CHAPTER 15
REPORTING A MITIGATION ASSESSMENT

15.1 INTRODUCTION

The results of a mitigation assessment may be presented in various ways depending on the nature of the assessment. It is suggested that the results be presented separately for the energy and non-energy sectors. If an integration of energy and non-energy analyses has been conducted, these results should also be presented and discussed. Finally, a summary should present the main findings from each sector as well as from integrated analyses.

15.2 ENERGY SECTOR

15.2.1 Introduction

The following suggestions for presenting a mitigation assessment for the energy sector are fairly extensive and should be looked upon as general guidelines. In some countries, lack of data and limitations in model structure may make it difficult to include the level of detail suggested here; presentation should be tailored to country-specific conditions.

It is important that the presentations not only focus on the results of the assessment but also discuss significant assumptions made when modeling the energy system. It should also present background information and data used in the analysis.

15.2.2 Model Description

Describe the model and methodology used for the mitigation assessment. Describe how the structure of the national energy system is constructed using the modeling tool(s).

Discuss the sectoral breakdown that is used in the study and the level of disaggregation within sectors.

15.2.3 Scenario Assumptions and Input Data

15.2.3.1 General scenario assumptions

Macro-parameters. Discuss the overall macro-parameters—GDP and population and their distribution—that drive energy use. Present projections for these over the whole analysis period.

Price Assumptions on Imported and Exported Fuels. Present assumed price paths for imported fuels, such as crude oil, oil products, and natural gas. If applicable, present prices assumed for exported energy carriers.

Discount rate(s). Present the discount rate(s) used in the analysis. If different discount rates are used in different sectors (to reflect different market barriers, capital scarcity, etc.), discuss how the values for these were established.

15.2.3.2 Projections of activity levels

Present the base year and future development of activity levels (e.g., value added, residential area, passenger-km, tonne-km, etc.) for each sub-sector within the main sectors of transport, industry, residential, and services.

Describe how the projections were established. Explain how the macro-parameters drive the activity levels in the different demand sectors and sub-sectors. Discuss important assumptions like development of infrastructure for transportation. If a macro-economic model is used for projecting the activity levels, give a short description of, and the assumptions used in, the model.

15.2.3.3 Projection of energy intensities

List assumptions and sources used when estimating the base year intensities and assumptions made for projecting future development. For simulation and optimization models, where the choice of technologies is made within the model, it is important to explain to what degree improvements in technology efficiencies are included in the projected intensities as opposed to given as specific technology options. Similarly, in accounting models, it is important to distinguish between improvements included in the baseline intensities and improvements included in the mitigation options.

Describe (if applicable) the historical time-series used to project future energy intensities. If the assumed development of the projected intensities differs between the baseline and various mitigation scenarios, explain what these differences are assumed to reflect.

15.2.3.4 Description of energy resources and technologies

Discuss the process of screening technology options:

- **Energy Resources**. Describe the resources for primary energy carriers included in the analysis. Present future production profiles for domestic extraction of oil, gas, and coal, if applicable. Discuss energy use and GHG emissions resulting from the production and possible options for mitigation in the production processes, e.g., reduced flaring of associated gas.

  Present price assumptions for domestic fuels and discuss limitations on availability, (e.g., due to pipeline capacity).

  For each source of biomass, present estimates of resource availability that can be utilized for energy purposes. Describe the resource potential as a function of the cost of producing and collecting biomass. Discuss environmental impacts of the extraction and competing non-energy use of the biomass.

  Describe other renewable resources, like wind, hydro, and solar, similarly.

- **Energy Supply Technologies**. Present data describing the main features of each of the options. These include data on investment costs, variable and fixed O&M costs, efficiency, emission coefficients, maximum market penetration rates, if any, and installed capacity in base year. Specify data that are time-dependent, e.g., reduced costs for PV-cells over time or improved efficiency in electricity grid.

- **Energy Demand Technologies**. Present data describing the main features of the technology options selected for each end-use sector. This includes data for investment costs, variable and fixed O&M costs, efficiency, emission coefficients, maximum market penetration rates, if any, and installed capacity in base year.

15.2.3.5 Emission coefficients

Present the emission coefficients for technologies and/or energy carriers used in the study. If GHGs other than CO_2 are considered, describe the assumptions that are made about global warming potential for each gas, expressed in CO_2-equivalents. If emissions of non-GHGs are included in the study, list emission coefficients for the gases considered.

15.2.4 Scenario Definitions

15.2.4.1 Baseline scenario

Describe key assumptions in the scenario, including policy measures such as insulation standards and efficiency programs, expansion plans for electricity production, and taxation or subsidy of energy products.

If an optimization model is used for the analysis, discuss to what degree the baseline is constructed exogenously as opposed to allowing the model to shape the baseline through choosing among the same options as are available in the mitigation scenarios.

15.2.4.2 Mitigation scenarios

Describe how the assumptions for the mitigation scenarios differ from the baseline. Examples of types of scenarios include:

- GHG-constraints (e.g., 20% reduction from baseline by 2010);
- GHG-"taxes" (by making the model add a cost per unit of emission);
- focus on specific technologies (nuclear, renewable, etc.); and
- other assumptions that differ from the baseline (e.g., subsidies for targeted technologies).

15.2.5 Results

15.2.5.1 GHG emissions

Present emission levels for the baseline and all mitigation scenarios. If GHGs other than CO_2 are considered, show emissions by type of gas expressed in CO_2-equivalents.

When a dynamic model is used, the emissions should be presented as a function of time for the whole time horizon. If a "snap-shot" model is used, present base year emissions and the target years studied. Show breakdown of the emissions into main sectors for the baseline and the mitigation scenarios.

All scenarios should have the same emissions in the base year. Explain any deviations from the emission inventories in this year.

15.2.5.2 Energy use

Primary Energy. Present the primary energy requirements[1] for the different scenarios for all years studied. Show the shares of primary energy sources (oil, natural gas, coal, nuclear, biomass, hydro, other renewables). Discuss implications for imports and exports and the depletion of domestic resources.

Electricity Generation. Discuss the development of capacity expansion of the power system and the types of technologies being used in the various scenarios. Address improvements in transmission and distribution, and peaking requirements.

Present the figures for annual electricity production and the fuel mix in the power production. Discuss the estimates of capacity utilization.

Show figures for import/export of electricity, if applicable.

Final Energy. The final energy use should be presented for each scenario and for each main sector.[2] Show breakdown into major fuels and electricity. Describe differences between the scenarios and discuss impacts of end-use efficiency.

Final energy intensities should be presented in terms of final energy use per unit of activity level for each sector (e.g., PJ/$ value added, PJ/person-km, PJ/household, etc.). Also present intensities for important end uses.

---

[1] Explain how the primary energy requirements are calculated. Which conversion factors are used for electricity production from hydro, solar, wind power, and nuclear power?

[2] Final energy use refers to actual consumption by end users. This includes purchased fuels and electricity, consumption of biomass, and uses of solar and wind energy. Final energy excludes all transmission and distribution losses.

15.2.5.3 Cost of emission abatement

The presentation of the costs of emission abatement will to some degree depend on the model that is used in the analysis. For the pure engineering models that do not include feedback to the general economy, the costs only include technical costs of the energy system, as opposed to the hybrid model MARKAL-MACRO and the general equilibrium model LBL-CGE that also include impacts on GDP. The cost representation in the engineering models can also vary. For example, the optimization models ETO and MARKAL have the option to select technologies on the basis of the total cost of industrial production rather than on the basis of energy costs alone.

The presentation of costs should include a short description of what elements the cost figures include:

Additional Energy System Costs. Present the differences in total system cost between each mitigation scenario and the baseline. If a multiperiod, dynamic model is used, present the cost increase as a function of time, as well as the cumulative costs for the whole time horizon considered. For putting the costs in perspective, the cost figures can be expressed as percentages of GDP in the specific years.

Cost Structure. The total cost of the energy system can be divided into three components:

- investment costs to replace and expand the capital stock in energy supply, conversion, and end-use sectors;

- fuel supply costs, broken into expenditures for domestic fuels and for (net) imported fuels; and

- other costs, like operating and maintenance costs.

In addition to understanding how the total costs change when moving to lower emission levels, it is important to monitor how the cost components change. Typically the capital cost is the most important component when costs increase in mitigation scenarios. Nuclear energy, renewable technologies, more efficient equipment, and investment in energy savings all drive up investment costs as capital substitutes for fossil fuel. In some cases, as when using expensive carbon-free hydrogen instead of fossil fuels, the fuel costs can also increase.

The increase in investment costs can be crucial in developing countries where capital is scarce. For example, if the total system costs increase by 0.5% of GDP in a mitigation scenario, and the increase in costs consists of 1% higher capital costs and 0.5% lower fuel costs, the extra capital costs may raise the total investments in the economy (typically around 15-30% of GDP in developing countries) by as much as 4-7%.

To the extent information about implications on foreign exchange for different technology options is included in the model, the total impacts on foreign exchange should be presented for each scenario. Even if the information on foreign exchange is not directly available from the model, the impacts on the foreign exchange from fuel imports and exports can be reported by presenting the net expenditure on imported fuels.

Cost Curves. Cost curves for emission abatement express the costs per unit of emission reduction as a function of the quantity of GHG reduced. As discussed in Chapters 2 and 3, these curves can be established in different ways, depending on which model is used and the level of detail in the study. We recommend that the integrated approach is used to the extent possible.

A cost curve for average cost, reflecting the cost difference between a mitigation scenario and baseline, should be presented. When optimization models are used, the marginal cost curve should also be presented. For the other models, the incremental cost curve can be used as an approximation of the marginal cost curve. (See Chapter 2 for definitions of average, incremental, and marginal costs.) Refer to figures in Chapter 2 and 3 for examples of cost curves.

The costs of GHG abatement, and thus the cost curves, will typically vary significantly between different time periods. Cost curves should therefore, when possible, be presented for more than one year or time period. When using a dynamic model, the cost curves can also represent cumulative reductions over the entire time horizon studied.

15.2.5.4 Contribution of technology options to GHG abatement

Energy Supply Options. For each scenario, present the mix of technologies used in generation of electricity and technologies used in production, transportation, and processing of energy carriers (e.g., enhanced oil recovery techniques, refinery processes, gas pipelines, charcoal production, etc.).

End-use Options. For each end-use sector, present the mix of technology options contributing to satisfying the demand for energy. Focus on the differences between scenarios, and explain major fuel shifts and impacts of conservation and higher equipment efficiencies.

15.2.5.5 Other environmental impacts

If included in the study, present emissions of other pollutants such as SO_x and NO_x.

Discuss impacts on land-use in the various scenarios (important with hydropower).

15.2.5.6 Summarize evaluation of options

Summarize the technology options that are attractive for emission abatement under different scenario assumptions. If criteria other than cost are considered, describe the characteristics of the options with respect to these criteria. If a multiperiod model is used, address in which time periods the various options are most attractive. Discuss timing of investment in new capacity.

Assess the robustness of the options chosen in the mitigation scenarios and the uncertainty of the data used.

15.2.6 Macroeconomic Impacts

Describe the type of macroeconomic analysis conducted (if any).

Discuss feedback to the general economy from the results of the energy sector analysis. This can be done through checking against assumptions on macro-parameters and development of activity levels. If applicable, iterate through modifying key parameters.

Discuss capital requirements and impacts on foreign exchange in the different mitigation scenarios.

15.2.7 Policy Options

Discuss ways to implement the most attractive and promising mitigation options and the possible barriers for implementation. Distinguish between short-term and long-term considerations.

Describe the type of evaluation of policies conducted (if any).

15.3 NON-ENERGY SECTORS

15.3.1 Introduction and Land-Use Framework

A description of methods and results should be presented for each sector studied. A report should first present the overall land-use context as it affects the forest, agriculture, and rangelands/grasslands sectors. This section is critical since it sets the basis for the analysis of the non-energy sectors.

Discuss the base-year allocation of land for various uses, including national forests, urban areas, agriculture, pasture, hydro reservoirs, etc. Present and discuss:

- base-year situation and future potential for the intensity with which different types of land may be used for various purposes;
- projected demand, for one or more target-years, for land-based products such as cattle, food products, mineral extraction, and urban use; and
- the future land use pattern in baseline and mitigation scenarios, and, if applicable, the need to import products should the land area be inadequate to meet domestic needs.

15.3.2 Sectoral Mitigation Assessment

The presentation format described below can generally be used for each of the non-energy sectors. The text below refers to carbon sequestration and is oriented toward the forest sector, but a similar presentation can be made for assessment of methane abatement and carbon sequestration options in other sectors.

- **Model/Method Description**. Describe the model(s) or method(s) used for the assessment.
- **Scenario Assumptions and Input Data**. Describe the key assumptions used to develop a baseline scenario and the nature of the input data.
- **Mitigation Options**. Describe and discuss the mitigation options that were selected for analysis. Explain the reasons for their selection. For the forest sector, explain whether a sustainable rotations or plant and store approach was used to evaluate the impacts of mitigation options.
- **Carbon Sequestration**. Describe and discuss the analysis of carbon flows for each mitigation option. Explain the assumptions regarding carbon content of biomass, biomass density, soil carbon, survival rates, rotation period, etc., which were used to arrive at carbon flow estimates

for vegetation, soil, forest product, and decomposing matter. Present both base year and future time period estimates for the baseline and mitigation scenarios.

- **Monetary Costs and Benefits**. Describe and discuss the analysis of monetary flows for each mitigation option. Explain the assumptions regarding unit costs, product prices, discount rates, and opportunity cost of land. Present both base year and future time period estimates.

  Present estimates of the costs and benefits of the mitigation options for different participants.

- **Comparison of Monetary and Carbon Flows**. Present indicators of cost-effectiveness which compare monetary and carbon flows. These include the initial cost, establishment cost, and net present value of benefit per unit of carbon protected or sequestered.

  Present cost of conserved carbon curves, which show the cost-effectiveness indicator plotted against the amount of carbon sequestered or protected for a series of mitigation options.

- **Scenarios of Carbon and Monetary Flows**. Present scenarios of future carbon and monetary flows until the final year chosen for analysis. Present estimates of both cumulative and annual flows.

- **Macroeconomic Implications**. Discuss the key macro-economic issues such as GDP, value of timber- and forest-products, international trade, and jobs creation.

- **Barriers to Implementation and Policy Options**. Discuss the main barriers to implementation and the national and local policy interventions that may be required to implement the mitigation options. The discussion should focus on economic, regulatory, and infrastructure policies.

15.4 SUMMARY OF ENERGY AND NON-ENERGY MITIGATION ASSESSMENTS

The presentation of a national mitigation assessment should contain a section that summarizes the results from the analyses done for the energy and non-energy sectors. A summary should present the key results from each of the sectoral assessments, particularly the GHG impacts, costs, and other impacts of specific mitigation options or groups of options. The total additional cost of the mitigation scenarios should be reported for each sector, and the evolution of costs over time should be graphed if such data are available. A ranking of options in each sector, based on both quantitative and qualitative criteria, may also be presented. Information on other environmental impacts and indirect economic impacts should be reported for each scenario or for important mitigation options. Results from top-down analysis of mitigation costs should also be presented if such analysis has been conducted. The summary should also discuss policies and programs that could encourage adoption of mitigation options in each sector.

Analyzing the results of assessments for the energy and non-energy sectors in an integrated framework is a challenging task since the methods and many of the assumptions will differ among the sectoral studies. In reporting the results of such an integrated analysis, the approach used should be carefully explained. Whenever impacts of GHGs other than CO_2 are presented in terms of CO_2-equivalent, the factors used to convert to GWP values should be clearly stated.

15.4.1 Summary Description of Mitigation Options

The costs, GHG impacts, and other effects of specific mitigation options should be reported for the most attractive options in each sector. This reporting will permit a comparison of the various options in terms of the criteria that are of most importance. Table 15-1 illustrates a sample format. Costs should be reported in terms of capital investment, life-cycle cost, and net cost (net of monetizable benefits). In practice, many of the values will be presented as a range.

Estimates of unit cost (cost/tCeq) should be reported for each mitigation option. In the energy sector in particular, it can be difficult to estimate a specific cost per tonne of carbon-equivalent since the cost of any given option is dependent on the configuration of the total system (see discussion of cost curves in Chapters 2 and 3). In this case, a range of costs should be given for each option.

15.4.2 National GHG Emissions

Summing results across sectors can yield estimates of total gross and net (after subtracting carbon sequestration) GHG emissions in a baseline scenario. Selected options from different sectors can also be grouped into national-level mitigation scenarios, although ensuring consistency of assumptions across sectors can be problematic. For example, a cross-sectoral mitigation scenario could include all options up to a given cost per tonne of carbon-equivalent. As discussed in Chapter 2, cost curves from different sectors can be combined in order to identify the options that provide a least-cost solution for satisfying a specific emission reduction target.

15.5 CONCLUSION

The reporting of a mitigation assessment should be guided by consideration of the audiences for whom the report will be of interest. One audience consists of professional colleagues in the scientific community both within a country and in other countries. In many cases, a mitigation assessment will become a definitive analysis for the country to which it applies and will serve as a reference for the international community of scientists involved in work related to global climate change. Thus, the reporting of an assessment should have a high level of scientific rigor and good documentation of methods and data sources; the degree of uncertainty associated with the findings should also be discussed.

Perhaps the most important audience for a mitigation assessment consists of policy-makers who may take various actions based on the results of the assessment. For this audience, the comprehensibility of the report and the clarity of its conclusions is of utmost significance. The results need to be presented in a way that is relevant to policy-makers. In addition, a report must strike a balance between acknowledging the uncertainty associated with the findings and drawing conclusions that can form a basis for policies and programs.

Table 15-1: Sample Format for Reporting the Impacts of Mitigation Options

Criteria	Mitigation Option 1	Mitigation Option 2	Mitigation Option n
GHG saving or storage (tCeq) Carbon (tC) Methane (tCeq) Other gases (tCeq)	100,000	150,000	20,000
Life-cycle-cost (currency/tCeq) Capital investment (currency/tCeq) Net costs (currency/tCeq)	3.5 2.0 3.3	40 30 40	120 80 110
Indirect economic impacts Jobs created (#) Reduced imports (US$)	300,000	100,000	Uncertain
Equity considerations, impact on Low-income jobs Low-income monthly expenditure	Low High	Medium Low	Uncertain None
National environmental impacts (net change) Sulfur oxides (tonnes) Particulates (tonnes) Biodiversity	-150 -30 No effect	-200 None Reduction	-75 -50 Uncertain
Potential impact of implementation policies	Low	Medium	High
Sustainability of option	High	Uncertain	Medium
Consistency with national development goals	High	Low	Medium
Uncertainty of data Technology performance and costs Costs of implementation programs	Low High	Medium Low	High Medium