCO2 = 2.5% of el. use, Can: 8 MtCO2 in total by 2010, Br: 0.38 MtCO2/year AUS: 7.9 MtCO2 by 2010	High	AUS: -52$/$tCO_2$ in 2020, US: -65$/$tCO_2$ in 2020; EU: -194$/$tCO_2$ in 2020 Mor: 0.008 $/kWh	Factors for success: periodic update of standards, independent control, information, communication and education	IEA 2005a, Schlomann et al. 2001, Gillingham et al 2004, ECS 2002, WEC 2004, Australian GHG office 2005, IEA 2003a, Fridley and Lin 2004
Building codes	SG, Phil, Alg, Egy, US, UK, Cn, EU	High	Hkg: 1% of total el. saved US: 79.6 M tCO_2 in 2000; EU: 35-45 MtCO2, up to 60% savings for new bdgs UK: 2.88 MtCO2 by 2010, 7% less en use in houses 14% with grants& labelling Cn: 15-20% of bdg energy saved in urban regions	Medium	NL: from -189$/$tCO_2$ to -5$/$tCO_2$ for end-users, 46-109$/$tCO_2$ for society	No incentive to improve beyond target. Only effective if enforced	WEC 2001, Lee/Yik 2004, Schaefer et al 2000, Joosen et al. 2004, Geller et al. 2006, ECCP 2001, IEA 2005a, Defra 2006
Procurement regulations	US, EU, Cn, Mex, Kor, Jp	High	Mex: 4 cities saved 3.3 $ktCO_2$eq. in 1 year Cn: 3.6Mt CO_2 expected EU: 20-44MtCO_2 potential US: 9-31Mt CO_2 in 2010	High/ Medium	Mex: $1Million in purchases saves $726,000/year; EU: <21$/tCO_2	Factors for success: Enabling legislation, energy efficiency labelling and testing. Energy efficiency specifications need to be ambitious.	Borg et al. 2003; Harris et al. 2005; Van Wie McGrory et al. 2006, Gillingham et al. 2006
Energy efficiency obligations and quotas	UK, Be, Fr, I, Dk, Ir	High	UK: 2.16 M tCO_2/yr	High	Flanders: -216$/$tCO_2$ for households, -60$/tCO2 for other sectors in 2003. UK: -139 $ /tCO_2	Continuous improvements necessary: new energy efficiency measures, savings target change, short term incentives to transform markets etc.	UK government 2006, Sorell 2003 Lees 2006, Collys 2005, Bertoldi and Rezessy 2006, Defra 2006
Regulatory- informative instruments							
Mandatory labelling and certification programs	US, CAN, AUS, Jp, Mex, Cn, Cr, EU,Sa	High	AUS: 5 MtCO_2 savings 1992-2000, 81Mt CO2 2000-2015, SA: 480kt/yr Dk: 3.568Mt CO_2	High	AUS:-30$/t CO_2 abated	Effectiveness can be boosted by combination with other instrument, and regular updates.	WEC 2001, OPET network 2004, Holt/Harrington 2003, IEA 2003a

Policy instrument	Country/ regions exples	Effectiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits	References
Mandatory audit programs	US; Fr, NZL, Egy, AUS, Cz	High but variable	US: Weatherisation program: 22% saved in weatherized households after audits (30% according to IEA)	Medium/ High	US Weatherisation program: BC-ratio: 2.4	Most effective if combined with other measures such as financial incentives, regular updates, Stakeholder involvement in supervisory systems	WEC 2001, IEA 2005a
Utility demand-side management programs	US, Sw, Dk, Nl, De, Aut	High	US : 36.7 $MtCO_2$in 2000, Jamaica: 13 GWh/ year, 4.9% less el use = 10.8 ktCO2 Dk: 0.8 MtCO2 Tha: 5.2 % of annual el sales 1996-2006	High	EU: - 255$/tCO2 Dk: -209.3 $/tCO2 US: Average costs app. -35 $/$tCO_2$ Tha: 0.013 $/kWh	More cost-effective in the commercial sector than in residences, success factors: combination with regulatory incentives, adaptation to local needs & market research, clear objectives	IEA 2005a; Kushler et al 2004, Evander et al. 2004, Mills 1991, Parfomak and Lave 1996
Economic and market-based instruments							
Energy performance contracting/ ESCO support	De, Aut, Fr, Swe, Fi, US, Jp, Hu	High	Fr, Swe, US, Fi: 20-40% of buildings energy saved; EU:40-55MtCO2 by 2010 US: 3.2 $MtCO_2$/yr Cn: 34 MtCO2	Medium/ High	EU: mostly at no cost, rest at <22$/$tCO_2$; US: Public sector: B/C ratio 1.6, Private sector: 2.1	Strength: no need for public spending or market intervention, co-benefit of improved competitiveness.	ECCP 2003, OPET network 2004, Singer 2002, IEA 2003 a, WEC 2004, Goldman et al. 2005, Evander et al. 2004
Cooperative/ technology procurement	De, It, Sk, UK, Swe, Aut, Ir, US, Jp	Medium / High	US: 96 ktCO2 German telecom company: up to 60% energy savings for specific units	High/ Medium	US: - 118 $/ tCO2 Swe: 0.11$/kWh (BELOK-program)	Combination with standards and labelling, choose products with technical and market potential	Oak Ridge National Lab 2001, Le Fur B. 2002, Borg et al. 2003, Nilsson 2006
Energy efficiency certificate schemes	It, Fr	Medium	I: 1.3 MtCO2 in 2006, 3.64 Mt CO2 eq by 2009 expected	High/ Medium	Fr: 0.013 $/tCO2 estimated	No long-term experience yet. Transaction costs can be high. Adv. institutional structures needed. Profound interactions with existing policies. Benefits for employment.	OPET network 2004, Bertoldi/Rezessy 2006, Lees 2006, Defra 2006, IEA 2006, Beccis 2006
Kyoto Protocol flexible mechanisms	Cn, Tha, CEE (JI &AIJ)	Low	CEE: 220 K tCO_2 in 2000 Estonia: 3.8-4.6 kt CO2 (3 projects) Latvia: 830-1430 tCO2	Low	CEE: 63 $/$tCO_2$ Estonia: 41-57$/tCO2 Latvia: -10$/tCO2	So far limited number of CDM &JI projects in buildings. Success factors: Project bundling, Information & awareness campaigns, link to GIS	ECS 2005; Novikova, Urge-Vorsatz et al. 2006, Evans 2001

Policy instrument	Country/ regions exples	Effectiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits	References
Fiscal instruments and incentives							
Taxation (on CO2 or household fuels)	Nor, De UK, NL, Dk, Sw	Low/ Medium	De: household consumption reduced by 0.9 % 2003: 1.5 MtCO2 in total Nor: 0.1-0.5% 1987-1991 NL:0.5-0.7 MtCO2 in 2000 Swe: 5% 1991-2005, 3MtCO2	Low		Effect depends on price elasticity. Revenues can be earmarked for further energy efficiency improvements. More effective when combined with other tools.	WEC 2001,Kohlhaas 2005, Larsen and Nesbakken 1997, MURE 2007, Brink and Erlandsson, 2004
Tax exemptions/ reductions	US, Fr, Nl, Kor	High	US: 88 $MtCO_2$ in 2006 FR: 1Mt CO2 in 2002	High	US: B/C ratio Commercial buildings: 5.4 New homes: 1.6	If properly structured, stimulate introduction of highly efficient equipment and new buildings.	Quinlan et al 2001, Geller and Attali 2005, MURE 2007
Public benefit charges	BE, Dk, Fr, Nl, US states	Medium	US: 0.1-0.8% of total el. sales saved /yr, 1.3 $ktCO_2$ savings in 12 states NL: 7.4TWh in 1996 = 2.5 Mt CO2 Br: 1954 GWh	High in reported cases	US: From -53$/$tCO_2$ to - 17$/$tCO_2$	Success factors: Independent administration of funds, involvement of all stakeholders, regular evaluation/ monitoring& feedback, simple and clear progr. design, multi-year progrs	Western Regional Air Partnership 2000, Kushler et al 2004, Lopes et al. 2000
Capital subsidies, grants, subsidised loans	Jp, Svn, NL, De, Sw, US, Cn, UK, Ro	High / Medium	Svn: up to 24% energy savings for buildings, BR: 169ktCO2 UK: 6.48 $MtCO_2$ /year, 100.8 MtCO2 in total Ro: 126 ktCO2/yr	Low sometimes High	Dk: – 20$/ tCO2 UK:29$/tCO2 for soc, NL: 41-105$/tCO2 for society	Positive for low-income households, risk of free-riders, may induce pioneering investments	ECS 2002, Martin Y. 1998, Schaefer et al 2000, Geller et al. 2006, Joosen 2004, Shorrock 2001, Berry and Schweitzer 2003
Support, information and voluntary action							
Voluntary certification and labelling	De, Sw, US, Tha, Br, Fr	Medium / High	Br: 6.5-12.2 MtCO2 1986-2005, US: 13.2 MtCO2 in 2004, 884 $MtCO_{2eq.}$ in total by 2012, Tha: 192 tCO_2	High	US: from -53 to - 53 $/tCO2 Br: 20 $ Million saved	Effective with fiscal incen-tives, voluntary agreements and regulations, adaptation to local market is important.	OPET 2004, Geller et al. 2006,WEC 2001, Egan et al. 2000, Webber et al. 2003, US EPA 2002

Policy instrument	Country/ regions exples	Effectiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits	References
Voluntary and negotiated agreements	Mainly Western Europe, Jp, US	Me-dium / High	US: 88 $MtCO_{2eq.}$/yr US: 66.45 $MtCO_{2eq.}$in 2000 EU: 50 ktCO2, 100 GWh/yr (300 buildings) UK: 14.4Mt CO_2, in 2004	Me-dium	Swe: 0.0166 $/kWh	Can be effective when regulations are difficult to enforce. Effective if combined with fiscal incentives, and threat of regulation. Inclusion of most important manufacturers, and all stakeholders, clear targets, effective monitoring important	Geller et al. 2006, Cotrell 2004: 45, Gillingham et al 2006, Bertoldi et al 2005, Bertoldi and Rezessy 2007
Public leadership programs	NZL, Mex, US, Phil, Arg, Br, Ecu, SA, De, Ghana	Me-dium /High	De: 25% public sector CO_2 reduction in 15 yrs US: 2.3 ktCO2/yr Br: 6.5-12.2 MtCO2/ year Ghana: 27 MWh = 5tCO2 (14% of baseline) Mex:9.6 ktCO2/year (13% of baseline), 200 GWh/yr	High/ Me-dium	US DOE/FEMP estimates $4 savings for every $1 invested, EU: 13.5 billion $ savings by 2020 SA: 0.06$/kWh= 25$/tCO2 Br: -0.07$/kWh = -125 $/tCO2	Can be used to demonstrate new technologies and practices.Mandatory programs have higher potential than voluntary ones. Clearly state, communicate and monitor, adequate funding and staff, involve building managers and experts	Borg et al. 2003 &2006; Harris et al. 2005; Van Wie McGrory et al. 2006, OPET 2004, Van Wie McGrory et al. 2002
Awareness raising, education, information campaigns	Dk, US, UK, Fr, CAN, Br, Jp, Swe	Low/ Me-dium	UK: 10.4ktCO_2 annually Arg: 25% in 2004/05, 355 ktep Fr: 40tCO2/ year Br: 2.23kt/yr, 6.5-12.2 MtCO2/ year with voluntary labeling 1986-2005 Swe: 3ktCO2/ year	Me-dium/ High	Br: -66$/t$CO_2$; UK: 8$/tCO_2 (for all programs of Energy Trust)/ Swe: 0.018$/kWh	More applicable in residential sector than commercial. Deliver understandable message and adapt to local audience.	Bender et al. 2004; Dias et al. 2004, IEA 2005, Darby 2006; Ueno et al. 2006, Energy Saving Trust 2005, Lutzenhiser 1993, Savola pers.com.
Detailed billing and disclosure programs	Ontario, It, Swe, Fin, Jp, Nor, Aus, Cal, Can	Me-dium	Max.20% energy savings in households concerned, usually app. 5-10% savings UK: 3% Nor: 8-10 %	Me-dium		Success conditions: combination with other measures and periodic evaluation. Comparability with other households is positive.	Crossley 2000, Darby 2000, Roberts/Baker 2003, Energywatch 2005

Country name abbreviations: Alg - Algeria, Arg- Argentina, AUS - Australia, Aut - Austria, Be - Belgium, Br - Brazil, Cal - California, Can - Canada, CEE - Central and Eastern Europe, Cn - China, Cr - Costa Rica, Cz - Czech Republic, De - Germany, Ecu - Ecuador, Egy - Egypt, EU - European Union, Fin - Finland, GB-Great Britain, Hkg - Hong Kong, Hu - Hungary, Ind - India, Irl - Ireland, It - Italy, JP - Japan, Kor - Korea (South), Mor- Morocco, Mex - Mexiko, NL - Netherlands, Nor - Norway, Nzl - New Zealand, Phil - Philippines, Pol - Poland, Ro- Romania, SA- South Africa, SG - Singapore, Sk - Slovakia, Svn - Slovenia, Sw - Switzerland, Swe - Sweden, Tha - Thailand, US - United States.

It also needs to be kept in mind that in developing countries the savings achieved by energy-efficiency policies may not fully or even partially materialise as reductions compared to even a business-as-usual baseline[13]. This is because in the case of restricted energy services the purpose of energy saving policies is often not to reduce total energy consumption, as it is in many cases in developed countries, but rather to ensure that more energy services can be afforded from the available resources.

The effectiveness of economic instruments varies, but some of them such as energy performance contracting (EPC) and cooperative procurement are promising. Most new instruments such as Kyoto Flexibility Mechanisms are currently not effective in the buildings sector, possibly due to their newness and associated design problems, for instance the absence of a methodology adapted to the buildings sector. In addition, project-based instruments may have limited effectiveness in the buildings sector due to the typically small project sizes, substantially raising transaction costs. The same concern applies to instruments that require stringent verification and monitoring of savings, such as white certificates, due to the complex nature of buildings and many efficiency upgrades and small project size. However, there is as yet not sufficient evidence about these new instruments to derive solid conclusions on this issue.

Fiscal instruments also vary considerably in their effectiveness and have numerous success conditions. For instance, in the short run, instruments which increase the energy price such as taxation are often less effective than fiscal incentives such as tax exemptions, loans and subsidies due to the limited price elasticity of households. Grants and rebates are especially needed in developing countries because the first cost-barrier often completely prevents energy efficiency improvements there. In general, tax exemptions are the most effective tool in the category of *fiscal instruments,* while subsidies, grants and rebates can also achieve high savings, but are usually costly to society. Financial instruments are also often most effective if they are applied in a package with other instruments, such as labelling combined with a tax exemption.

Voluntary instruments vary in their effectiveness which depends for example on the demand for energy efficient products in the case of voluntary labelling and on whether the companies take their voluntary commitments serious. Though they have often failed to reach their goals they can be a good starting point for countries which are just introducing building energy efficiency policies or when mandatory measures are not possible. Finally, information instruments can be effective, but have to be specifically tailored to the target group. For example, detailed billing or smart metering programs are more effective than general information campaigns. Combination with other instruments such as regulatory instruments can increase the effectiveness of both instruments and limit the rebound effect.

The identification of the most cost-effective instruments was much more difficult as for some instruments no quantitative information could be found (see Table 30). In the assessed sample, appliance standards, public benefit charges, utility demand-side management programs, mandatory labelling and energy efficiency obligations seemed to be the most cost-effective policy measures. Since most of these instruments are classified under *regulatory and control instruments,* this category is apparently also the most cost-effective one – in contrast to a generally prevailing expectation that economic instruments

[13] In the literature this effect is often referred to as the "rebound effect". In developing countries, however, we do not consider the increase of the service levels as result of the energy efficiency policy as undesirable, thus we do not use this term in this context.

are the most cost-effective. Actually, all instruments in this study which achieved negative costs in the triple digit negative range were regulatory instruments.

These findings are partly confirmed by the MURE database[14] : when comparing the impact ratings of all 501 policy measures included in the database, as can be seen on table 31, out of all categories, regulatory and especially legislative-normative are the most effective instruments with the highest number of instruments ranked as highly effective as well as the highest average rating. Cooperative, i.e. voluntary instruments are the least effective category in both sets of samples (Mure and present research): most cooperative measures in the Mure database are evaluated as low in their effectiveness and the calculated average impact is the lowest of all categories. Legislative information instruments such as labelling and audits are characterized as rather ineffective, as are information/education instruments and tax exemptions in contrast to our findings on the effectiveness of the latter. Fiscal incentives and grants are moderately effective. Many of these results correspond to our findings, but normative information instruments such as labelling were rated lower and taxes higher than in our sample. These differences might be due to the high numbers of instruments characterized as "unknown" in the MURE database or to the fact that the characterizations are often estimates.

Table 31: Impact rating of all measures included in the MURE database

Impact **Category of instrument**	**High (3)**	**Medium (2)**	**Low (1)**	**Average**	**Unknown**	**Total**
Cooperative(voluntary)	2	2	**16**	1.3	5	25
Fiscal	42	32	**47**	1.95		121
- Grants, subsidies	**33**	21	32	2.01	32	118
- Loans	1	**6**	5	1.6	0	12
- Tax exemptions	3	1	6	1.7	3	13
- Taxes	**5**	4	4	2.08	1	14
Information/Education	10	12	**22**	1.72	14	58
Regulatory	**88**	34	60	2.15		253
- Legislative-informative	19	16	**29**	1.84	31	95
- Legislative-normative						
- Buildings	**68**	14	25	**2.47**	38	145
- Appliances	1	4	6	1.6	2	13

Source: MURE 2007

The numbers represent the total number of instruments rated as "high", "medium" or "low" in their impact/effectiveness. For the average, a score was given to each grade (high-3, medium-2, low-1) and multiplied by the number of instruments before dividing by the total (therefore, average scores above 2 indicate a high effectiveness). Figures in bold represent the highest number in the respective category.

The results of this study as well as of the MURE database that may be contra-indicative to general expectations, especially the high effectiveness and cost-effectiveness of regulatory compared to economic instruments, are specific to the building sector in our view, and might be explained by considering which barriers specific policy instruments address. Table 32 summarizes the major barriers (see Table 1) and corresponding policy instruments to overcome them.

Regulatory and control instruments can overcome many of the numerous barriers to energy efficiency in the buildings sector presented in table 1 and especially some of the

[14] The MURE database classified the instruments in a slightly different way than in this report.

most important barriers in this sector, i.e. hidden costs (transaction costs) and market failures. The transaction and opportunity costs for obtaining the necessary information to choose the most cost-effective appliance are high, whereas these are eliminated by a well-set appliance standard. Regulatory instruments therefore achieve major financial savings for both society and the end-user by eliminating these transaction costs. On the other hand, project-based mechanisms, such as the Kyoto flexible mechanisms (JI and CDM) are less effective and cost-effective since they create themselves transaction costs due to the usually small size of projects in the buildings sector.

Table 32: Barriers to energy efficiency and policy instruments as remedies

Barrier category	Instrument category	Policy instruments as Remedies
Economic barriers	Regulatory-normative/ regulatory-informative	Appliance standards, building codes, energy efficiency obligations, mandatory labelling, procurement regulations, DSM programs
	Economic instruments	EPC/ESCOs, cooperative procurement, energy efficiency certificates
	Fiscal instruments	Taxation, public benefit charges, tax exemptions, subsidies/rebates/grants
Hidden costs/benefits	Regulatory-normative	Appliance standards, building codes
	Economic instruments	EPC/ ESCOs
	Support action	Public leadership programs
Market failures	Regulatory-normative/ regulatory/informative	Appliance standards, building codes, energy efficiency obligations, mandatory labelling, procurement regulations, DSM programs
	Economic instruments	EPC/ESCOs, cooperative procurement, energy efficiency certificates, Kyoto Flexibility mechanisms
	Fiscal instruments	Taxation, public benefit charges, tax exemptions, subsidies/rebates/grants
	Support, information, voluntary action	Voluntary labelling, voluntary agreement, public leadership programs, awareness raising, detailed billing
Cultural/ behavioral barriers	Support, information, voluntary action	Voluntary labelling, voluntary agreement, public leadership programs, awareness raising, detailed billing
Information barriers	Support, information, voluntary action	Voluntary labelling, voluntary agreement, public leadership programs, awareness raising, detailed billing
	Regulatory/informative	mandatory labelling, procurement regulations, DSM programs, mandatory audits
Structural/ politcal		Public leadership programs

Sources: Adapted from IPCC 2007, Carbon Trust 2005, Urge-Vorsatz *et al*. 2007b

6. Combinations of policy instruments

6.1. The need for combinations of policy instruments

As shown in this report, every policy measure has its own advantages, ideal target groups and specific operational mechanisms. Each is tailored to overcome one or a few certain market barriers, but none can address all the barriers. Thus, none of them can alone capture the entire enormous potential for energy efficiency improvements even in a single location, nor can one instrument be singled out as a generally applicable best solution. In addition, as described above, most instruments achieve higher savings if they operate in combination with other tools, and often these impacts are synergistic, i.e. the impact of the two is larger than the sum of the individual expected impacts (IEA 2005b). Therefore, policies are rarely enacted in isolation, but rather as part of complex policy architectures. However, unfortunately quantitative evaluations of policy packages are difficult and rare. For this reason, only a qualitative assessment is possible for policy packages in this report.

Table 33: A selection of possible policy instrument packages and examples of commonly applied combinations

Measure	Regulatory instruments	Information instruments	Financial /Fiscal Incentives	Voluntary Agreements
Regulatory instruments	Building codes and standards for building equipment	Standards and information programs	Building codes and subsidies	Voluntary agreements with a threat of regulation
Information instruments	Appliance standards and labelling	Labelling, campaigns, and retailer training	Labelling and subsidies	Voluntary MEPS and labelling
Financial/Fiscal Incentives	Appliance standards and subsidies	Energy audits and subsidies Labelling and tax exemptions	Taxes and subsidies	Technology procurement and subsidies
Voluntary Agreements	Voluntary agreements with a threat of regulation	Industrial agreements and energy audits	Industrial agreements and tax exemptions	

Source: adapted from IEA 2005b
Note: MEPS- Minimum Energy Performance Standards

A number of combinations of policy instruments are possible as illustrated in Table 33. Usually, combining sticks (regulations), and carrots (incentives), with tambourines (measures to attract attention such as information or public leadership programs), have the highest potential to reduce GHG emissions (Warren 2007). Measures to attract attention can be information programs, but also simply choosing the right channels to reach citizens such as via energy suppliers as intermediaries.

6.2. Market transformation

One of the important examples where combinations of measures are important is market transformation, i.e. a change in the structure and function of the market for energy consuming products. As market transformation is very difficult to achieve and consists of several stages, it requires combinations of policy tools as well as the involvement of several actors such as manufacturers, end-users and government agencies (Neij 2001). Neij distinguishes as the key stages of any market transformation market introduction, commercialisation and market enlargement. As Figure 4 shows, market introduction can happen through cooperative procurement or public leadership/ demonstration programs. The commercialisation phase can be supported by a number of instruments such as information programs, certification, voluntary agreements or demonstration. The final phase of enlargement can be accompanied by the introduction of further instruments such as codes and standards, certification, education and incentives.

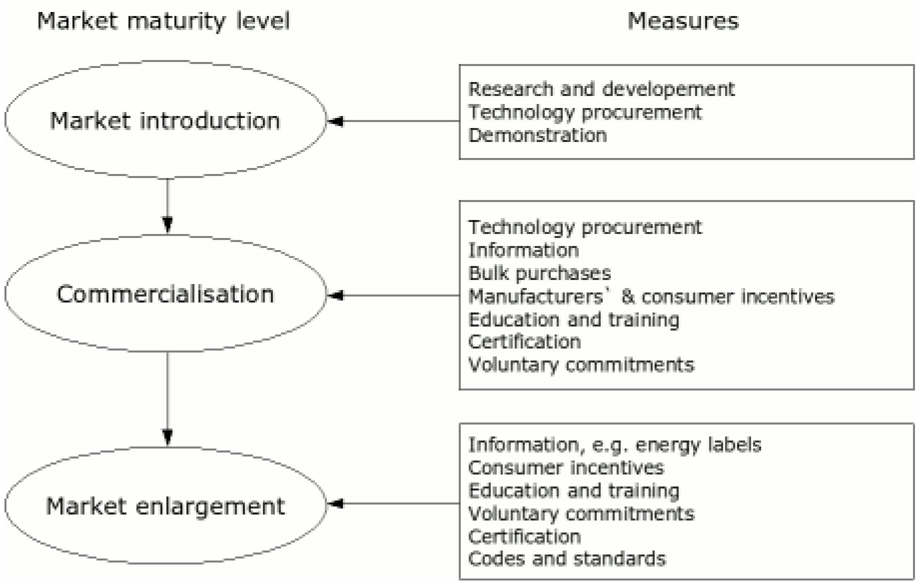


Fig. 4: Stages of a market transformation process
Source: Neij 2001

Many countries have adopted market transformation strategies for products using instruments such as appliance standards, procurement regulations and labelling, but only very few have done so for buildings (EURIMA 2006). However, a market transformation is happening in many countries even if not actively promoted by the government. A market transformation strategy requires standardised measurement procedures to monitor the quality of a building and, secondly, a classification of the performance of buildings such as the energy certificates through the EPBD.

Ideally, three levels of building performance are recommended (EURIMA 2006):
- A minimum performance level, mandatory for all buildings: this can be reached by setting minimum performance standards.
- A best practice level which is reasonably feasible to achieve with available technologies: this level is often used as a basis for defining subsidies, grants, loans and tax exemptions such as preferential mortgages as in Austria as well as governmental public leadership programs or procurement regulations thereby stimulating the market.
- A state-of-the art level which is set as a long-term target. This way, the industry is provided incentives to further improve their products.

Birner and Martinot (2005) recommend the following actions for market transformation programs:
1. Targeting of both supply and demand sides of a market
2. Careful examination of all stages of the supply and demand chain
3. Use of competitive market forces whenever possible
4. Flexible design to enable rapid and effective responses to changing market dynamics
5. Careful consideration of how technical assistance and know-how transfer can work
6. Use of standards, labelling, and building codes
7. Allocation of a portion of the budget for replication and dissemination activities

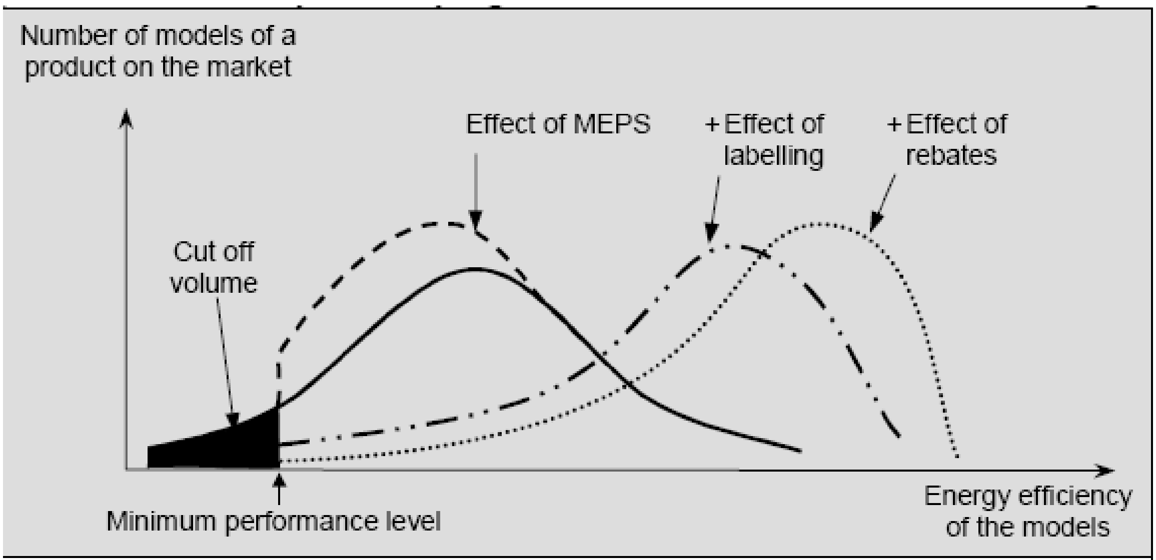
8. Early start of monitoring and evaluation to measure pre-program baselines.

6.3. Effective combinations of policy instruments

As already mentioned combinations of policy instruments are most promising. But which policy instruments should be combined? The following sections bring a few successful and frequently used examples.

6.3.1. Standards, labelling and financial incentives

Appliance standards are often combined with labelling and rebates in order to give incentives for investments beyond the level required by the minimum energy efficiency standard. Figure 3 shows the combined effect of these 3 instruments. The minimum performance standards are needed to eliminate inefficient products from the market and labelling beyond the minimum standard level stimulates technological innovation, as energy efficiency then becomes a competitive issue between manufacturers (IEA 2005b). This strategy is used in the European Union for many products as well as in developing countries such as China, Tunisia and Thailand. In addition, rebates for the most energy efficient products encourage consumers to buy these, which reinforces and sustains market transformation. This strategy was very successful in Denmark for example, but much less successful in the Netherlands where the rebates were not limited in time and therefore effective, but not cost-effective due to free-riders (see section 4.3.4). Therefore, removing rebates as soon as the market transformation is achieved is important to ensure their cost-effectiveness.



Source: CLASP (2004)

Fig. 5: Combined effect of minimum energy performance standards, labelling and rebates

Building codes can also be successfully combined with voluntary or mandatory certification of buildings such as through rating systems like the British BREAM-system or the American LEED-system. The EU is for example currently introducing the requirement of building passes in addition to the already existing building codes so that consumers can see the energy consumption and possibly consider energy use as one decision criterion when purchasing dwellings. A number of developing countries such as China also want to introduce building rating schemes to complement building codes.

6.3.2. Regulatory and information programs

As shown in this report, regulatory policy instruments are usually effective, but the rebound effect and lack of compliance and enforcement can be barriers. Since awareness can improve compliance and help to overcome the rebound effect in more effluent population groups where energy service levels are not constrained, information campaigns and trainings directed and designed for specific target groups are very important. For example, a success condition for labelling programs or building codes is proper information of construction companies, retailers and the general public about the existence of these programs. Information programs can reinforce the effectiveness of almost every other policy instrument.

However, in developing countries the result of the regulation, similarly to any other energy saving program or policy, may not be an absolute reduction in energy consumption even compared to a baseline, because the resources saved through the program may get redirected into increased service levels in other areas. In countries and population groups where energy service levels are inadequate and the demands for basic comfort are constantly rising it should be clear that the goal of an energy-efficiency program is often to increase service levels from constant or lower energy input levels as well as improving energy use efficiency.

6.3.3. Public leadership programs and energy performance contracting

By improving its own energy efficiency, the public sector can not only save costs, but also demonstrate to the private sector the potential and feasibility of energy efficiency improvements and trigger market transformation. Energy performance contracting in the public sector is especially advantageous as the budget of many public administrations is limited, for example in developed as well as developing countries. Executive orders which oblige public authorities to reduce their energy consumption by 30% and the federal energy management program in the US as well as the Energy Saving Partnership in Berlin, Germany, have significantly boosted the ESCO industry. However, significant barriers still hamper EPC in the public sector for example in China, India and other countries.

6.3.4. Financial incentives and labelling

In order for financial incentives such as loans, subsidies and tax credits to be most effective, labelling of energy efficient products is necessary, which ensures that only the most efficient categories of equipment are financially supported (Menanteau 2007). On the other hand, labelling, particularly voluntary labelling alone might not be effective (Menanteau 2007), because if the premium labelled products are substantially more expensive, that discourages especially low-income households from purchasing them.

6.4. Special measures for developing countries

6.4.1. Special barriers in developing countries

The situation in developing countries differs considerably from those in developed countries. Major barriers against energy efficiency improvements in developing countries include lack of awareness on the importance and the potential of energy efficiency improvements, lack of financing, lack of qualified personnel and insufficient energy service levels (Urge-Vorsatz *et al*. 2007). In the MEDA-countries[15], many stakeholders don't trust new energy efficiency technologies because of lack of knowledge or negative experiences with these (Mourtada, pers. comm.). Sometimes if low-quality versions of the efficient technology enter the market first, the early movers may experience disappointment in the technology and may not try the higher quality versions again, such as in the case of some low-cost CFLs that fail prematurely. Energy efficient equipment, together with other equipment, is often not sufficiently certified and checked for quality in these countries.

Subsidized, not cost-reflective energy prices are one of the most important barriers in many developing countries. High cost-reflective energy prices have been cited as one of the most important success factors for energy efficiency programs in developing countries, for instance in Brazil, Malaysia and other countries. However, in the poorest countries subsidies enable minimal energy service levels to certain population groups, so taking them away may be socially difficult. In these cases energy efficiency programs may be especially important because improved efficiency can either reduce the need for public subsidies, or, if the "rebound" is substantial, enable elevated service levels at a more effective use of subsidies.

In countries or regions with lack of access to reliable energy supply such as Africa, the priority of governments is to improve access to energy for inhabitants rather than to improve energy efficiency. Therefore, renewable energy projects and rural electrification often play a more important role for governments than energy efficiency (Mueller, pers. comm.). As discussed above, if energy efficiency investments are implemented, part of the resulting energy saving effects might be cancelled out due to increased energy consumption after increased service levels or comfort improvement, for example, installation of air conditioning. Policy instruments which have been revealed in this study as highly effective in developed countries such as regulatory instruments or building codes are often less effective in developing countries, if implemented as a single instrument, due to insufficient funding, enforcement problems and lack of capacity (Deringer *et al*. 2004). One reason for the frequent enforcement problems of energy efficiency standards in developing countries is lack of funding for implementation and monitoring.

In summary, developing countries require an integrated policy framework combining regulations, (financial or other) incentives, capacity building and measures to increase not only the awareness about energy efficiency, but also to increase the trust of stakeholders (Brulez, pers. comm.).

6.4.2. Existing policy instruments in developing countries

Several developing countries have already enacted legislation on energy efficiency in buildings, for example Thailand, India, China, South Africa, Egypt, Bahrain, Tunisia, Morocco, Mexico, Brazil, Argentina, Chile, Colombia, Ghana and Peru. A number of other countries such as Kenya, Uganda and the United Arab Emirates are currently introducing such mechanisms (Kirai, pers. comm.), often supported by international organisations. The most commonly applied measures are voluntary and mandatory labelling, appliance standards, building codes, public leadership programs, DSM programs, subsidies, grants and rebates, awareness raising campaigns and mandatory audits.

[15] The 10 Mediterranean MEDA countries comprise Algeria, Morocco, Tunisia, Egypt, Algeria, Israel, Syria, Turkey, Palestinian Territories, Lebanon.

However, only very few evaluations of instruments operating in these instruments are available. Due to the lack of quantitative data, the analysis of the situation in developing countries situation needs to rely mainly on qualitative information.

6.4.3. Enabling factors: high energy price levels and energy shortages

Increasing energy prices are often considered the most important precondition for improved energy efficiency in developing countries (IPCC 2007). Low, subsidized energy prices in many developing countries imply very long payback periods of up to 25 years for energy efficiency investments, which renders such projects unprofitable. The differences in energy prices explain why certain governments in the Mediterranean region such as Tunisia and Morocco are interested in energy efficiency while others, especially oil-producing countries such as Algeria, are not or are less interested (Wenzel, pers. comm.). Lifting energy subsidies gradually can help to avoid negative social effects. The revenues from lower energy price subsidies can be rechannelled into rebates for energy efficient programs, loans, special assistance for low-income households to increase their energy efficiency and thereby reduce energy costs.

Since policy-makers often consider energy efficiency as a low priority behind many more vital economic goals such as poverty alleviation or increased employment, it is essential that the co-benefits of energy-efficiency policies are well-mapped, quantified and well understood by the policy-makers. These co-benefits include energy security, poverty alleviation or improved social welfare, reduced mortality and morbidity or improved health, job creation and improved industrial productivity. Policy integration with other policy domains is particularly effective to leverage these co-benefits in developing countries, and energy-efficiency goals can often be pursued more effectively through other policy goals that have much higher ranks on political agendas and thus may enjoy much more resources and a stronger political momentum.

Energy security considerations as well as rapidly rising energy demand have been a driver for energy efficiency investments and policies for example in Tunisia. In South Africa, large energy shortages in 2006 (similarly to the capacity constraints earlier in California) have driven the government and utilities to implement several measures including creation of an energy agency, public procurement regulations, and DSM programs, such as the free distribution of CFLs (Glynn, pers. comm.). In Brazil, the energy shortages of 2001 and the resulting 20% mandated reduction of energy use as well as the ensuing energy crisis are often described among the most important drivers for the introduction or success of energy efficiency programs such as labelling programs (Gomes, pers. comm.).

6.4.4. Need for technical assistance and training

Capacity-building and training are indispensable for developing countries. For example, lack of knowledge on energy saving construction techniques among architects has been identified as a major barrier to energy efficiency, even in most developed countries in Europe (Energy Efficient Buildings Forum 2007, IPCC 2007). Sustainable construction know-how needs to be introduced into the base curriculum of architects and other construction-related professions all over the world. This is even more important in developing countries because of the often much more dynamic new construction rates. As the training of countries' own nationals will take some time, technical assistance through international consultants and organisations can bridge this gap for a period. Even in

Tunisia which is often considered as a best practice developing country with a successful energy efficiency policy architecture in the buildings sector (Wenzel pers. comm., Mueller pers. comm.), representatives of the energy efficiency agency request technical assistance for the development of thermal building standards due to lack of national expertise in this area (Kawther-Lihidheb, pers. comm.). In order to ensure that the right kind of technical expertise is provided it is important that governments can choose the experts themselves according to their needs, which is, however, sometimes not allowed by certain funds with restricted spending criteria. Frequently, energy efficiency laws, for example the introduction of mandatory energy audits or reporting requirements, require the training of new officials or institutions. For instance, governments or international organisations have trained energy managers for public buildings successfully in Thailand and Tunisia among others (Mueller pers. comm., Brulez, pers. comm.).

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6.4.5. Need for demonstration projects and information

The lack of information and awareness are among the major barriers in developing countries, but also human barriers exist, for instance the lack of trust. In order for information campaigns to be most effective, they need to be well adapted to the audience. Lebanon has started an extended information campaign using different types of media whereby the media do not charge the government for broadcasting the advertisements which give advice on how to save energy (Mourtada, pers. comm.).

Trust and awareness can be raised through pilot projects administered and financed by international organisations or bilateral donor agencies or through demonstration projects in the public sector. The MED-ENEC initiative in the Mediterranean region aims for instance at promoting energy efficiency through the exchange of best practices, a number of demonstration programs and regional cooperation. Demonstration programs at all levels (capital, villages and cities) such as the “Green Buildings for Africa” program in South Africa are actually very important as they prove the advantages of energy efficiency to every citizen, independent of the education level (Essessé, pers. comm.). Especially in rural areas, for example in Africa, characterized by relatively high levels of illiteracy, communication and learning often take place via informal channels such as learning from neighbours; hence the importance of demonstration projects.

6.4.6. Need for financial assistance or funding mechanisms

However, even with cost-reflective (not subsidized) energy prices, the higher first cost of energy efficient technologies may still hamper their penetration in these countries, especially if the technologies have to be imported. In China, Greece and Spain for example, solar water heaters have already achieved a high level of market penetration due to their low price, whereas the first cost still represents a major barrier for such technologies in Tunisia (Mueller, pers. comm.). Therefore, especially poorer consumers need investment support or affordable loans from bilateral and international donor agencies, governmental funding or through energy service company (ESCO) financing (Deringer *et al*. 2004). Developing countries, at least those which are already more developed, can raise money on their own through public benefit charges or taxes. For instance, in Thailand the government has raised funds through a petrol tax since 1992, which is coupled to the world market price, i.e. lowered when the oil price increases (Brulez *et al* 1998). The tax revenues are collected in a fund and are now used for supporting energy efficiency projects. The introduction of an additional public benefit charge for DSM-measures has also been proposed for Thailand (du Pont 2006). Tunisia also had a fund for energy efficiency improvements which is fed by a new tax on cars as well as other equipment such as air-conditioning, while Brazil has obliged utilities to spend 1% of their annual revenues on end-use energy efficiency improvements and on research and development. In South Africa, the government also introduced a public benefit charge which is used to finance energy efficiency improvements. It is important that such funds are managed by independent agencies or institutions to avoid political influence.

However, many countries, especially least developed countries, have limited funds for the introduction of energy efficiency policies, or lack access to local capital and expertise. Theoretically, CDM projects may offer carbon finance for energy efficiency projects as well as the transfer of know-how, but as mentioned before, there are currently only very few CDM projects worldwide in the buildings sector due to high transaction costs, the lack of a common methodology and the comparatively small project size in the sector. There are signals that this may improve, and it is essential that a future climate regime accommodates better or encourages building-sector energy-efficiency investments in order to tap into one of the largest domain of low-cost mitigation measures.

6.4.7. The role of regulatory measures

As part of the integrated framework of policy tools, regulatory instruments and standards are very important. Many developing countries such as Malaysia, Brazil, Morocco and partly Thailand first introduced voluntary standards or voluntary labelling for appliances or buildings which are, however, often less effective than mandatory ones (Kawther-Lihidheb, pers. comm.). Mandatory audits for public buildings and commercial sector buildings above a certain annual consumption are a frequently used instrument, applied for example in Tunisia and Thailand. However, compliance is often difficult to achieve. In order to ensure enforcement, special efforts are necessary such as combination of regulatory measures with incentives like subsidies or awards. In Tunisia, the implementation of the energy efficiency actions proposed by audits is supported by financial assistance measures. It is very important (also for international agencies) to allocate sufficient budget for implementation, enforcement and monitoring, also by international agencies in order to ensure the effectiveness of regulatory measures.

6.4.8. Need for monitoring and evaluation

In many countries, baseline data on energy consumption are missing. This is problematic as measuring the success of implemented policy instruments requires the knowledge of the baseline consumption. Regular monitoring and evaluation of programs are necessary in order to adapt the program if possible to changing circumstances and thereby maximize its outcome. Evaluation studies quantifying energy or GHG emission reductions are needed to determine cost-effectiveness and make necessary program adjustments (Januzzi 2005).

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6.4.9. Need for institutionalization

Developing countries with successful energy efficiency policies have usually started with the adoption of an Energy Efficiency law or an Energy Efficiency Strategy outlining the major aims and policies such as in Thailand, South Africa and Tunisia. Specific ministries, commissions or departments dealing with energy efficiency as well as energy agencies played an important role as well.

In order to assist public sector building managers, but also private persons to get the information, the creation of energy agencies is usually very helpful. For example, the Tunisian energy agency ANME is one of the main drivers behind the country's currently successful energy efficiency programs (Wenzel pers. comm.). Thailand, South Africa and Mexico also have energy agencies. Numerous Arab states are currently introducing such agencies, often with external assistance. The agency can be established as a non-profit foundation, which provides flexibility in hiring and contracting (Szklo and Geller 2006). A board of directors with representatives from both the public and private sectors can provide oversight. The establishment of an energy agency, independent of the utilities which would be responsible for the implementation and oversight of all energy efficiency projects is also proposed for Brazil (Szklo and Geller 2006).

The aim of this institutionalization is to get energy efficiency recognised as a priority among government ministers and officials as well as among energy regulators, utilities and other stakeholders. In addition, such an institutionalization provides continuity in the government's energy policy and priorities which is very important for stakeholders such as investors as long-term government commitment is an essential success factor for the long-term effectiveness of policy tools. Furthermore, in universities, the establishment of energy management curricula can contribute to knowledge dissemination and training of professionals. These professionals can then become competent staff members of the mentioned institutions.

6.4.10. Need for adaptation to local circumstances

Finally, although best practices and experiences can be shared and regional cooperation is useful, the success of programs depends among other factors on their adaptation to the local economic, political, social and cultural context (Klinckenberg, pers. comm.). Numerous programs have already failed because they were just copying programs from other countries without taking into account differences in culture, political system or other areas. Therefore, a thorough assessment of the local social, economic, political and cultural fabric as it affects the operation of the policy instrument is very important before any decision is taken. In large countries, the design of energy efficiency programs has to be adjusted to different regions. For instance in China, building code specifications cannot be the same all over the country due to climatic differences (Deringer et al. 2004). In Brazil, in some regions, electric showers are the second most important electricity consumers in households and therefore require labelling whereas fridges are more important in other regions (Gomes pers. comm.).

As shown in this chapter, applying policy instruments in packages increases the overall effectiveness since all single tools have their limitations and shortcomings. In addition, individual instruments are tailored to best overcome a small number of market barriers, thus, only several instruments can address the larger number of barriers prevailing all over the world. Policy packages are especially important in developing countries and when a market transformation is aimed at. In addition, developing countries especially require technical and financial assistance, demonstration and information programs and training. However, many of the other success factors such as institutionalization of energy efficiency within the governmental structure, regular monitoring and evaluation or adaptation to local circumstances are relevant for the success of policy instruments in developed countries as well.

7. Summary and recommendations

7.1. Summary of the results

Residential and commercial buildings account for approximately one third of all energy related CO2 emissions worldwide, which is expected to further increase in the future. A broad spectrum of barriers such as market failures, hidden costs and benefits, first-cost barriers, behavioural, informative and structural barriers hinder the realization of the often calculated significant saving potential. These barriers can be addressed by diverse policy instruments. However, as numerous policy instruments exist choosing the appropriate instruments requires a thorough assessment of these tools and the profound understanding of the local situation as well as the policy environment. The purpose of this report was to provide an assessment of the instruments available for improving energy efficiency in buildings in order to assist policy-makers in the decision process. Since the data do not exist for a primary evaluation of a large number of policies operating around the world and would unlikely be consistently collected and harmonised for a comparative analysis, the method of secondary assessment of existing policy evaluations was chosen. Therefore, over 50 government officials, research institutes, Non-Governmental Organizations and other energy experts in about 40 countries were contacted via email and phone in order to collect policy evaluations from a broad range. In addition, 12 detailed country studies were conducted, mostly by nationals of the respective countries. Over 80 evaluation case studies of implemented policy instruments or review articles referring to such studies were identified and served as the basis for the analysis. They cover 52 countries[16] from all inhabited continents. In addition, 6 interviews were conducted to complement the available information and for qualitative assessment of the instruments and more than 50 questionnaires were filled out by experts characterizing and evaluating the policy instruments.

The collected case studies indicate that many of the 20 policy instruments evaluated in this study can achieve high savings at low or even negative costs for society. Regulatory and control instruments such as building codes and appliance standards were revealed as the most effective and cost-effective category of instruments in the sample, if enforcement can be secured. A number of regulatory instruments achieved savings in the triple negative digit range, and all successfully implemented such instruments achieved negative savings.

Economic instruments such as energy performance contracting and white certificates achieve diverging results as some of them are still rather new for the buildings sector, but have a high potential. Under the of category fiscal instruments, subsidies, grants and tax exemptions can lead to high saving, but subsidies are less cost-effective to society. Financial incentives can be helpful to kick-start the market for new energy efficient products as well as for developing countries where funding is not always available. The effectiveness of voluntary instruments such as voluntary labelling and agreements depends on the context as well as on accompanying policy measures. Information instruments such as information programs are moderately effective alone which depends also on their design, but can successfully reinforce other instruments.

The highest GHG emission reductions in the sample were achieved by appliance standards, building codes, DSM programs, tax exemptions and labelling. Among the most

[16] The 25 member states (as of 2006) of the European Union were counted individually.

cost-effective instruments were appliance standards, energy efficiency obligations, DSM programs, public benefit charges and labelling. Most of these are regulatory and control instruments. Appliance standards are especially cost-effective with net projected societal benefits of -65$/tCO2 in 2020 in the United States and -194$/tCO2 in 2020 in the European Union. An important success factor for these is the continuous evaluation and regular updating of the thresholds to reflect changing market conditions and ambitious targets.

These results can be explained by the special characteristics of the buildings sector which is very fragmented and characterized by many barriers to energy efficiency (see table 1). Regulatory instruments seem to be the most effective as they can overcome some of the most important barriers, for example reduce the transaction costs since they eliminate the need to search for information and negotiation. Due to the especially large number of barriers it is also important to recognise that a single instrument will rarely serve as the panacea or reach ambitious energy saving targets, and thus combinations of instruments are necessary for progressive results. In addition, packages of instruments often achieve synergistic effects. This document has reviewed a few frequently used policy packages, and among these, public leadership programs combined with the support of energy performance contracting; appliance standards and building codes with labelling; financial incentives and labelling have shown to be especially effective in case studies.

However, the success of policy instruments strongly depends on certain success conditions. They vary from instrument to instrument, but correct enforcement and appropriate combination with other instruments are very important for most of them. Even regulatory instruments are most effective if combined with incentives and measures which evoke attention such as information programs.

Another precondition for long-term success is regular evaluation and monitoring from the beginning and incorporating the results of evaluations into the process as fast as possible. Furthermore, involvement of stakeholders and simple procedures and mechanisms usually increase effectiveness. Long-term commitment of stakeholders and funding agencies, also during the implementation phase, is crucial. Regulatory instruments require regular updates and ambitious provisions. Adaptation to the local situation is a success factor for most instruments.

However, these results, especially the conclusions for cost-effectiveness, require further research as the amount of quantitative data was still limited in 2007 and sometimes difficult to compare due to missing information on baselines, diverging methodologies of calculation or other factors. Evaluations are especially rare for developing countries. In addition, many policy measures are implemented as part of policy packages which makes assessment of single policy measures difficult.

7.2. Recommendations

This study has shown that regulatory instruments and control instruments, such as building codes and appliance standards, were both most effective and normally also most cost-effective, and have always achieved positive results in our sample of 80 case studies if implemented properly. Therefore, such measures are recommended for all countries, with the careful observation of their success factors. However, sufficient resources need to be dedicated to their implementation and enforcement, as well as regular updating of the thresholds to follow market dynamics. Mandatory and for developing countries possibly subsidized audits are an effective method for already existing buildings, especially if there are incentives or regulations to implement the cost-effective measures. By procuring energy efficient products and buildings and high-efficiency retrofits the public sector can not only reduce its own energy costs, but also act as a role model, create a demand for energy efficient products in the country and give incentives to the private sector.

Furthermore, if energy prices reflect real costs a much broader set of efficiency investments becomes profitable than with subsidizes prices, therefore, a phase-out or gradual lifting is an important precondition to the success of other energy efficiency policies. In return, the introduction of new energy efficient, but more expensive technologies can be supported through grants, rebates or subsidised loans as well as labelling. Limitation in time is a main success factor for fiscal measures as well as combination with information measures in order to prevent or at least limit increases in consumption following the improved efficiency. National or international financial support or the easy and broad access to financing as well as capacity-building are especially important success factors for developing countries.

Country-specific solutions which analyse in detail the local market structure, culture, climate, traditions and construction styles are more likely to be successful. In the past, many buildings were constructed in way that was well adapted to the local climate and were therefore energy-efficient, but this local traditional know-how is increasingly lost or neglected when modern architecture is used and uniform products are supplied by or as the result of the globalised construction industry. It is therefore important that the traditional construction know-how is conserved and its components that are still applicable are integrated into the in the curriculum of architects and other construction professionals.

However, it is also important to recognize that the same instruments can significantly vary in their success in different settings due to differences in design and other success factors. Success factors vary from instrument to instrument and to some extent location to location, but correct enforcement and appropriate combination with other instruments as well as involvement of stakeholders and simple procedures and mechanisms are important for all of them. Regular evaluation and monitoring from the beginning help to recognize and correct possible mistakes in the program design and implementation. Long-term commitment of stakeholders and funding agencies, also during the implementation phase, is a success condition, for example for building codes and other regulatory measures which also require regular updates. Adaptation to the local situation and the local barriers is crucial as well. One of the most important success factors for most policy instruments is a long-lasting transformation of the product or building market which implies a sustainable shift to more energy efficient products or buildings.

Since all instruments have advantages and disadvantages, and they all only overcome some of the prevailing market barriers, appropriate combination with other policy instruments can maximize the overall effectiveness. The following policy instruments, for example, can be effectively combined:

- standards, labelling and financial incentives
- regulatory instruments and information programs
- public leadership programs and Energy performance contracting (EPC), i.e. EPC in the public sector.

Policy packages are particularly essential for the success of policy measures in developing countries due to the special barriers there, such as lack of funds and access to financing, lack of awareness, lack of experts as well as technology and know-how (depending on the country) and problems with enforcement of laws. An integrated policy framework combining regulatory instruments, such as standards or mandatory audits in certain buildings, capacity building, training and information campaigns as well as demonstration projects coupled with (fiscal or other) incentives is most likely to effectively reduce GHG emissions in developing countries. Regulatory measures are important, but only effective if special efforts are made to implement and enforce them. While in developed countries combinations of instruments may moderate the rebound effect that constrain the effectiveness of regulatory instruments, in developing countries, energy-efficiency policies rarely result in a reduction of energy consumption, but most often in the increase of the affordable energy services with the available resources. In order to ensure continuous commitment, capacity-building and assistance, the creation of special institutions dedicated to energy (efficiency) is useful such as ministries, commissions and/or energy agencies. As developing countries vary considerably in their level of development, traditions or climatic zones, country-specific and even regionally adapted solutions are especially important. Cost-reflecting energy prices are an important precondition for far-reaching energy-efficiency programs, however, lifting subsidies is socially and politically difficult for very poor population segments. Since policy-makers often consider energy-efficiency as a low priority behind many more vital economic goals such as poverty alleviation or increased employment, it is essential that the co-benefits of energy-efficiency policies, such as energy security, poverty alleviation or improved social welfare, reduced mortality and morbidity or improved health, job creation and improved industrial productivity are well-mapped, quantified and well understood by the policy-makers. Policy integration with other policy domains is particularly effective to leverage these co-benefits in developing countries, and energy-efficiency goals can often be pursued more effectively through other policy goals that have much higher ranks on political agendas and thus may enjoy much more resources and a stronger political momentum.

In addition, developing countries especially need capacity-building and technical assistance. Information campaigns and demonstration projects are very important to increase knowledge about and trust in energy efficiency programs. Financing represents a major challenge in less affluent countries. It can be secured in more developed countries such as economies in transition through internal mechanisms, for instance public benefit charges or taxes, and in all other developing countries through international financial support.

The following success factors as crucial for energy efficiency programs in developing countries (Evander et al. 2004):

- Setting of clear program objectives
- Phased implementation which allows pilot projects.
- Coordination with other similar projects
- Well-planned implementation.
- Hiring of staff according to the project's needs, for instance a financial specialist is required if the project deals with financial institutions.

Further recommendations for designing policy measures effectively especially in developing countries are included in Table 34.

Table 34: Recommendations for designing an effective energy efficiency program

Program Design and/or Development	Program Adoption and/or Implementation	Program Monitoring and Evaluation
1. Obtain commitment from legislature, utility commission, or other body 2. Evaluate existing building energy code and other laws and options for implementation and enforcement 3. Involve key stakeholders and assess their support early 4. Use sound economic and environ-	1. Use clear basis for assessing compliance. 2. Update goals regularly 3. Ensure additionality over and above existing program commitments 4. Coordinate with PBF programs 5. Ensure that supply-side resource filings reflect the energy savings	1. Use methods proven over time 2. Include key tracking and reporting practices in program design 3. Provide qualitative in addition to a quantitative

mental quantitative analysis – determine cost-effective achievable potential for energy efficiency 5. Start with low-cost well established programs, lighting for instance 6. Set annual and cumulative targets using analysis and stakeholder input, for instance % of base-year energy sales 7. Establish a long-term time-frame to over-come market and funding cycles 8. Ensure that workable funding methods are available to meet EEPS target 9. Take care to select the most appropriate entities responsible for program implementation and/or meeting the target and the procurement rules they must follow 10. Assess training needs and other forms of technical support for code officials, builder associations, building supply organizations, auditors. 11. Contact material and equipment suppliers to ascertain availability of code compliant products	goals 6. Approve long-term funding cycles (5-10 years) 7. Design programs to meet customers' needs in the relevant market 8. Keep program design simple 9. Educate and train key participants regularly – builders, building officials, supply companies 10. Provide right resources, code requirements overview, laminated cards, simple software packages, how to conduct plan and site inspections, who to contact for more information. 11. Implementing and enforcing codes requires a high level of engineering expertise that many code officials do not have. Contact universities, and architect engineering firms for detailed analysis of codes. 12. Provide budget and staff for the program, and train staff	evaluation 4. Evaluate programs regularly against stated objectives 5. Utilize a third party verifier 6. Provide for adequate funding for evaluation 7. Provide feedback to oversee agencies and adjust future savings goals as needed 8. Provide for consistent and transparent evaluations 9. Maintain a functional database that records customer participation over time by geographical location and customer class

Source: Sathaye et al. 2006.
Note: EEPS- Energy Efficiency Portfolio Standards, PBF- Public Benefit Fund

Significant research gaps still exist: the situation in developing countries clearly requires further implementation of policy measures as well as further research as many of them have not yet introduced or are just about to introduce policy instruments for reducing GHG emissions from buildings. Only very few evaluation studies are currently available and even fewer include quantitative data on effectiveness and cost-effectiveness or success factors. Baseline data on details of energy consumption is often missing in developing countries while monitoring of energy consumption is currently just being introduced in many places. However, systematic monitoring of energy consumption as well as evaluation of projects and policies based on a common methodology would be necessary to continuously improve programs all over the world. In addition, collecting lessons learned from different places enhances learning and makes improvement of program designs possible.

Furthermore, since policy packages have been identified as most effective, some typical combinations of instruments need further research, especially quantitative evaluations. Finally, the relatively new instruments such as Energy Efficiency Certificate schemes, which have only been applied for a few years in selected countries, require further attention as do some instruments which are presently ineffective such as the Kyoto flexibility mechanisms in buildings. More research is needed also on some measures that could not be included in this study due to limited information, such as pricing schemes or green building rating schemes.

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List of most important Personal Communications

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About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

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> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

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> **Sustainable Consumption and Production** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
> **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
> **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
> **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
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Buildings contribute on average to 30% of energy use in society causing similar levels of associated greenhouse gas emissions. There are many proven ways to reduce the energy use in new and existing buildings but experience shows that this will not happen without intervention from policy makers. This study presents the qualitative and quantitative experiences from different kinds of policy tools applied in countries all around the world. The study reviews 20 different tools into four main categories: Regulatory and control instruments; Economic and market based instruments; Fiscal instruments and incentives; and Support, information and voluntary action. This report provides an assessment and summary of their effect in terms of efficiency, effect on emission reduction, cost effectiveness, and lessons learned. This study essentially also includes a database presented in 34 tables with detailed data provided on each instrument applied in each country. Based on the database an analysis with recommendations is provided.