Economics of Greenhouse Gas Limitations

MAIN REPORTS

Summary Guidelines

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1. INTRODUCTION

This document is a summary version of the methodological guidelines for climate change mitigation assessment developed as a part of the Global Environment Facility (GEF) project *Economics of Greenhouse Gas Limitations; Methodological Guidelines* (Halsnæs, Callaway & Meyer 1998). The objectives of this project have been to develop a methodology, an implementing framework and a reporting system which countries can use in the construction of national climate change mitigation policies and in meeting their future reporting obligations under the FCCC. The methodological framework developed in the *Methodological Guidelines* covers key economic concepts, scenario building, modelling tools and common assumptions. It was used by several country studies included in the project.

2. POLICY ISSUES

2.1 International climate change policy developments

Climate change is probably the most complex and challenging environmental problem facing policy makers today. The Intergovernmental Panel on Climate Change (IPCC) published its *Second Assessment Report* in December 1995 (IPCC 1996). The report states that the balance of evidence suggests a discernible human influence on global climate, and since the late 19th century, global mean surface air temperature has increased by about 0.3-0.6 degrees Celsius. Different scenarios developed by the IPCC project that the global mean surface air temperature will rise by between 1 and 3.5 degrees Celsius between 1990 and 2100, with potentially large regional variations.

The IPCC Second Assessment Report examines a wide range of options to reduce emissions of greenhouse gases and to enhance their sinks. Truly significant reductions in current net greenhouse gas emissions, however, can only be achieved if a large number of countries take action at the national level, and at the same time collaborate at the international level to reduce emissions. The legal framework for national action and international co-operation in the field of climate change is provided by the **United Nations Framework Convention on Climate Change** (FCCC). The convention entered into force in March 1994, less than two years after it had been signed by more than 150 countries during the United Nations Conference on the Environment and Development in Rio de Janeiro, Brazil (June 1992). It establishes a set of commitments that should contribute to the overall objective of the FCCC which is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2). Guiding principles to achieve this objective include that all Parties to the FCCC should "protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities". Furthermore, Parties should "take precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects" (Article 3).

The FCCC specifies three categories of commitments. There are general commitments that apply to all Parties to the FCCC, commitments that only apply to Parties listed in Annex I and commitments that apply only to Parties listed in Annex II. General commitments include:

- the preparation and communication of national greenhouse gas inventories,
- the development and communication of programmes containing measures to mitigate climate change and to facilitate adaptation to climate change,
- to promote and co-operate in the development, application and diffusion of relevant technologies, practices and processes, and
- to take climate change considerations into account in relevant social, economic and environmental policies and actions.

Parties listed in Annex I more specifically are committed to adopt policies and to take measures aimed at climate change mitigation. The Parties listed in Annex II additionally are committed to provide financial resources to assist developing countries in the preparation of national communications, and to provide financial resources for technology transfer.

The first Conference of the Parties to the FCCC (COP-1) was held in Berlin in March / April 1995. One of its major decisions is referred to as the “Berlin Mandate”, which concluded that the current commitments of Annex I Parties are inadequate. The third Conference of the Parties to the FCCC (COP-3), held in Kyoto in December 1997, adopted the **Kyoto Protocol** (Climate Change Secretariat 1998) that outlines a general framework for these common actions. In the Kyoto Protocol, Parties in Annex I of the FCCC agreed to commitments with a view to reducing their overall emissions of six greenhouse gases (GHGs) by at least 5 % below 1990 levels in the commitment period 2008 to 2012. The protocol also establishes an initial framework for emission trading, joint implementation, and a “Clean Development Mechanism” to encourage joint emission reduction projects between developed and developing countries. The Fourth Conference of the Parties (COP-4) held in Buenos Aires, Argentina, in November 1998 adopted an 'Action Plan' establishing deadlines for finalising work on the Kyoto Mechanisms (Joint Implementation, Emission Trading and the Clean Development Mechanism), compliance issues, and policies and measures.

The Conference of Parties has established a permanent UNFCCC secretariat in Bonn, Germany to help to fulfil the objectives of the FCCC, and a number of formal mechanisms to encourage information exchange, networking and training. They include *CC:INFO* (Climate Convention Information Exchange Programme), *CC:TRAIN*, that aims to support the efforts of developing country Parties with their implementation of the FCCC by providing training, technical and financial support, and *CC:FORUM*, that provides an informal consultative forum among policy-makers from developing countries, countries with economies in transition, non-governmental organisations and multilateral and bilateral agencies. The FCCC, on an interim basis, has designated the Global Environment Facility (GEF) as the body entrusted with the operation of the mechanism for the provision of financial resources for projects that address climate change. The projects and activities financed by GEF are implemented by the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP) and the World Bank.

2.1.1 The national decision making framework

The sources and sinks of GHG emissions are directly linked to key economic sectors, particularly the energy, industry, transport, agriculture, forestry and waste management sectors. Most developed country Parties to the FCCC have by now developed comprehensive climate change mitigation strategies, with policies and measures in all or at least most of the above sectors. For most of the developing countries the priority issues are first of all economic and social development needs, while environmental policies primarily focus on local environmental problems. In many cases, however, developing countries have started implementing measures which, while designed for social and economic policy goals, will also contribute to the aim of limiting greenhouse gas emissions. Areas where climate change policy objectives can be achieved simultaneously with social and economic policy objectives include i.e. efficiency improvements in energy production and consumption, sustainable agriculture and forest management practices, and increased institutional capacity for sustainable development.

The present guidelines focus on the definition of main concepts in relation to formal national climate change mitigation assessments. National governments, political institutions, non-governmental organisations, businesses and researchers in the countries will be important actors in the establishment of action plans and project implementation in the foreseeable future. The implementation of climate change mitigation policies will also involve large cross-cutting efforts. Because climate change mitigation is already closely integrated in key sustainable development issues, new greenhouse gas mitigation efforts, in many cases, will involve only "small" changes to ongoing development programmes for the power sector, agriculture, forestry, and infrastructure. The success of climate change mitigation efforts will therefore be highly dependent on how well projects can support and be linked to local interest groups and populations as well as to implementing agencies in the sectors concerned.

2.2 Basic common country study approach: An overview

National climate change mitigation studies will vary in coverage, details and sophistication of assessment efforts involved. This is a consequence of different national institutional capacities, analytical tools and statistics. Some countries have participated in other similar study activities and can utilise already implemented models, while others have few experiences in climate change assessments.

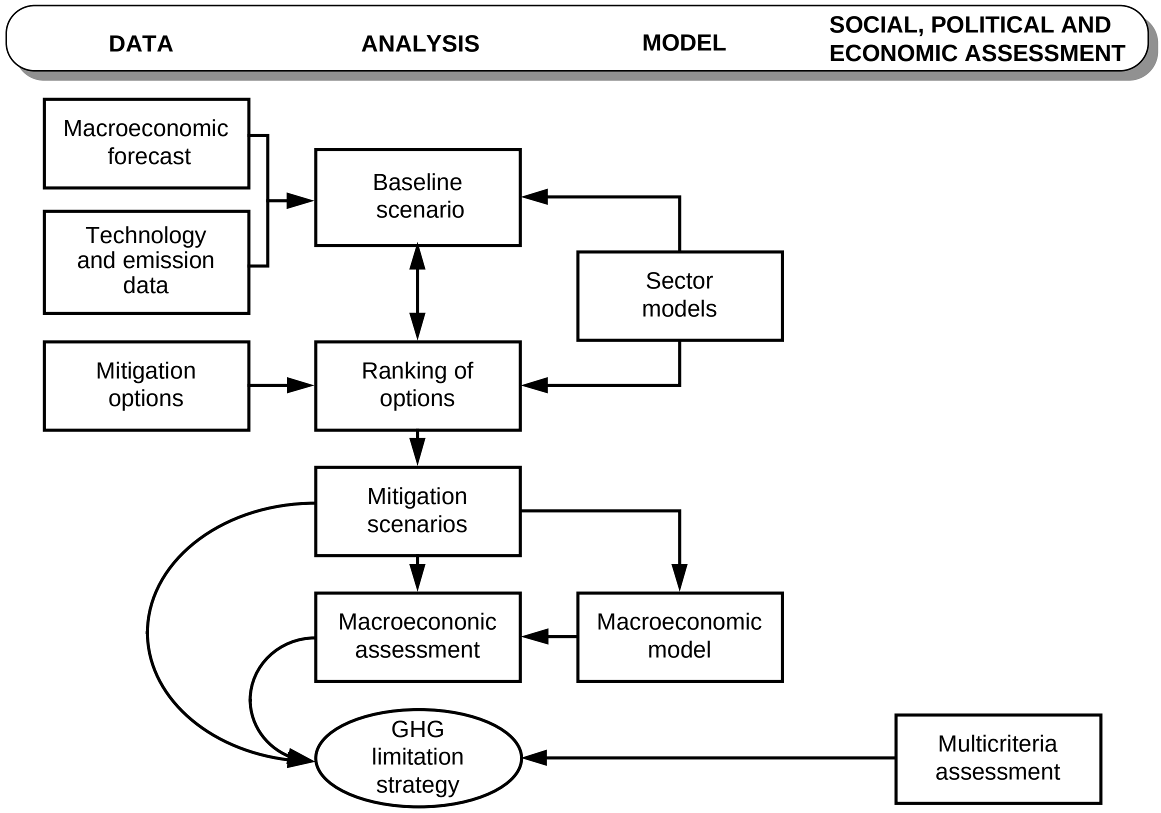
The *Methodological Guidelines* of the *Economics of Greenhouse Gas Limitations* project as presented here are purposely defined broadly to enable national analysis to be carried out with different focus and depth. It is however recommended that all countries follow a common analytical structure. The elements in this analytical structure are summarised below:

1. **Comprehensive evaluation of national social and economic development framework for climate change mitigation**
   - Comprehensive description of national framework for climate change mitigation including: base year statistics on GDP structure, social conditions, energy balance, aggregate GHG inventory, major land use activities, population.
   - Evaluation of main national economic and social national development trends and the GHG emissions that are expected to occur as a result of economic development.
   - Overview of other climate change studies including impact-, adaptation-, inventory and mitigation studies.
2. **Baseline scenario projection**
   - 10-15 year baseline scenario projection for CO_2 emissions from energy consumption and land use activities.
   - 30-40 year baseline evaluation of main development trends.
3. **Mitigation scenario(s) projection(s)**
   - Identification of mitigation options related to the most important future sources and sinks sectors.
   - Assessment of reduction potential and cost of mitigation scenarios.
   - Integration of GHG reductions and costs across measures and sectors, through construction of marginal reduction cost curves.
4. **Macroeconomic assessment**
   - Qualitative description of main macroeconomic impacts of national climate change mitigation strategies.
   - Assessment of key macroeconomic parameters.
5. **Implementation issues**
   - Identification of main implementation requirements including: financial support, technologies, institutional capacity building, regulation policies and further improvements of the national decision framework.

These basic country study elements emphasise the establishment of a broad overview of the most important national activities related to future GHG development trends as a background for a more detailed assessment of individual mitigation options. The country study steps can be conducted at many different levels of sophistication ranging from a broad description of main development trends and statistics to a formalised modelling at sector and macroeconomic level.

The common analytical structure of the country studies is illustrated in Figure 1.

Figure 1 Common analytical structure of the country studies.



3. DEVELOPMENT OF SCENARIOS

3.1 National scenario concepts

National mitigation assessment should consider the impacts of implementing climate change mitigation strategies in relation to a “business-as-usual” baseline projection that by definition assumes that the policies included in the mitigation scenario are not expected to be in place in the baseline. Thus, the baseline projection will be generated using a set of assumptions that would depict the expected pattern of economic development, as currently formulated in formal government plans, or as interpreted through current governmental policy objectives. This baseline projection is used to assess the “sacrifices” of allocating resources to mitigation policies compared with the non-policy case. The non-policy case will in the following be termed the baseline scenario.

Climate change mitigation involves the implementation of *individual projects, sectoral strategies and comprehensive national action plans*. To the extent possible, this should also include the assessment of various policy options for achieving these options. The assessment involves a systematic comparison of the mitigation- and the baseline scenario and these two scenarios should therefore be constructed on the basis of consistent assumptions.

Major scenario assumptions include:

- Activity projections for main GHG emitting sectors and sinks. For most countries, this will include the energy sector, industry, transportation, agriculture, and forestry, other land use activities and waste management.
- Technological development related to the main GHG emitting sectors and sinks.
- Technological development related to mitigation projects.
- Market behaviour and implementation aspects related to mitigation projects.
- Assumptions defined for alternative sensitivity cases. These include assumptions on technology costs, discount rates, fuel prices and other international background parameters.
- Alternative policy instruments for achieving sectoral and national level goals.

In the case of national analysis, the scenario assumptions should reflect the decision problem facing the individual country given a set of assumptions on economic development and mitigation efforts in a broader international context.

The mitigation assessment can consider individual projects, sector strategies and cross-sectoral national strategies. Baseline definitions should be defined in accordance with these aggregation levels. Scenarios can, following that, be defined at *project, sector* and *national* level.

Project assessment considers the implementation of individual mitigation projects. A baseline case will in this case be defined to show how the same activity would develop without the mitigation project.

Sector assessment considers the total impacts of implementing either a large number of mitigation projects in a sector or making larger structural changes, such as large-scale fuel switching. The technical potential and costs of individual mitigation projects are in many cases interdependent and the project impacts should therefore be assessed at sector level. Sectoral models for the system as a whole represent a preferable approach. Sectoral assessments should also include efforts to evaluate different types of policies to achieve sector-level goals.

National assessment focuses on the total impacts of implementing mitigation projects and system changes in one or more sectors. The focus should here be on the wider sectoral and macroeconomic impacts such as land allocation, capital and foreign exchange demand, trade, employment, consumption, production, and other macroeconomic impacts. National assessments should also include efforts to evaluate different types of policies to achieve sector-level and national goals.

3.2 Baseline scenarios and projections

As previously stated, the assumptions that are used to define the baseline scenarios should reflect that the government has not instituted the specific GHG emission reduction policies considered in the mitigation scenario. Since climate change mitigation in many countries is not among the key national social and economic development priorities, the participation of developing countries in global climate change efforts must be structured in a way where main national development priorities can be fulfilled alongside the implementation of mitigation strategies. Thus, national baseline scenarios should be consistent with these national development priorities. The mitigation assessment that follows will consider the cost and other impacts of integrating mitigation policies in broader national development programmes.

The baseline scenario assumptions as already said should be developed to reflect the costs of climate change mitigation in relation to a non-policy case. The assessment involves a comparison of GHG emitting activities in the mitigation- and baseline scenarios. The assumptions on technological development, sectoral production practices and cost parameters in these two scenarios have major implications on the assessed mitigation potentials and costs.

3.2.1 Baseline typology

Cost is always measured as an incremental cost relative to a given baseline case, and the costs are, therefore, to a high degree, given by the assumptions underlying such baseline cases. Baseline definition is following that one of the most critical issues in mitigation costing studies.

Three main typologies of baseline definitions are:

1. The economic efficient case
2. The business-as-usual case.
3. The most likely case.

The economic efficient case reflects what in economics is called efficient resource allocation. The economy is here assumed to utilise all production factors efficiently implying that the implementation of mitigation projects always will have a positive cost.

The business-as-usual case. The baseline case is here constructed as a continuation of current trends. It can for example be that the structure of energy supply systems, agricultural production and other land use activities are assumed to continue in the future with the exception that already approved sectoral development plans are integrated in the baseline scenario.

The most likely case is the compromise between *The economic efficient case* and *The business-as-usual case.* This implies that the most likely case can include assumptions on a gradual transformation to market liberalisation policies and other adjustment programmes.

The business-as-usual case and *The most likely case* are both reflecting a state of the economy, where markets and institutions do not behave perfectly (according to the principles of efficient resource allocation). Some climate change mitigation options with negative costs in these cases can exist, if the implementation costs of these options are less than the value of eventual fuel savings, efficiency improvements and / or indirect social and environmental benefits related to the options.

In conclusion, the baseline can be defined in several different ways and it is therefore important that the scenario definition entail explicit assumptions about activities and technologies related to main projects to be analysed in mitigation scenarios. These assumptions, in addition to cost and efficiency parameters, should include environmental- and social impacts.

3.2.2 Inclusion of climate change impacts in the baseline scenario

In making a baseline projection, it may be important to include the impacts of climate change on climate sensitive sectors in which mitigation takes place. This is because both emissions reductions and the costs of mitigation can depend on the impacts of climate change. This is especially true for the forest and land use sectors, the agricultural sector, and the energy sector.

3.2.3 Sources for national baseline development

Important data sources for national baseline scenario construction are official economic development programmes, environmental programmes and specific sector planning. Such official planning documents should be critically assessed as background material for national baseline construction. This includes an evaluation of consistency, reality and policy implications of the projections.

An important starting point for baseline scenario construction is the assessment of macroeconomic development trends that are connected to the major GHG emitting sectors, as projected under a development path assuming that the specific climate change mitigation case is not a policy objective. The aim of this macroeconomic assessment is to identify key national economic priority areas and the implications for future GHG emission and policy options.

It is often the case that the time horizon of official national plans will be no more than five to ten years. This means that a special analysis will be required to extend the projections to cover the longer time horizons. The long-term projections can be more aggregate than the short-term projections, due to lack of information and uncertainty about developments in specific sectors. The focus should be on the main future trends in population, sectoral growth and technological progress in parallel with a number of specific development factors. These factors include future development of the informal sector, major infrastructural investments, land use changes and natural resource management. It is, in the long-term, important to assess the main structural changes in the productive sectors and the shift from the informal- to the formal sector of the economy.

4. MITIGATION COST ASSESSMENT

The national mitigation scenarios serve as a structural framework for assessing the impacts of implementing alternative climate change mitigation policies. These policies include the implementation of individual projects, sectoral strategies and national action plans. The mitigation scenarios should be based on a screening of potential individual projects for the sectors.

National studies should focus on the assessment of individual mitigation projects for sectors where the mitigation effort can be expected to have significant impacts but do not need to be exhaustive in the selection of mitigation projects in the sectors or across sectors. It will in general be a good idea to include both a number of low, medium and high cost options in the assessment in order to provide a general overview of the economic implications of alternative emission reduction targets.

The implementation of mitigation policies will have implications on a variety of parameters including environmental effects, social impacts, GHG emissions and monetary costs and benefits. The parameters to be quantitatively assessed should be chosen specifically for the project being analysed. The integration of broader social and environmental impacts in the decision process is very important

The formal mitigation assessment as described in the *Methodological Guidelines* (Halsnæs, Callaway & Meyer 1998) focuses on the assessment of economic costs and benefits and other impacts of implementing climate change strategies in relation to a national baseline scenario. Actions taken to abate GHG emissions or to increase the size of carbon sinks will generally divert resources from other alternative uses. The purpose of the methodological framework outlined in the guidelines is to estimate the value of the resources which society must give up when a climate change mitigation action is taken, as opposed to not taking that action. These resources are measured in relation to a “no action” reference, or “base case” which represent a scenario in which the economy follows its normal development path, without the considered mitigation policies. The incremental cost concept is one of the key concepts used in measuring the value of the resources.

4.1 Incremental costs

Mitigation costs by definition should be assessed as the costs of following a mitigation strategy measured as the “incremental” change in relation to the defined non-greenhouse gas policy case – the so-called baseline case.

The rationale for focusing on incremental costs is that the resources demanded by a mitigation activity have an opportunity cost - they are, in principle, taken away from other alternative uses. The prices used to value the specific resource components therefore should reflect their value in best alternative use which either can be based on market prices, shadow prices or opportunity costs.

The incremental cost concept is an integral part of the FCCC (UN 1992) and is here used to establish a set of principles for financial transfer to non-Annex I countries. The Global Environment Facility following that has used the incremental cost concept as the financing principle in their Operational Strategy (GEF 1994).

From a country’s point of view there is a distinction between the cost of a project (total or marginal) and the incremental cost. Both concepts are relevant for decision making. The incremental cost concept is the relevant one to reflect social welfare, while the total cost of a project reflects more the financial requirements.

4.2 Cost assessment approach

The cost concepts in the guidelines are defined on the basis of traditional cost-benefit analysis as applied in international guidelines for project assessment. The aim of the cost-benefit analysis is to measure the project impacts in comparable units. The term costs is used here to denote negative impacts while benefits denote positive impacts. Benefits, following that, can also sometimes be denoted as negative costs.

It is important to note that social cost-benefit analysis is not a technique, but an approach that provides a rational framework for project choice on the basis of specified national objectives and values. The aim is to integrate the national cost assessment in a broader national decision framework for climate change mitigation. Some of the analytical approaches presented in the guidelines are:

- Cost-benefit Analysis
- Cost-effectiveness Analysis
- Multi-attribute Analysis

Social cost-benefit analysis can be carried out in different ways depending on the assumptions applied to the impacts considered. A further development of the cost-benefit analysis is the multi-attribute-analysis where monetized costs and benefits as well as other quantitative impacts are considered in an integrated objective function. Box 1 gives an overview of the analytical approaches.

Box 1 Analytical approaches.

Cost benefit analysis

The basic idea is to measure all negative and positive project impacts in the form of monetary costs and benefits. Market prices are used as the basic valuation as long as markets can be assumed to reflect "real" resource scarcities. In other cases it is recommended to use shadow prices. Shadow prices are meant to reflect prices that would occur in a "perfect" market.

Cost effectiveness analysis[1]

A special sort of cost benefit analysis where all costs of a portfolio of projects are assessed in relation to a policy goal. The policy goal in this case represents the benefits of the projects and all other impacts are measured as positive or negative costs (negative costs, with the exception of the benefits of the policy goal, will correspond to benefits of the policy). The policy goal can for example be a specified goal of emission reductions for GHGs. The result of the analysis can then be expressed as the costs ($/ton) of GHG emission reduction.

Multiattribute analysis

The basic idea of the multiattribute analysis is to define a framework for integrating different decision parameters and values in a quantitative analysis without assigning monetary values to all parameters. Examples of parameters that can be controversial and very difficult to measure in monetary values are human health impacts, equity, and irreversible environmental damages.

[1] The term cost-effectiveness analysis is sometimes used in more narrow way, where only the financial costs and no indirect positive and negative costs - of a private agent in meeting a specific policy goal is considered.

4.3 Main cost concepts

One can distinguish the assessment of *social*- and *private costs* and *benefits*. *Social* costs reflects all costs to society including private costs and externalities, while *private* costs include only the costs faced by individual firms or households. Another often-used concept is *financial* costs which measures expenditures, or outlays, of money seen from the perspective of an implementing entity.

4.3.1 Economic opportunity cost or economic cost

An economic cost of producing a commodity is the value of the scarce resources that have been used in producing it. This, in turn, is measured in terms of the value of the next best thing, which could have been produced with the same resources and is called *economic opportunity costs*. In designing mitigation strategies a main objective is to minimise the *economic opportunity costs* of the programme. *Economic opportunity costs* are sometimes called just the *economic costs* and are closely related to *social costs* and are in this context used interchangeably. It is also related to the concept of *shadow prices*, both of which are discussed below. For a more complete discussion of these concepts see Markandya, Halsnæs & Milborrow (1998).

4.3.2 External costs, private costs and social costs

The term *external costs* is used to define the costs arising from any human activity that are not accounted for in the market system. For example, emissions of particulates from a power station affect the health of people in the vicinity but there is no market for such impacts. Hence, such a phenomenon is referred to as an *externality*, and the costs it imposes are referred to as the *external costs*. These external costs are distinct from the costs that the emitters of the particulates do take into account when determining their outputs (e.g. prices of fuel, labour, transportation and energy). Categories of costs influencing an individual's decision-making are referred to as *private costs*. The total cost to society is made up of both the *external costs* and the *private costs* and together they are defined as *social costs*.

Social Costs = External Costs + Private Costs

4.3.3 Shadow Prices

The above discussion concluded that the proper cost to consider in GHG projects is one based on *economic opportunity cost*. As noted above, where markets operate competitively and efficiently, the prices will reflect the opportunity costs and can be used to estimate the correct costs. In many instances, however, this will not be the case, and some correction will need to be made. The corrected market price, which should be equal to the *economic opportunity cost* of the resource, is called the *shadow price*.

4.4 Cost assessment levels

The costs assessed at project, sector and macroeconomic level are defined in accordance with the system boundaries determined for the level for which costs are being assessed.

- *Project Level:* The assessment at project level considers an individual project assuming that this project is an isolated implementation without affecting any other part of the economy.
- *Sector Level:* The assessment at sector level considers a case where a number of mitigation projects are implemented in one specific sector. Technical and economic

interdependencies between projects in that sector are to be included, but the macroeconomic development and other economic sectors are assumed exogenous.

- *Macroeconomic Level:* The macroeconomic assessment, finally, considers the full socio-economic impacts of implementing mitigation strategies in one or more sectors, and the interaction between the different sectors and the economy.

A full assessment of all policy impacts is very complicated especially if significant changes are generated across markets. In such cases all the economic impacts can only be completely integrated in and economy-wide model like for an example a Computable General Equilibrium (CGE) modelling framework. The development of such a modelling framework is generally very demanding and the section on macroeconomic assessment in the guidelines therefore outlines a framework for a simplified assessment of a number of the key general equilibrium impacts.[2]

4.5 Cost Effectiveness Analysis

For programmes that estimate the costs of achieving a certain reduction in GHGs the main output of the assessment is normally costs per unit of GHG emissions avoided.

The cost-effectiveness analysis involves a comparison of cost flows and GHG emission reductions occurring at different points in time. The cost flows can be compared in a net present value, NPV_c.

$$NPV_c = \sum_{t=0}^{T} \frac{C_t}{(1+i)^t} \qquad \text{Eq. 1}$$

where i is the interest rate and C_t is the cost at time, t.

The GHG emission reductions occur at different points in time in the same ways as the costs. Therefore the time specific value of these reductions have a major implication for the calculated emission reduction costs. There is a high uncertainty about climate change damages and it is therefore difficult to assign a time specific value to emission reductions. It is therefore suggested to use a simplified approach where the GHG reductions are discounted[3] with the same discount rate as used in the above-specified NPV_c formula. The net present value of emissions reduction (NPV_e) can then be calculated as:

$$NPV_E = \sum_{t=0}^{T} \frac{E_t}{(1+i)^t} \qquad \text{Eq. 2}$$

The costs can also be represented as levelised costs, where the annual costs - as well as GHG emission reductions - are transformed to constant annual flows over the lifetime of the investment. Mitigation projects that imply constant annual emission reductions can be directly compared with levelised cost at a given point in time. The total levelised cost, C_0 of a project can be calculated with the following formula:

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2 The main problems in developing countries are the lack of data for a CGE model and the potential rapid growth and shift between sectors. These two problems together make the output of CGE models for developing countries very uncertain.

3 The discounting of physical units of GHG emissions can be done when it is assumed that the emissions represent a constant proxy value of avoided climate change damages.

$$C_0 = NPV_c \frac{i}{1-(1+i)^{-t}} \qquad \text{Eq. 3}$$

and the levelised GHG emission reduction can similar be calculated as:

$$E_0 = NPV_E \frac{i}{1-(1+i)^{-t}} \qquad \text{Eq. 4}$$

Guidelines for project assessment use a number of different concepts to compare cost-effectiveness of projects. The most often used concepts are net present values (NPV), internal rate of return (IRR), and levelised costs. These concepts basically provide similar project rankings. The relationship between the NPV, IRR and levelised costs is further explained in Box 2.

Box 2 The NPV, IRR and Levelised Cost Concepts.

The NPV concept

The NPV determines the present value of net costs by discounting the stream of costs back to the beginning of the base year (*t*=0).

$$NPV = \sum_{t=0}^{T} \frac{C_t}{(1+i)^t}$$

The IRR concept

The IRR is defined as the rate of return on an investment, which will equate the present value of positive and negative cost components of an investment with zero. It is found by an iterative process and is equivalent to the discount rate *i* which satisfies the following relationship:

$$NPV = \sum_{t=0}^{T} \frac{C_t}{(1+i)^t} = 0$$

The levelised cost concept

The levelised cost is, as already shown, a transformation of the NPV using the formula

$$C_0 = NPV \frac{i}{1-(1+i)^{-t}}$$

The use of the concepts NPV, IRR and levelised costs as project ranking criteria is valid given a number of assumptions:

NPV

An investment I_1 is more favourable than an another investment I_2 if: the NPV of I_1 per unit GHG reduction is smaller than the NPV of I_2 per unit GHG reduction. It should here be noticed that the use of NPV's to compare the cost-efficiency of projects requires that some discounting principles be applied to the annual GHG emission reductions. The NPV can in terms of NPV/GHG reduction be used as ranking criteria for investments with different time horizon.

IRR

An investment I_1 is more favourable than another investment I_2 if the IRR of I_1 per unit GHG reduction is smaller than the IRR of I_2 per unit GHG reduction. This ranking criterion however is both neutral to the scale of the costs and the GHG emission reduction achieved by the project. The IRR can therefore only be used as an initial screening criterion. The IRR can be used as ranking criteria for investments with different time horizon.

Levelised cost

An investment I_1 is more favourable than an another investment I_2 if the levelised cost of I_1 per unit GHG reduction is smaller than the levelised cost of I_2 per unit GHG reduction. The levelised cost should be calculated for a similar lifetime of the investments of with the inclusion of a terminal value for long-term investments.

The full *economic costs* of a project (in so far as they can be monetised) and not just the direct financial costs, measuring the cost effectiveness can be formulated as:

$$C_{Full} = C/E \qquad \textit{Eq. 5}$$

Where *C* and *E* can either both in net present values (as defined in Eq. 1 and 2 or the levelised costs (as defined in Eq. 3 and 4).

The full economic costs, C_{Full}, are distinguished from the direct financial cost of the project, which will be discussed below. Note that for C_{Full}, all costs are economic costs, as described in economic opportunity cost or economic cost. The values of C_{Full} will depend on the precise value attached to the different components of costs and, as noted earlier, these costs are uncertain, with ranges of values rather than a single value. In view of this, it is important to present a range of such values and to indicate the impacts from which the uncertainty arises. Related to that, it will be useful to present a more detailed table of the components of the costs by time period, so that the policy-maker can draw on this information should it be considered necessary.

4.6 Choice of discount rates

The debate on discount rates is a long standing one (see IPCC 1996). As IPCC notes, there are two approaches to discounting; an ethical approach based on what rates of discount should be applied, and a descriptive approach based on what rates of discount people actually apply in their day-to-day decisions.

- The ethical approach suggests that a discount rate that reflects the preferences of society to investments in long term sustainability impacts associated with climate change mitigation be used.
- The descriptive approach argues that the marginal rate of return on capital is the appropriate discount rate.

The former leads to relatively low rates of discount (around 3 percent in real terms[4]) and the latter to relatively higher rates (in some cases very high rates of 20 percent and above). The arguments for either approach are unlikely to be resolved, given that they have been going on since well before climate change was an issue.

In addition to discounting future costs and benefits there is the further issue of whether or not future emission reductions should be discounted when compared to present reductions. The justification for discounting is that emission reductions in terms of reduced impacts have a time specific value. The choice of the appropriate rate, however, remains an unresolved issue and, again, taking a range of plausible values is the only solution.

One point perhaps which should be noted relates to the use of low discount rates for appraising GHG programmes in developing countries, where capital is scarce and market rates of discount are very high. This low real rate for mitigation programmes can be justified on the ethical grounds mentioned above. The scarcity of capital, on the other hand, can be dealt with by having a shadow price for capital that is greater than one.

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4 The real rate of discount is the market rate net of inflation. Thus if a market has a discount rate of 12% and inflation is 8% then the real rate is 4%.

4.7 Implementation issues

Mitigation cost assessment should in principle include all costs needed to implement a given policy options. In the traditional bottom up studies employing cost-benefit analysis, it is assumed that the market establishes incentives for the agents to implement the project and no specific activities are considered to be necessary to promote implementation. Therefore, implementation costs traditionally only include overheads such as planning activities, administration, information, training, monitoring etc. However, in several cases including in environmental projects and mitigation projects, there are additional costs due to market imperfections, lack of institutions or their failure, externalities, lack of property rights or their enforcement etc. These factors act as barriers in implementation and transaction costs in such projects can be significant. Therefore, implementation costs should also include these transaction costs to remove the implementation barriers, termed as *barrier removal costs*.

Barrier removal costs are costs of activities aimed at correcting market failures and reducing transaction costs. For example costs of improving institutional capacity, reducing risk and uncertainty, setting up regulatory framework to enforce policies etc. The effect of barrier removal is not limited to immediate project or strategy but reduces transaction costs for similar projects in the future.

Several types of barriers can be identified:

- *Market barriers*, that may be due to missing or segmented markets, monopoly, entry barriers, externalities and price distortions;
- *Inflexibility of existing technical systems* which implies capital irreversibility, economies of scale and specific learning requirements for a technology and;
- *Institutional barriers* that may be due to absence or unreliability of legal institutions, under developed financial markets, limited flow of information and administrative capacity constraints;
- *Human capacity barriers* that may be due to limited supply of skilled labour and lack of opportunities for education and training.

Barrier removal policies may thus include efforts to increase potential markets through incentives, introduction of new institutions, risk reduction and specific support activities in the early market development phase. Support to renewable energy technologies by UNDP and GEF through specific projects are thus aimed at such barrier removals and development of the market (UNDP 1996; GEF 1994).

5. ASSESSMENT OF BROADER SOCIAL AND ENVIRONMENTAL IMPACTS OF MITIGATION POLICIES

Climate change mitigation policies have a number of important impacts additional to those measured as direct resource costs connected to the implementation of a specific policy. These impacts include indicators that either can be measured in monetary units, in physical units or as more qualitative information. Some of such impacts are in relation to employment, income distribution, environmental changes, and sustainability indicators.

5.1 Evaluating employment effects of GHG projects and policies

If a project creates a job, this has a benefit to society, to the extent that the person employed would otherwise not have been employed. In other words, the benefits of employment are equal to the social costs of the unemployment avoided as a result of the project. These benefits will depend primarily on the period that a person is employed, what state support is offered during any period of unemployment, and what opportunities there are for informal activities that generate income in cash or kind.

A physical measure of the extent of the employment created is therefore the first task of any project assessment. The data that have to be estimated are:

- the number of persons to be employed in the projects,
- the duration of time for which they will be employed,
- the present occupations of the individuals (including no formal occupation),
- their gender and age (if available).

This physical information should be reported in a summary table for the project, which can be used in the selection criteria discussed in section 5.5. In addition, however, it is possible to place some money value on the employment, or to deduct from the payments made to the workers the value of the benefits of the reduced unemployment. See a more detailed outline of this broader analytical framework in the Handbook Report. The Indirect Costs and Benefits of Greenhouse Gas Limitations by Markandya, 1998.

5.2 Income distribution and poverty

The impacts of GHG limitation projects on income distribution and poverty are of great importance and merit careful attention and treatment. The main effort has to be devoted to collecting information on which income groups and which sections of the population are affected by the measures proposed. The measures will impose costs as well as benefits and both are important. The breakdown of data on who is impacted need not take the form of household income alone, but could include, for example, rural and urban households, households classified by race etc. A matrix of the distribution of gains and losses is required, classified in the categories that are believed to be important both for a correct estimate of the true costs of the project as well as for a successful implementation of the project. If the analysis fails to identify groups who would lose as a result of the project, but who have the power to block it or to thwart its effective implementation, the whole exercise will be a failure.

5.3 Valuation of joint environmental products

Climate change mitigation projects will in many cases have other environmental impacts than decreased GHG emissions. Substituting coal fired power production with hydropower will, for example, result in reduced sulphur, nitrogen and particulate emissions in addition to reduced GHG emissions. On the other hand, hydropower projects have a number of other environmental impacts such as changes in the aquatic ecosystem and biodiversity. The negative or positive values of such joint products should in principle be integrated in the project assessment. It is however difficult to value many of such impacts. The valuation is especially difficult to carry out for environmental impacts that cannot be meaningfully related to market goods. See the section 5.5 on how quantitative and qualitative impact assessment can be integrated.

5.4 Sustainability

The issue of sustainability arises here because environmentalists are concerned that the policies followed should contribute to the resolution of conflicts between protection of the natural environment and economic development in the longer term. The issue, which was first brought into the public domain in a significant way by the Bruntland Report (World Commission, 1987) was posed as a search for a path of development that meets the needs of present generations without compromising the abilities of future generations to meet their needs.

Subsequent developments of the sustainability idea refer to the concepts of “weak” and “strong” sustainability. The notion of weak sustainability is that society should develop its resources in such a way as to ensure the passing on of a stock of wealth (including natural capital) to future generations at least as great as the one inherited by present generations. This stock is measured in money terms. The notion of strong sustainability is to ensure that critical parts of the natural capital are not degraded and that renewable resources are used in a manner that is as sustainability as possible, given other constraints on resource use and economic development. The appeal of weak sustainability depends on the degree of substitution between natural and man-made capital in the production process. There are significant difference of opinion about that among environmentalists and economists.

Annex 2 of the *Methodological Guidelines* includes a list of sustainability indicators that can be evaluated in relation to climate change mitigation projects.

5.5 A framework for integrating quantitative and qualitative impact assessments

The previous sections discussed the application of cost concepts to traditional costs and benefits and to a wider range of impacts that should be included in either the cost assessment or in an over-all evaluation of a mitigation action. In many cases, there will be important impacts from a project that either can not be valued in the cost assessment, due to lack of data, or should not be included in the cost assessment for sound economic accounting reasons. In the final analysis, it is important to integrate all of the cost and non-cost elements into an over-all framework that can be used to assess all of the impacts of a mitigation action.

The information collected on the impacts of a GHG limitation project or programme needs to be summarised so that different projects and programmes can be compared. There are three kinds of information to be summarised. These are:

1. Quantitative information in money terms.
2. Quantitative information in physical units.
3. Qualitative information.

Quantitative monetary information includes direct and indirect costs associated with the implementation of projects.

Quantitative non-monetary information can be available for:

1. Employment impacts.
2. Income gains and losses of different groups.
3. Associated environmental changes.
4. Sustainability indicators.
5. Macroeconomic impacts.

Qualitative information on impacts is important and should not be ignored. It cannot be integrated into the summary cost effectiveness values or the multi-criteria number, but it is relevant to the selection of projects and, more crucially, to the design of the projects. Once a GHG-related project has been identified, a preliminary screening should generate important qualitative information. This should then be used to modify the design of the project so that the key negative impacts are mitigated wherever justified. The revised project will still have some impacts but these will have been passed as "acceptable". This preliminary screening of projects will avoid serious environmental damages, as well as serious political blunders where projects that seem technically acceptable have such negative impacts on key stakeholders that they are bound to fail on political grounds.

5.5.1 Multi-attribute analysis

A number of methodologies consider the assessment of broader impacts. One of the most commonly applied methodologies is the multi-attribute methodology. This methodology is described in the literature, one of the most important sources for further reading is Keeney & Raiffa (1993).

Multi-attribute analysis: the method

The present description is a short presentation on how a multi-attribute analysis can be used to support the assessment of climate change mitigation costs.

The basic idea of multi-attribute analysis is to base decisions upon several objectives. The focus is on identifying decision criteria specified in attributes and weights in order to measure and evaluate trade-offs between different criteria. Meier & Munasinghe (1994) outline the following five steps to be undertaken in a multi-attribute assessment:

1. Selection and definition of attributes, say A_i (i=1,….N) selected to reflect important planning objectives.
2. Quantification of the levels A_{ij} of the i attributes estimated for each of the j alternatives.
3. Scaling of attributes, in which the level of an attribute is translated into a measure of value, $V_i(A_{ij})$ (also known as the attribute value function). This is sometimes combined with a normalisation procedure (usually on a scale of zero to one where the lowest value of the attribute is assigned to zero, the highest attribute value assigned to one).

4. Selection of weights w_i for each attribute.
5. Determination and application of a decision rule, which amalgamates the information into a single overall value or ranking of the available options, or which reduces the number of options for further consideration to a smaller number of candidate plans.

A multi-attribute decision rule can then be specified as follows:

Select the option with the highest score on $\sum_i w_i V_i(A_i)$,

where w_i is the weight and $V_i(A_i)$ is the value function of attribute A_i.

One of the most complicated elements in the design of a multi-attribute analysis is the selection of attributes. It can seem to be attractive to select and evaluate as many attributes as possible, but this will not necessarily provide a good decision basis. The attributes must be selected carefully on the basis of methodological consistency and practical considerations. Some of the main methodological issues are related to double counting, value independence, proliferation of attributes, and importance of the attributes in relation to policy decisions (Meier & Munasinghe 1994). Furthermore the attributes must also be measurable and predictable.

The use of MCA in national decisions

The MCA can be used to add broader information on social, environmental and other impacts to the cost assessment as a further development of the mitigation cost assessment.

A formal multi-criteria analysis can be integrated in the mitigation analysis through the following steps:

- construction of baseline scenario on the basis of national development plans including a macroeconomic forecast. The baseline scenario projects the scale of activities in the sectors for the most important sources and sinks. Definition of main variables to supplement the mitigation cost assessment.
- identification of mitigation options. Assessment of mitigation potential and cost of individual projects.
- assessment of mitigation potential and cost at sector level for “baskets of projects”.
- assessment of non-cost variables for projects or baskets of projects. Presentation of the cost variables and the other variables as background information for the evaluation of trade-offs, priorities, dominance, etc.
- assessment of weights connected to cost and non-cost variables in the objective function.
- formal analysis using variables and weights as input to a well-defined criteria function.
- interpretation of results as input to the national decision making framework.

This assessment will in practice be a very difficult exercise where many actors need to be involved in the setting of priorities. This can also be seen as part of the inputs to a broader national decision making process where various stakeholders and policy makers consider the outputs of the formal mitigation assessment and take the further lead in the development of national action plans.

5.5.2 Conclusions on decision criteria

Ultimately the decisions on which projects to undertake is a political one. The screening rules discussed above are a guide to those decisions. As has been noted these rules will not provide unique guidance on which policies or projects to choose, but they will provide a range of indicators on financial costs, full economic costs and on the other quantitative and qualitative impacts that are inputs to the decision-making process.

6. SECTORAL AND MACROECONOMIC ASSESSMENT

The energy, transport, forestry, agriculture and waste sectors are major GHG emitting sectors and mitigation options for each are discussed in this section.

Energy sector: In case of the energy sector, GHG emissions originate from production of primary fuels, transformation, and consumption by energy sector and final consumption by other sectors. Import and export of fuels as well as losses during distribution also need to be accounted for in the emission calculations. While compiling the inventory of emissions from the energy sector, emissions from physical emission source are considered at each stage following the IPCC / OECD methodology (IPCC 1997). Thus, in the case of coal mine CH_4 emissions from coal bed are considered as part of the fuel production process, and in case of oil and gas, CO_2 emissions from flaring of gas are also considered besides CH_4 emissions. Combustion processes in both cases accounts for CO_2 emissions at the point of final combustion.

Future baseline emissions from the energy sector are determined through energy demand and supply projections normally using modelling approaches. A variety of modelling approaches such as simple econometric models, optimisation models, simulation models or energy-economy models can be used for projections. Mitigation options in case of the energy sector will include short-term GHG reduction projects such as energy efficiency improvements and small-scale renewable technologies, and long term options involving new power supply technologies and advanced renewable technologies, and infrastructure and transmission projects.

Some of the mitigation options at the end use include lighting efficiency improvements through use of efficient fluorescent lamps in place of incandescent lamps, electronic ballasts and reflectors, use of high efficiency motors and variable speed drives, efficient refrigerators, improved cooking stoves etc. Co-generation wherever possible, efficient motors and boilers, heat pumps and the use of efficient fuels such as natural gas or renewable energy are some of the potential options for commercial and industrial facilities. Similarly, efficient options are also available for space heating and space conditioning. On the supply side efficient options including high efficient gas turbines, combined cycle power production and advanced high efficiency measures such as integrated gasification combined cycle (IGCC) and pressurised bed combustion (PFBC) can be considered to replace existing coal and oil based systems. Renewable options for power production, such as wind power, small-scale hydro, solar systems and biomass based electric generation systems are other mitigation options on supply side.

Transport: Transport is a sub-sector of energy but discussed separately in view of its importance in emissions. It accounted for about 20-25% of global CO_2 emissions in 1990 (IEA 1993; IPCC 1996) and is expected to grow substantially. While considering mitigation options for the transport sector, it is necessary to account for impacts and costs outside the transport sector to be included in a comprehensive assessment. Mitigation options for transport consist of better demand and supply management, efficiency improvements in transport systems and individual vehicles, and fuel switch to lower emission fuels.

The demand reduction can i.e. be achieved through increase in the cost of transport. Selective cost increase can shift the demand to more efficient modes of transport (for example, to higher capacity efficient public transport from private), or to non-motorised transport. For long term, urban planning that helps reduce distance to travel and ship goods is a potential option. On supply side, increased capacity utilisation through better route planning for public transport, redesign and development of inter and intra-city mass transit system, encouraging car pooling through suitable instruments are some measures.

The efficiency of fuel usage can be increased through the use of efficient vehicles. It can also be increased through better maintenance practices, training, providing good quality roads, decrease in congestion through proper traffic planning etc. For new vehicles, efficiency standards can be prescribed. Fuel switch to lower emission fuels include the use of renewable resources such as ethanol, electricity (provided emissions from electric power generation are lower), and to electricity from coal or diesel in case of locomotives. Measures that promote shift to modes with lower emissions can also be considered. These include measures to promote walking, bicycling, public transportation and railroad relative to automobile and truck etc.

Forestry: Forest clearing is a major source of emissions in some countries. This is done either to provide land for agricultural development or fuelwood to their populations. Mitigation options for the forestry sector include reduction in the rate of deforestation, afforestation (increasing forested area) and increasing stock of carbon in existing forest, increasing wood use efficiency and substitution of fossil fuels by biomass.

Deforestation can be reduced through switch to sustainable energy sources such as biomass, solar and wind energy and increasing efficiency of fuelwood use through use of efficient stoves. Measures to increase agricultural productivity can also reduce the demand for land for agriculture. The stock of carbon in the existing forests can be increased through forest protection and conservation measures, better management, agroforestry, increase in soil carbon through selective crop planting and tillage choice, and urban and community forestry.

Agriculture: Land clearing for agriculture and associated emissions from soils are the source of CO_2 emissions from agriculture. Agriculture in many countries is a major source of CH_4 emissions that come from rice paddies, anaerobic fermentation and enteric fermentation. Methane is also released from savannah burning and agricultural residues, and soil cultivation. Agriculture is also a source of nitrous oxide emissions and provides sinks for carbon through its absorption in soils, and short-rotation crops.

The mitigation options in agriculture in the case of methane emissions from rice paddies include reduction in cultivated rice area, reduction in period of flooding (as flooding causes anaerobic conditions), introduction of new plant varieties requiring less flooding, and use of organic fertilisers that reduce emissions substantially. Methane emissions from livestock (mostly ruminant animals) can be reduced through feed processing to increase digestibility of feed, feed supplementation and use of methane reducing agents. Productivity increase of animals through genetic improvement and other methods can also decrease the number of animals needed for a given level of output from animals. Methane emissions from anaerobic fermentation of the animal waste can be reduced through production of biogas in digesters and covering lagoons to capture methane.

Carbon storage on agricultural land can be increased through crop and grazing management involving low till cultivation, rangeland rehabilitation etc., and planting windbreaks and shelterbelts. Nitrous oxide emissions from agriculture can be reduced through conservation and adoption of agronomic practices that increase efficiency of fertiliser use, and better water management to reduce leaching of nitrogen.

Waste: Major GHG emissions from the waste sector are that of methane caused by disposal of solid waste on land and wastewater handling. The amount of methane produced from the solid waste disposal depends on the composition of waste and on management practices with better managed landfills producing more methane due to anaerobic conditions. In the case of waste water also, anaerobic treatment of municipal and industrial wastewater causes methane emissions.

Mitigation options for solid waste include recovery of methane from landfills and reduction of waste quantity through recycling or other waste management practices. For wastewater handling, aerobic processes can be used and wherever anaerobic processes are used, closed systems can be employed to recover and use methane.

6.1 Macroeconomic assessment

Macroeconomic assessment is concerned with the study of impacts of a mitigation project or strategy on macroeconomic variables such as GDP, employment, imports and exports, and public finances. The relationship between output from various sectors and emissions is brought out and analysed to estimate impacts of emissions reduction on various economic activities. Macroeconomic analysis ensures that economic assumptions and projections are consistent across the sectors in formulating a mitigation strategy. Impacts at macro level provided by the analysis help in understanding consequences for economic growth, distribution and so on, depending on the level of details in the analysis.

Macroeconomic analysis is data intensive and requires information on several variables such as demographic variables, national accounts including GDP, consumption, investment, public finance, foreign trade, prices, money supply, and interest rates.

Macroeconomic assessment can be carried out using various modelling approaches. It can be a rough assessment or a more advanced analysis depending on availability of data and model. A rough analysis can be carried out when available economic data is merely in terms of economic indicators. Econometric modelling input-output modelling and computable general equilibrium (CGE) modelling require available computer models as well as disaggregated data. Econometric models are suitable for short-term analysis, typically up to 10 years time frame. CGE models can analyse structural changes between sectors and indicate their development potential. However it assumes market clearing and, is thus suitable for economies with market features.

A simplified macroeconomic analysis of GHG reduction policies can be carried out if CGE modelling is not feasible. Such an analysis can use the available statistics and models in a country, at the same time ensuring internal data consistency. See the section on macroeconomic assessment of the *Methodological Guidelines* for more details on that approach.

7. POLICY INSTRUMENTS

Once the mitigation options have been identified, it is important to specify how the option can be implemented with the support of various policy instruments. The policy instruments can be broadly classified in two categories depending on the approach. These are:

7.1 Command and control (CAC) approach

This is a regulatory approach and examples of this are environmental regulations used to achieve pollution reductions in air and water quality in many nations. For GHG emissions reductions, the following CAC systems can be used:

- direct regulation of GHG emissions,
- regulation of the chemical contents of fuels,
- standards to regulate energy efficiency in buildings and energy-using durable goods in the industrial, residential, commercial, and agricultural sectors,
- regulations to mandate carbon conserving forest practices (forest practice laws), and
- vehicle fuel efficiency standards.

The use of command and control systems for direct GHG emission regulation is problematic because CO_2 removal technologies are costly and have a small potential compared to indirect abatement options such as fuel switching, conservation and renewable energy, and efficiency improvements in transmission and distribution systems. In addition, many of the measures that can be used to mitigate GHG emissions involve even more indirect actions, such as planting trees, switching production to less GHG intensive goods and services, and a host other types of actions that are really not very amenable to direct regulation. Therefore most plans to reduce GHG emissions envision a mixed system of regulation and economic incentives.

CAC is by many experts seen both as an expensive and inflexible approach that is difficult to enforce. On this background it is expected that CAC will be inefficient seen from an economic perspective. Developing countries have also experienced difficulties with CAC for different reasons including; lack of capacity and institutions, and monitoring and enforcement problems.

7.2 Market approach

The market approach which sometimes also is referred to as the “Economic Instruments” approach, broadly consists of the following:

- market restructuring policies in energy markets,
- taxes on primary fuels, energy, and emissions including carbon taxes, and
- cost-based market mechanisms, such as emissions trading.

7.2.1 Market restructuring policies

This refers to a broad range of policies that involve removing government intervention in energy markets. These policies aim broadly at bringing energy prices in line with the prices that would prevail in competitive markets.

Taxes and pollution charges: The theoretical rationale of a pollution tax is to internalise the social costs created by the pollution into the price of market goods and services. The purpose is to fix the level of output for a good at social optimum level. The externalities can be internalised through taxes on energy, on primary fuels, or through charges on pollutants. For GHG emissions, carbon taxes can be levied. This can be through direct taxation on CO_2 emissions or indirectly through taxation on energy. However, taxes on energy and primary fuels allow firms to substitute inputs that can also lead to increases in CO_2, if the tax is not related to CO_2 emissions.

Cost-based market mechanisms: These are; tradable emission instruments (viz., allowances, permits, and quotas) , emission (CO_2) offsets and joint implementation. In case of these instruments pollution levels for some group of sources are fixed and they are allowed to pay other sources to reduce their emissions. The deals are made if there are emission reduction cost differentials across the sources. Each is briefly discussed below.

- Tradable emission instruments: Emissions trading allows regulated emissions sources facing different abatement costs to shift from their own emission abatement marginal cost curve to an aggregate emission abatement supply curve. For example, in case of a permit system, the government issues tradable permits based on level of emissions fixed for a pollutant. Trading of permits is expected to occur until abatement costs are similar across the polluters.
- Emissions offsets: This system allows both regulated and unregulated entities to trade emissions reductions with regulated entities. For example, if a utility is a regulated source, an offset system may create a possibility for either the utility itself or another firm, NGO, or individual that was not regulated, to establish an emission offset through a tree-planting program.
- Joint implementation: Joint implementation (JI) is a mechanism that may allow nations to meet their obligations to reduce net GHG emissions by trading emission offsets with other countries. The use of this instrument is based on the widely acknowledged fact that GHG emissions reductions / offset costs vary widely between countries.

7.2.2 Issues in policy implementation

Several issues need to be addressed before a market approach through the introduction of economic instruments can be taken. Taxes such as carbon tax, emissions taxes and energy taxes are usually regressive, implying adverse impact on low-income groups. Therefore, before these are imposed, a compensation mechanism may have to be devised. Determining the level of taxation is one of the most complex tasks as it is difficult to establish the link between the tax base and the achievable environmental effect. Further, market based instruments require a well-developed market, which may be a constraint in several countries, especially in developing countries. Incentives and pricing mechanisms can operate properly only in a well developed market. Since economic instruments involve changes in costs of production, adverse effect on competitiveness of the firms is a possibility.

Other issues include establishment of a suitable administrative and institutional mechanism, choice of appropriate instruments and associated implementation strategy, and possibility of market distortion due to monopoly power of some big firms.

Developing countries have large non-market sectors. These may not be amenable to market policies. Even where markets exist, monitoring and enforcement may be a problem due to lack of skilled personnel and institutions. In many cases, political acceptance of the tax may be a major issue.

7.3 Criteria for the selection of policy instruments

Given a number of issues surrounding various types of policy instruments, choice of appropriate instrument is very important. It may not be possible for a single instrument to address various issues while inducing emissions reduction. A combination of policies may have to be adopted, where the choice of instruments is based on importance of issues and policy planners assessment of the extent to which the instruments can address these issues. Developed countries, which have been mandated to reduce emissions by the Kyoto agreement, would look for measures that will have least effect on their economic growth. Since economic instruments offer several advantages including cost effectiveness, it may be natural to introduce them in conjunction with CAC measures. On the other hand, although developing countries have currently no obligation to reduce emissions, they are mandated by FCCC to take such appropriate measures to reduce emissions that are consistent with their development priorities. Therefore, they need to look for instruments that meet their development requirements besides reducing emissions. One of the major objectives should be to reduce emission intensity of the output without effecting the growth. For example, efficient use of energy and other resources can put developing countries on a lower energy intensive path, thereby reducing emission intensity of the development.

Within developing countries, there is wide disparity in terms of current emissions and economic development. On one end of the spectrum are fairly advanced economies that are close to developed countries, while on the other yet very poor countries. Further, future baseline emissions in some cases may indicate highly emission intensive economic growth, while in other cases growth may be moderate and emissions well below average emissions. Some poor developing countries are also dependent on bio-fuels to meet a substantial part of their energy requirements, rendering use of carbon tax instruments on fossil fuels meaningless. There is yet another group of developing countries that export energy and hence find any taxation on energy affecting their economic growth. Since emissions are due to energy conversion, the action for emissions reduction therefore may have to be related to the final energy consumption.

Developing countries that are close to developed economies in terms of development and emissions may have the option to introduce economic instruments without significant adverse impact on their economies. For other developing countries, the options may be limited in the short term. In the short term, their focus may be on efficient use of energy and other resources, which may help them reducing emissions besides fitting in their development priorities. Therefore policies that would encourage efficient use of energy and other resources, fuel switch to less carbon intensive fuels (wherever desirable), reduction in energy intensity of the output etc. may be desirable. It is important that barriers to this are identified and instruments selected accordingly.

In the medium and long run, developing countries may also face requirement for more far going emission reduction policies. The interim period then seen in that perspective can be used to develop institutions and mechanism, build up skills and gain experience through pilot experiments.

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