MCA4climate: A practical framework for planning pro-development climate policies

Mitigation Theme Report: Energy Efficiency

Contribution to the MCA4climate initiative

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Practical Note

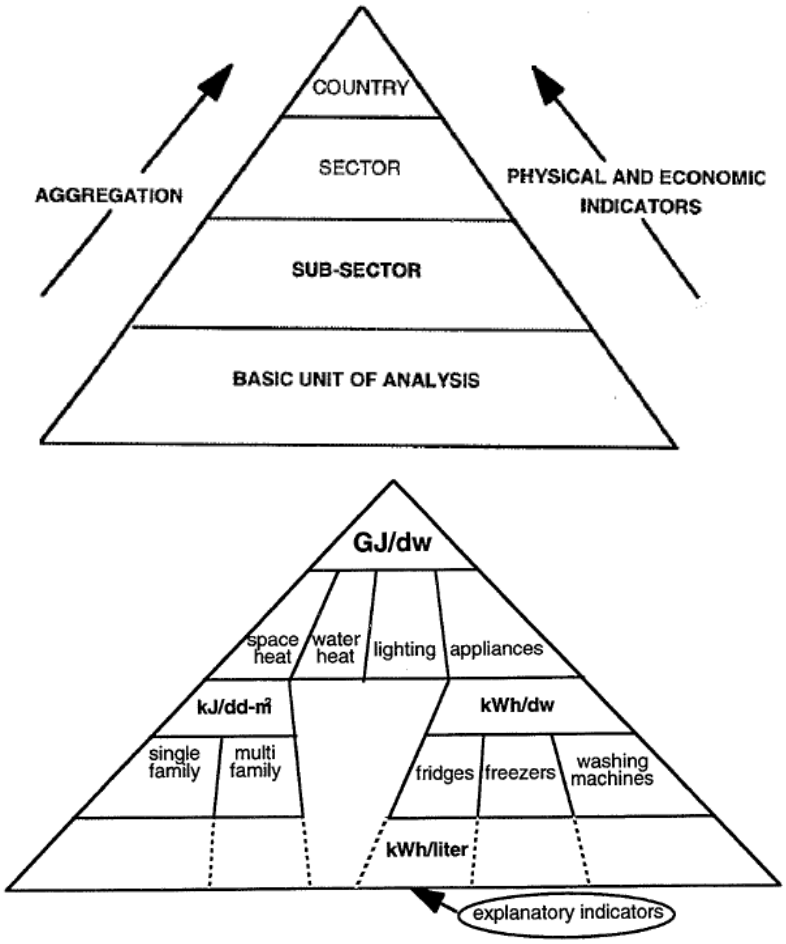
For an overview of the MCA4climate initiative and a step-by-step guidance on how the theme-specific information reported below may be practically applied in countries wishing to develop pro-development climate policy planning, please see the main MCA4climate report and other associated documents (such as the case studies) available on www.mca4climate.info. For further information, please contact the UNEP team, Serban Scrieciu, Sophy Bristow, Daniel Puig or Mark Radka at unep.tie@unep.org.

1. Introduction

Striving for energy efficiency means trying to obtain a certain result with a minimum of input (Schipper and Meyers, 1992; Blok, 2007). As energy is used to fulfil human needs, one may define the energy efficiency of an activity as the degree to which given human needs can be fulfilled with a minimum amount of energy. So, energy efficiency improvement can be defined as reducing the energy use per unit of human activity. The energy use per unit of human activity is also called energy intensity. In most cases, energy efficiency measurement is done by measuring energy intensity, but it is important to recognize that it is actually the inverse energy efficiency.

Energy intensity can be measured on different levels, often the concept of the indicator pyramid is used (see Figure 1).

Figure 1: General indicator pyramid for measures of energy intensity (top) and an elaboration for the household sector (bottom) (Martin et al., 1992)



At the highest level, energy intensity is measured as the total primary energy consumption per unit of GDP. At the lowest level, it can be measured for individual processes or individual appliances. In the latter case we talk about physical energy intensity or specific energy use. Primary energy is defined as the amount of energy extracted from primary sources, e.g. the amount of fuel extracted from the earth's crust. Final energy is the amount of energy that is left after the last stage of conversion, e.g. the heat output of the central heating system that supplies heat to a house.

The highest level, the energy/GDP ratio, is influenced by structural changes in the economy. Higher development levels often come with changes in the economic sectors of a country, e.g. a shift from agriculture to services. The energy/GDP ratio cannot be explained by energy efficiency levels alone, economic structure is also important. Therefore, the energy/GDP ratio is considered a poor indicator of the actual development of energy efficiency. On the other extreme, measuring energy efficiency for individual processes and appliances is very labour-intensive, and often the data are not available to do this. Therefore, in many practical cases an interim solution is chosen, where energy efficiency is measured at the sectoral level. Well-know examples are:

- Specific energy use for key industrial sectors (e.g. energy use per tonne of steel)
- Specific fuel use of passenger cars (in MJ/km)
- Specific energy use for space heating (in MJ/m^2)

Methods exist to re-aggregate indicators at the sectoral level to the national level.

Energy efficiency improvement is a phenomenon that also occurs without the presence of energy or climate policies. Therefore, we may measure the improvement of energy efficiency in two different ways:

- in absolute terms, compared to a so-called frozen-efficiency baseline
- in relative terms, compared to a non-intervention or business-as-usual baseline.

The first type of indicator measures the total development of energy efficiency, whether it is autonomous or policy-induced. Determination is quite straightforward, provided that reliable and sufficiently detailed statistics are available. Nevertheless, determination of energy efficiency improvement is still quite labour-intensive.

In a policy context, the second type of indicator is more relevant, as it measures the impact of policies while excluding 'what would have happened anyway'. Measurement is more difficult; there are two approaches:

1. determining a baseline, and measuring the energy efficiency improvement against this baseline;
2. separately measuring the impact of all the different policies involved.

In both cases, additional investigation is necessary, e.g. econometric analysis or theory-based policy evaluation.

2. Policy options

To improve energy efficiency, the following policy instruments can be considered:

- Energy or carbon taxation
- Investment subsidies or fiscal incentives
- Emission trading
- Energy efficiency standards
- Negotiated agreements
- Energy efficiency labeling
- R&D subsidies
- Information and awareness raising

In the case of an **energy tax,** energy users have to pay a levy on top of the market price when they purchase an energy carrier. When this levy is proportional to the carbon content of the energy carrier, the tax is called a *carbon tax*. Automotive fuels are taxed in most countries, but generally only small levies are placed on other energy carriers. Only a few countries in northwestern Europe have substantial carbon or energy taxes for fuels other than automotive fuels, and even in these countries, energy-intensive companies are generally exempted.

The appeal of a general tax is that it leads to an optimum outcome: if one wants to reach a specific aim (e.g., reduction of carbon dioxide emissions), taxation related to that aim (in this case, a carbon tax) will – at least in theory – produce the lowest possible costs for society as a whole. On the other hand, a serious disadvantage of an energy or carbon tax is that there may be negative effects for specific groups, in this case energy-intensive companies (especially if the tax is only introduced in a few countries), as well as on low-income households. Furthermore, to achieve the desired results, taxation levels have to be fairly high. One specific application of a carbon or energy tax is to raise funds for subsidy schemes.

Subsidies are often provided to encourage investments in energy-efficient technology. Part of the investment is refunded, either directly or in the form of tax reduction (fiscal stimulation). Investment subsidies are in place or have been in place in many countries, often refunding a fixed fraction of the investment. Another form of subsidy is the rebate: purchasers of equipment that is more efficient than average (e.g. efficient refrigerators, compact fluorescent lamps) get a fixed amount of money back.

General investment subsidies, which provide a fixed percentage of the investment as a refund, have the disadvantage of so-called free-rider effects: part of the subsidies (which can amount to 50% or more of the investment) are given to actors that would have made the investment anyway. The free-rider effect is greater when the subsidy is generic, applying to all technologies, whether highly profitable or

unprofitable; but the free-rider effect tends to be smaller when the subsidies are directed at specific technologies. Investment subsidies can be effective, but in general the costs for the government are higher than for other policy instruments.

In the case of **emission trading**, each actor (in this case, a company) gets a certain number of emission allowances. The company needs to keep its emissions below this 'cap', but the emission trading system allows the companies to buy or sell their emission allowances. There are different ways the initial allowances can be set: the allocation of allowances can be made by the government, for instance based on historic emissions (this is called grandfathering), but the allocations can also be sold at auction.

Until recently, emission trading systems were rare. The oldest system of any significance is the emission trading system for SO_2 from power plants in the USA. However, in 2005 a large CO_2 emission trading system was introduced in the European Union, covering about half of the Union's emissions (including both power plants and large industrial energy users).

Like emission taxation, emission trading theoretically leads to the lowest possible costs of total emission reduction. Furthermore, total emissions can be tuned exactly to a pre-determined level. The most important problem – apart from administrative issues – is making a fair initial allocation to the various companies.

Energy efficiency standards prescribe minimum technical requirements for energy conversion systems and energy end-use systems. Two main approaches are prescriptive standards, which impose requirements on specific components of equipment, and performance standards, which impose requirements on the overall level of (specific) energy use.

Most industrialised countries have standards for the energy efficiency of new buildings, both prescriptive (e.g., insulation values of walls and roofs) and performance standards. A number of countries (e.g., the USA and countries in South East Asia) have standards for the energy efficiency of household equipment. In 1975, the USA introduced the corporate-average-fuel-economy (CAFE) standard for passenger cars: the average specific fuel use of all new cars sold by a specific car company needs to meet a certain level.

Energy efficiency standards can be very effective in reducing or limiting energy use, but they are rigid and especially prescriptive standards do not allow much flexibility. Furthermore, legislative processes can take much time, and an adequate system of monitoring is necessary to enforce compliance. Finally, companies are not stimulated to go beyond the energy efficiency standards.

Negotiated agreements, or voluntary agreements, are agreements between governments and actors or groups of actors to limit or reduce energy use, usually specific energy consumption. Agreements can refer to the actors' own energy use, or the energy use of the equipment they produce. Voluntary agreements on the energy efficiency of industrial processes are in place in a number of European countries. The European Union has made voluntary agreements with car manufacturers and with selected household appliance manufacturers. For companies, an advantage of such voluntary agreements is that they can be formulated in a way providing maximum flexibility. From the point-of-view of the government, the advantages are better cooperation on the part of the companies and a generally faster achievement than with energy efficiency standards. In order to attain ambitious voluntary agreements, the government needs to have a good negotiating position and it should actively support the process of implementing the desired energy-efficiency measures. Regular monitoring and independent verification are also necessary.

Energy efficiency labelling. Labelling is a way of informing the buyers or users of the equipment about its energy performance. For example, in the European Union, the energy use of electric appliances and cars is clearly marked. Labelling has some effect on purchasing behaviour, but the effect is limited, as is often the case with information tools. Nevertheless, labelling is an important first step in policy development, and its effect can be enhanced when it is combined with other policy instruments, such as subsidies.

Instead of stimulating the use of energy efficient equipment that is already available, governments can also stimulate the development of new energy-efficient technology. This is usually done by providing **R&D subsidies**. Only a few countries provide substantial funding for R&D on energy efficiency.

Other policy instruments to stimulate the development of new energy technology include:

- **Cooperative technology agreements**: agreements on technology development between governments and private actors. An example is the Partnership for a New Generation of Vehicles, an agreement in 1993 between the US administration and US car manufacturers to jointly work on prototype cars to be ready by 2005 that would consume only one third of the fuel of cars produced in the early nineties.
- **Technology procurement programmes**: a government sets certain requirements for the equipment it purchases. The supplier that meets these standards best is rewarded, for instance, through a guaranteed purchase. This was applied in Sweden and led to the development of cheaper and more efficient heat pumps.

- **Technology-forcing standards**: a government may set energy efficiency standards for the long-term that cannot be satisfied with existing technology and requires additional technological development. An example is a requirement in California to have a certain fraction of zero-emission vehicles on the road in the year 2010.

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 and Koeppel, 2007). A recent publication by OECD/IEA (2010) also presents the barriers to energy efficiency improvements. The most frequently cited barrier (mentioned in two-thirds of countries) is lack of information and low awareness. Other frequently cited barriers included low energy prices, difficulty in accessing affordable financing and lack of EE implementation capacity.
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).

Table 1: Policies to improve energy efficiency, based on WEC (2008)

Market based instruments

Policy option	Advantages	Disadvantages	Possible Remedies for Disadvantages
Energy - or carbon pricing	- low cost for society as a whole (in theory)	- negative effects for specific groups, e.g. low-income families - does not overcome market failures such as lack of information and low awareness	Combine with other policy instruments targeted to energy efficiency, for instance subsidies for low-income households to invest in energy efficiency
Tradable white certificates	- stimulates energy efficiency businesses (e.g. ESCO's) - flexibility for cost effective compliance	- need for advanced institutional structures - transaction costs can be high	- apply a simplified system, focused only on limited sectors or limite technologies - apply rules-of-thumb for energy conservation performance

Regulatory instruments

Policy option	Advantages	Disadvantages	Possible Remedies
Energy consumption reduction standards	- monitoring is simple - it is clear upfront what targets will be achieved	- system is inflexible and may harm economic development	- make 'energy allowances' tradable
Energy saving obligations	- provides a clear indications of what efforts are required	- strong compliance and enforcement regime required	

Economic instruments

Policy option	Advantages	Disadvantages	Possible Remedies
Subsidies: R&D subsidies	- Good mechanism if first cost is major barrier	- High government cost - no guarantee for long-term implementation of energy efficiency measures - risk of free riders	- make subsidy schems technology specific and focus on technologies in the early phase of market introduction
Tax incentives	- Reinforcement of impact of other instruments such as standards and subsidies, or make energy efficiency investments more profitable - Effective for advanced technologies with high first-cost	- Free-rider effect - Small size of credits - Application to old technologies	- Sufficiently high level of incentive
Loan facilities	- can be very helpful in case availability of capital is a problem - supportive for first movers	- difficult to tune the conditions of the loan in such a way that there is a real impact	- focus on specific options, e.g. efficiency buildings - apply tailor made approach e.g. for large industrial projects
Cooperative technology procurement or	- are a strong way to push suppliers to innovate	- only works if group of buyers is sufficiently large and	- good cooperation within buyer group is required and focus should be on

technology procurement programmes		powerful	technologies where a step-change in energy efficiency is possible
Technology-forcing standards	- strong means to force the development of new technology	- can become frustrating ineffective if government is 'over-asking'	- standard-setting should be well prepared and take into account international technology status

Information-based instruments

Policy option	Advantages	Disadvantages	Possible Remedies
Labeling	- makes both producers and consumers aware of the energetic performance of products	- limited effect	- Combine with other policy instruments, e.g. subsidies - Labelling programmes cannot sufficiently transform the market and are usually completed by minimum performance standards
Energy performance standard	- support the gradual removal from the market of the least energy efficient appliances.	- standards can quickly become obsolete - is relatively inflexilbe	- update standards on a regular basis, e.g. every 3 – 5 years, or use a Top-runner approach - organize a stakeholder process with manufacturing industry
Information and awareness raising campaigns	- Can reinforce long-term effect of other measures - direct visibility	- Lack of trust - effects wear off over time	Adapt the campaign to the audience
Training	- Know-how on energy-efficiency	- No capacity to train people	- Technical assistance through international consultants and organizations
Capacity building			

Voluntary agreements

Policy option	Advantages	Disadvantages	Possible Remedies
Voluntary agreements	- Flexible for Companies/industries and more cost-effective to them - Faster decision and Implementation - Since they have the support of manufacturers, they can be implemented more rapidly than regulations.	- Often impact below expectations	- continued involvement of government agencies improves the effectiveness - Combine with threat of regulation or taxes

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.

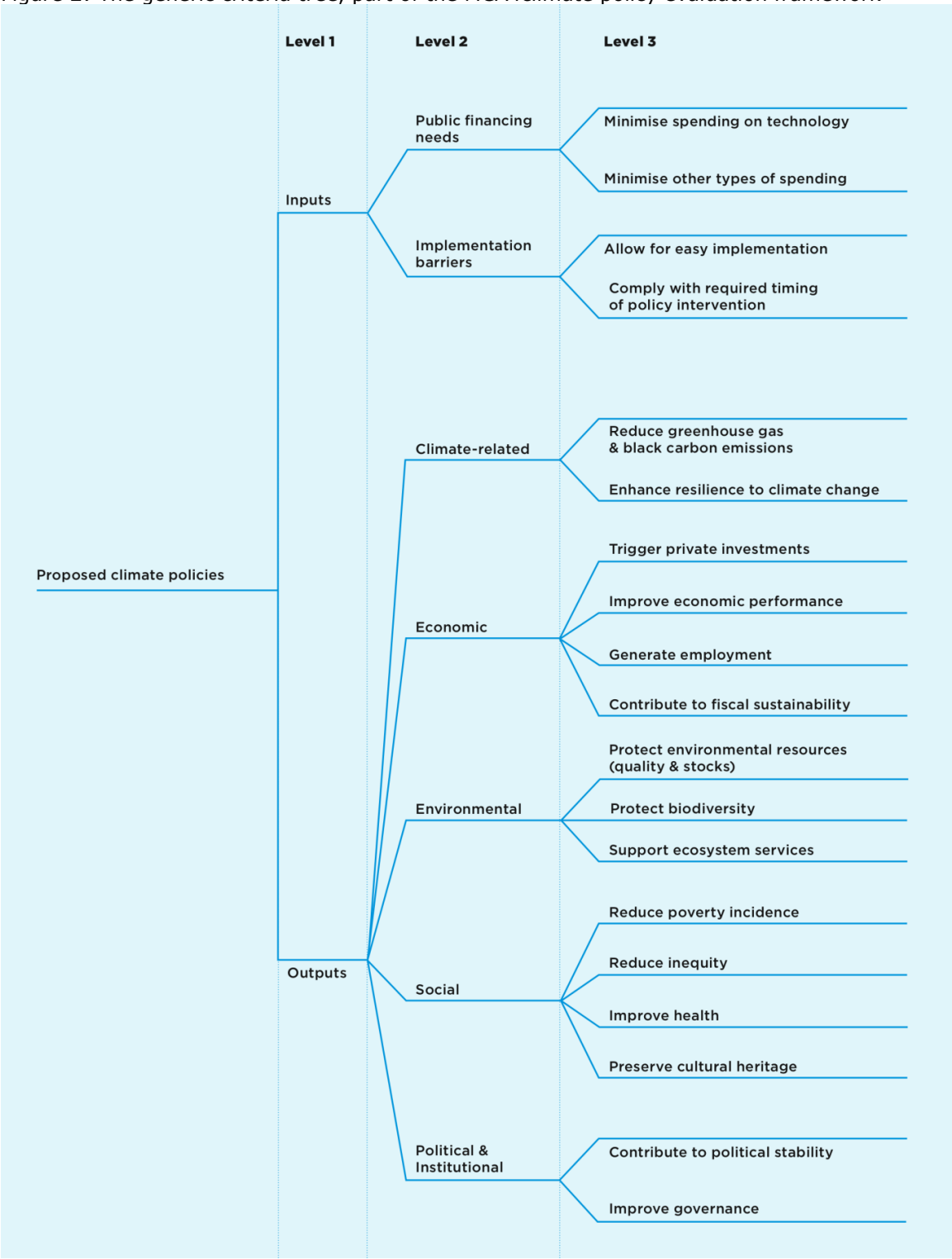
Definitions instruments: http://www.iea.org/textbase/pm/explanation.asp

3. Criteria and indicator for evaluating energy efficiency policies

The MCA4climate approach has laid out a suite of general criteria categories that national governments can apply to each theme area to guide their climate change mitigation and adaptation planning. Specifically, the MCA4climate policy evaluation framework articulates a multi-dimensional set of 19 level-three criteria (Figure 2) against which adaptation options for climate change policies and plans in the area of water resource management could be assessed. These criteria are developed at the generic level, cutting across all twelve climate change mitigation and adaptation themes being considered. These generic criteria are grouped, at the first level, under inputs (the costs or efforts required to implement a climate policy option) and outputs (the impacts of a particular policy option). The input side is linked to two dimensions (or level-two criteria): public financing needs and implementation barriers, which are in turn disaggregated in "minimise spending on technology" and "minimise other types of spending" for the former, and "allow for easy implementation" and "comply with required timing of policy implementation" for the latter (these are the four level-three criteria on the input side). The output side refers to five dimensions (level-two criteria): climate-related, economic, environmental, social, and political & institutional to describe likely positive or negative impacts of a policy option. These are in turn broken down into 15 level-three criteria: two on climate-related issues, four on economics, three on the environmental side, four on the social dimension and two linked to the political and

institutional dimension. For a more detailed discussion of the criteria tree at the generic level displayed in Figure 2 see the main MCA4climate report and the MCA4climate methodology document available on www.mca4climate.info.

Figure 2: The generic criteria tree, part of the MCA4climate policy evaluation framework



The goal of this contribution is to develop a useful set of criteria, descriptors and indicators to organize evaluations of energy efficiency improvement mitigation options. The criteria and descriptors discussed below provide details relevant for energy efficiency planning in accordance with the MCA4climate initiative's multi-criteria tree as depicted in Figure 2. These should be viewed as a (non-exhaustive) package, all of which may be relevant to the evaluation of a specific energy efficiency improvement mitigation proposal under consideration. In this report we develop a set of level-four-criteria and associated indicators for policy options related to energy efficiency improvements and climate change mitigation. The indicators will not be defined on the level of single energy efficiency instruments (e.g. car labels for fuel consumption and CO_2 emission), but on the level of energy efficiency policies in general.

Input criteria

Public financing needs

Criterion 1: Minimise spending on technology

- Indicator: overall cost for the national government to execute energy efficiency policies (€)
- Indicator: Investments in innovation and technical capacity
- Indictor: Subsidies, tax exemptions / deductions (€) for energy efficiency improvements

Methods of assessment: cost estimates

Criterion 2: Minimise other types of spending

Cost of energy efficiency improvement policies.

- Indicator: Implementation costs, administration costs, enforcement costs (in case of regulation), programme costs (campaigns, training etc.), costs for monitoring and evaluation
- Indicator: Investments in training, evaluation and expansion of consumer education and market-based initiatives (€).

Methods of assessment: government budgets

Implementation barriers

Criterion 3: Allow for easy implementation

Quality of institutional set-up: whether a country has the right institutions in place to govern the implementation, execution and monitoring of energy efficiency policies.

- Indicator: Number and size of institutes/organisations involved in policy implementation, execution and monitoring (# of people working at these institutes/organisations).

Methods of assessment: national statistics

Criterion 4: Comply with required timing of policy implementation

Timeline of energy efficiency policy implementation knows two dimensions:
- Indicator: time required for designing energy efficiency policies (# years)
- Indicator: time taken by the policies to be effective (# years)

Output criteria

Climate-related

Criterion 5: Reduce greenhouse gas & black carbon emissions

Reduction of greenhouse gas emissions compared to a business as usual baseline
- Indicator: Emission reduction in % reduction of greenhouse gases compared to business as usual

Target achievement
- Indicator: % efficiency improvement per year as a consequence of policy in households
- Indicator: % efficiency improvement per year as a consequence of policy in industry
- Indicator: % efficiency improvement per year as a consequence of policy in transport

Net impact
- Indicator: Avoided final energy consumption (GJ)
- Indicator: Avoided CO_2 emissions (Mtonnes)

Methods of assessment: statistics (e.g. energy efficiency indicators of the World Energy Council)

Criterion 6: Enhance resilience to climate change

Not applicable

Economic

Criterion 7: Trigger private investments

Do businesses invest in energy efficient equipment?

- Indicator: Residential sector - substitution of baseline equipment with high-efficiency models.
- Indicator: Residential sector/industry/services: Sales numbers of key energy efficient products targeted by policies and measures according to international standards (#). Key energy products could be lighting, airconditioning systems, refrigerators etc.
- Indicator: Residential sector: # of energy efficient appliances per household.
- Indicator: Industry - # of product or process innovations in the production process over time.

Target groups reached

- Indicator: Residential - # of households that have implemented energy saving measures

Methods of assessment: national statistics

Criterion 8: Improve economic performance

Energy use in industry

- Indicator: Energy intensity of industry, defined as the ratio between the final energy consumption of industry and the value added measured in constant purchasing power parities (ppp) (koe/ US$05bn).
- Indicator: Energy productivity per industrial sector, defined as the quantity of a given product per unit of energy required for its production. It can be used as a measure of the utilisation of energy in industrialised system.
- Indicator: Energy consumption per tonne of steel (GJ/ t steel)
- Indicator: Energy consumption per tonne of alumina (GJ/ t alumina)
- Indicator: Electricity consumption per tonne of primary aluminium (GWh/ t primary aluminium)
- Indicator: Energy consumption per tonne of clinker (GJ/t clinker)

Energy costs in industry

- Indicator: Share of energy costs in overall costs of industrial sectors (%)

Costs of measures

- Indicator: Costs per tonne of CO_2 avoided (€/tCO_2 avoided).
- Indicator: Cost reduction per tonne output (€/tonne product)

Energy use in households

- Indicator: % of household expenditures on energy
- Indicator: # of businesses attracted that sell energy efficiency equipment

Methods of assessment: energy statistics (e.g. energy efficiency indicators of the World Energy Council)

Criterion 9: Generate employment

Direct job creation

- Indicator: # of jobs created in energy efficiency services
- Indicator: # of technical staff trained

Indirect job creation

- Indicator: # of jobs created in other sectors than efficiency services

Methods of assessment: national statistics

Criterion 10: Contribute to fiscal sustainability

Development of public investment over time

- Indicator: Projected (and realised) public spending on energy efficiency policies

Impact of energy efficiency policy on government revenues

- Indicator: Government revenue from energy taxes

Methods of assessment: government budgets

Environment

Criterion 11: Protect environmental resources (quality & stocks)

Various problems in indoor air quality are recognized as important risk factors for human health in both developing as well as developed countries. In developing countries the indoor use of solid fuels for cooking purposes and consequently the exposure to smoke from coal and biomass poses a threat to human health. Indoor air quality problems in these countries are attributable to the lack of technology necessary to eliminate indoor air pollution (e.g. chimneys, hoods; use of clean fuels). Energy saving measures can attribute to the improvement of indoor air quality.

- Indicator: the use of appropriate fuels
- Indicator: pollution control
- Indicator: exposure reduction

Building codes and building material classification systems provide tools to reduce building material emissions and improve indoor air quality especially in *developed* country settings. Sufficient mechanical or natural ventilation is a key element in removing humidity, carbon dioxide, bioeffluents and other pollutants from indoor air.

Criterion 12: Protect biodiversity

- Indicator: Reduction in number of species

Criterion 13: Support ecosystem services

This criterion is not directly relevant to the energy efficiency theme.

Social

Criterion 14: Reduce poverty incidence

Cover basic energy needs to improve living conditions

- Indicator: % electrified households
- Indicator: % of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy
- Indicator: % of population living in houses with lack of functioning basic amenities (water, sanitation and energy).

Household energy use

- Indicator: % of household income spent on fuel and electricity
- Indicator: % of households that cook on modern fuels, solar cooking stoves or traditional cook stoves
- Indicator: % of households that rely on traditional cooking methods.

Methods of assessment: national statistics

Criterion 15: Reduce inequity

Energy efficiency measures can lead to reduced access-poverty, when an increasing number of people have access to energy

- Indicator: # of households connected to a local or centralized electricity network

Household energy use across income groups

- Indicator: % of household income spend on fuels and electricity across income groups.

Methods of assessment: national statistics

Criterion 16: Improve human health

Environmental conditions of the housing properties

- Indicator: Proportion living in households that are situated in neighbourhoods with above average pollution rate (water, air and noise).
- Indicator: % of households that cook inside the house

Criterion 17: Preserve cultural heritage

This criterion is not directly relevant to the energy efficiency theme.

Political & Institutional

Criterion 18: Contribute to political stability

Reduce dependency on energy imports

- Indicator: % share of commercial fuels exported
- Indicator: Percentage of net energy imported (%)

Physical reserves of energy

- Indicator: # of years of physical reserves of energy

Criterion 19: Improve governance.

Energy efficiency governance is the combination of legislative frameworks and funding mechanisms, institutional arrangements, and co-ordination mechanisms, which work together to support the implementation of energy efficiency strategies, policies and programmes (OECD/IEA, 2010).

- Indicator: Existing mechanisms to fund EE implementation (examples: general appropriations from government budgets, grants from other government agencies, energy or environment taxes, system public benefit charges, stimulus funding, carbon financing, licensing and permitting fees, donor funding and international co-operation and fee-for-service arrangements)

4. Interaction with other themes

Energy efficiency improvements might interact with the other themes. Table 2 lists the main interactions found.

Table 2: Interactions and interdependencies between energy efficiency theme and other themes

Theme	Relation with energy efficiency improvements
Health	Energy efficiency improvements might have positive effects for human health, because it improves indoor climate. E.g. using solar cookers instead of traditional cooking stoves lead to less indoor air pollution.
Improving land use management practices	NA
Increasing the share of low-carbon energy sources in fuel mix	NA
Capturing and storing emissions of carbon dioxide	Carbon capture and storage reduces energy efficiency of power plants
Improving coastal zone management	NA
Reducing agricultural output losses	Energy efficiency avoids land and water degradation associated with the extraction of coal, oil, gas and uranium
Increasing infrastructural resilience	NA
Improving water resources management	Energy efficiency avoids land and water degradation, biodiversity and forestry problems that may be associated with hydro-electricity
Increasing terrestrial marine ecosystem resilience	NA
Reducing extreme weather event impacts	NA

Notes on methods of assessment

In the above text we have tried to define indicators that are (quantitatively) measurable. There are several methods which can be used for ex ante evaluations of energy efficiency policies. This is a complex task and it may be that such information is not available for the energy efficiency policies. The tools, techniques and models that can be used to determine the value of the indicators (including qualitative descriptions) come down to the use of (national) statistics on the defined energy efficiency indicators. If not the necessary efforts to collect the data will be huge.

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