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General and cross-cutting issues in the preparation of GHG projections

Working paper

I. Introduction

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its nineteenth session, requested the secretariat "to organize a workshop in the second half of 2004 on emissions projections of Parties included in Annex I to the Convention (Annex I Parties), as a contribution to the preparation of their fourth national communications. The workshop would cover methods, assumptions, indicators, key parameters of models and sensitivity analysis, and dissemination of methodologies[1]".

2. This paper was prepared to support discussions at the UNFCCC workshop on greenhouse gas (GHG) projections of Annex I Parties in Bonn, Germany on 6–8 September 2004. Its objective is to outline major general and cross-cutting issues in the preparation of GHG projections, based on the experience with the preparation of GHG projections presented by Annex I Parties in the latest, usually third, national communications.

3. Specific issues in the preparation of GHG projections for the energy sector, transport, industry and waste management and issues in the preparation of GHG projections for agriculture and land use, land-use change and forestry, are dealt with in two other working papers prepared for the workshop.

4. The paper is structured as follows:

(a) Chapter II provides an overview of how Annex I Parties prepared their projections; two facets are distinguished: reporting on projections (including compliance with the UNFCCC guidelines) and the methodologies used;

(b) Chapter III outlines major outstanding issues that could form the basis of the discussions during the workshop; again, they are structured in two categories: reporting issues and methodological issues. The two lists of issues are not intended to be exclusive or definitive – participants may identify other issues and/or reformulate the issues presented here, as needed.

[1] FCCC/SBSTA/2003/15, paragraph 14(f).

II. Current status of reporting on GHG projections by Annex I Parties

A. Overview of reporting

5. Table 1 summarizes the information on GHG projections submitted by Annex I Parties in their latest national communications, and compares the submitted information with the requirements set out in the UNFCCC reporting guidelines.[2] For some reporting deficiencies indicated in the table, additional information was provided during in-depth reviews of national communications. Such cases are intentionally not reflected in the table because the purpose of the table is to characterize the reporting on projections in the national communications.

6. Almost all Parties provided a "with measures" scenario, although sometimes the definition of this scenario differed from that required by the guidelines. The "with measures" scenario was usually until 2020 (sometimes until 2010, 2012, 2015 or 2017). Most Parties also submitted a "with additional measures" projection, but information on this projection was sometimes less complete than that for the "with measures" projection. In some cases, the scenarios were not defined as "with measures", "without measures" or "with additional measures", but it was possible to interpret them in line with the UNFCCC guidelines.

7. A projection for carbon dioxide (CO_2) was available in most communications. Projections for methane (CH_4) and nitrous oxide (N_2O) were usually also available. Fewer Parties provided projections for hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

8. A breakdown of the projected GHG emissions by sectors was presented in most of the national communications. Sometimes the sectoral information was not complete; most often, either the emissions from transport or the GHG removals through land-use change and forestry (LUCF) were missing. A few Parties provided projections for CO_2 only and/or a projection of the GHG (or CO_2) total without a sectoral breakdown or without a breakdown by gas.

9. Overall, the presentation of GHG projections in the latest national communications of Annex I Parties complied, in general, well with most of the requirements of the UNFCCC guidelines. At the same time, table 1 shows a number of typical deficiencies in reporting: the absence of a GHG projection for transport and LUCF, the absence of a projection for HFCs, PFCs and SF_6, and the limiting of the projection period to 2010 (or another year) instead of 2020.

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[2] UNFCCC reporting guidelines refer to the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention Part II: UNFCCC reporting guidelines on national communications" (see FCCC/CP/1999/7).

Table 1. Summary of information on projections submitted by Annex I Parties

Party	Scenarios			Projection	GHG emissions	
	NM	WM	WAM	period to	By gas	By sector
Australia	Yes	Yes	No	2020	All 6 gases	All sectors
Austria	No	Yes	Yes	2020	All 6 gases	TRN, LUCF not available
Belarus	Yes*	Yes*	No	2020	CO_2, CH_4, N_2O	TRN not available
Belgium	No	Yes	Yes	2020	All 6 gases	All sectors
Bulgaria	Yes	Yes	Yes	2020	CO_2, CH_4, N_2O	TRN not available
Canada	Yes	Yes	Yes	2020	All 6 gases	LUCF not available
Croatia	No	Yes*	Yes*	2020	na	All sectors
Czech Republic	No	Yes	Yes	2020	All 6 gases	All sectors
Denmark	No	Yes	No	2017	All 6 gases	All sectors
Estonia	No	Yes	Yes	2020	CO_2, CH_4, N_2O	TRN not available
Finland	No	Yes	Yes	2020	All 6 gases	All sectors
France	Yes	Yes	Yes	2020	All 6 gases	All sectors
Germany	No	Yes	No	2010	All 6 gases	All sectors
Greece	No	Yes	Yes	2020	All 6 gases	All sectors
Hungary	Yes*	Yes*	No	2020	CO_2, CH_4	IND, WASTE not available
Iceland	No	Yes	No	2020	All 6 gases	Only ENERGY, TRN, IND
Ireland	No	Yes	Yes	2012	All 6 gases	All sectors
Italy	Yes*	Yes	Yes	2010	na (for WM)	All sectors
Japan	Yes	Yes	Yes	2010	All 6 gases	TRN, LUCF not available
Latvia	No	Yes	No	2020	All 6 gases	TRN not available
Liechtenstein	No	Yes	No	2010	CO_2, CH_4, N_2O	IND, LUCF not available
Lithuania	No	No	No	2012[a]	CO_2[a]	Only ENERGY[a]
Luxembourg	The 2nd national communication has not been submitted.					
Monaco	No	No	No	na	na	na
Netherlands	No	Yes	Yes	2020	All 6 gases	LUCF not available
New Zealand	No	Yes	Yes*	2020	CO_2, CH_4, N_2O	TRN not available
Norway	No	Yes	Yes	2010	All 6 gases	All sectors
Poland	No	Yes*	No	2020	CO_2, CH_4[a], N_2O[a]	TRN, WASTE not available
Portugal	No	Yes	Yes	2020	na	LUCF not available
Romania	The 3rd national communication has not been submitted.					
Russian Federation	No	Yes*	No	2020	CO_2	na
Slovakia	Yes	Yes	Yes	2015	All 6 gases	All sectors
Slovenia	No	Yes	Yes	2020	All 6 gases	LUCF not available
Spain	No	Yes*	Yes*	2010	CO_2	Only ENERGY and TRN
Sweden	No	Yes	No	2020	All 6 gases	All sectors
Switzerland	No	Yes	Yes	2020	All 6 gases	All sectors
Turkey	The 1st national communication is due by 24 November 2004.					
Ukraine	The 2nd national communication has not been submitted.					
United Kingdom	No	Yes	Yes	2020	All 6 gases	All sectors
United States	No	Yes	No	2020	All 6 gases	All sectors
European Community	No	Yes	Yes	2010	All 6 gases	LUCF not available
Total:	**9**	**35**	**23**	**25 Parties: to 2020**	**22 Parties: all 6 gases**	**17 Parties: all sectors**

Note 1: for simplicity, some details relating to the submissions are omitted in this table; more information is given in FCCC/SBI/2003/7/Add.3.
Note 2: na means not available in the national communication.
Note 3: * indicates that the scenario was not defined in accordance with the UNFCCC guidelines in the communication but it could be interpreted as a "without measures", "with measures", or "with additional measures" scenario.
Note 4: NM = "without measures", WM = "with measures", WAM = "with additional measures".
Note 5: TRN = transport, IND = industry, LUCF = land-use change and forestry and WASTE = waste management.
[a] An estimate is available but a consistent scenario was not provided.

B. Overview of the methodologies used

10. Table 2 provides an overview of the major features of the methodologies used by Annex I Parties in the preparation of GHG projections. The information in table 2 is not comprehensive; more information can be found in national communications and in the reports on in-depth reviews of national communications.[3] Some Annex I Parties, for which the description of projection methodology was not available or appeared to be incomplete, are not included in table 2.

Table 2. Summary of projection methodologies used by Parties

Party	Methods and tools used for GHG projections

[3] All national communications and in-depth review reports are available on the secretariat's web site <www.unfccc.int>.

Party	Methods and tools used for GHG projections
Australia	A combination of top down and bottom up economic models was used. The top down models (Global Trade and Environment Model – GTEM, Monash Multiregional Forecasting-Green – MMRF-Green) and Global General Equilibrium Growth Model (G-Cubed) are general equilibrium models. Some bottom-up models (from McLennan Magasanik Associates and National Institute of Economic and Industry Research and some others) were used for expert analysis of particular sectors and for providing inputs to the econometric models.
Austria	Energy Model DEDALUS was used for energy-related emissions (an econometric model for energy demand and an input-output model of energy transformations); macroeconomic multisectoral model MULTIMAC was used for multi-sectoral calculations; Austrian Carbon Balance Model ACBM was used for the emissions from industry, agriculture and waste (a carbon cycle model).
Belarus	For CO_2, simple calculations, based on CO_2 emission factors and assumptions about growth in fuel consumptions, were used. For CH_4 and N_2O, Excel-type calculations were applied based on projected changes in activity data and assumed emission factors.
Belgium	HERMES and EPM were used for medium term projections (to 2010 for all emissions), GEM-E3 and MARKAL for long term projections (to 2020 for energy emissions only). HERMES and GEM-E3 are econometric models. EPM and MARKAL are energy models differing in the modelling approach: EPM is a simulation model with detailed, specific representation of technologies; the model is tailored to Belgian conditions (i.e., the technology data are specific for Belgium). MARKAL is a generic optimization model for the energy sector.
Bulgaria	The US-developed ENPEP package was used (modules MACRO, DEMAND, BALANCE, WASP, IMPACTS). MACRO = input of macro-economic assumptions, DEMAND = demand projection, BALANCE = energy sector simulation, WASP = power sector optimization, IMPACTS = emission calculations.
Canada	A modelling approach that combines econometric, end use and process techniques was used to project energy, demand, supply and associated emissions. Macroeconomic indicators – changes in economic activity, employment, trade and competitiveness and government balances – were projected using the Informetrica Model. Energy demand by fuel is projected using the Interfuel Substitution Demand Model (IFSD), an econometric top-down model covering all major fuel types. Bottom-up, end-use process models were also used for sectoral energy demand (residential, commercial, industrial and transportation) for all provinces and territories. Two energy technology models – the Market Allocation Model – MARKAL, and the Canadian Integrated Modelling System (CIMS) – were used for electricity supply.
Croatia	The energy projections were prepared using four sets of models. To simulate the future trends of energy system development, the simulation (BALANCE) module of the US-developed ENPEP package was used. Two separate models describing the electricity and gas sectors in greater detail provided the necessary input for ENPEP. These were an optimization model, WASP, for the electricity sector and a simulation model, PLINSCO, for the gas sector. Energy demand projections were prepared with the MEDEE model.
Czech Republic	The MARKAL linear optimization model was used to project emissions of CO_2, CH_4 and N_2O from combustion processes. A tabular processor based on projections of trends was used to project emissions from industrial processes (CO_2 from cement production). An EXCEL tabular processor employing projections of trends was used for the agriculture sector. The economic module of MARKAL was used in macro-economic calculations. The final energy demand projections were obtained using the MEDEE model based on the results of these studies and on macroeconomic projections.
Denmark	Energy demand projections were based on ADAM/EMMA calculations for the business and public sectors (EMMA is a macro model of final energy consumption). For the domestic sectors, a bottom-up approach was applied (electricity and heat models linking energy consumption to assumptions on growth in the housing stock and the number/efficiency of energy use appliances). Electricity and heat production were projected with RAMSES, a model of the Danish Energy Authority. Industrial and local mini-CHPs were modelled separately.
Estonia	Expert analyses using results of MARKAL modeling were applied.
Finland	For modelling the energy system, EFOM was used – an optimization model (using linear programming) designed for modelling complex energy systems. For assessing economic impacts of GHG mitigation, two similar general equilibrium macro-economic models, developed by VATT – the Government Institute for Economic Research (the KESSU model) and the Research Institute of Finnish Economy (ETLA) were used.
France	MEDEE (a bottom-up model designed to project energy demand taking as input data assumptions on economic, social, and technological parameters) was used for energy demand projections; DIVA (a macro-economic model) in support of MEDEE economic assumptions. Energy supply was model was not specified in the NC3. Excel-type calculations were used for non-energy emissions.
Germany	Options for reducing CO_2 emissions were identified from the policy viewpoint and from the technical viewpoint. The set of technical options was studied with an optimization model, which contained a baseline ("Model Basis Scenario") and a reference ("with measures") scenario, the latter estimated by experts outside the model. Optimisation within the model was used to find a combination of measures leading to full compliance with the CO_2 reduction target at lowest cost. The modelling results underwent an expert analysis and several scenarios were formulated.
Greece	The ENPEP model (the BALANCE module with emissions calculations) was used for the emissions from energy supply and use; spread-sheet models were used for non-energy sectors (future changes in activity data are taken from statistics, and the emission factors are based on the IPCC/CORINAIR methodology).
Hungary	The ENPEP model (the BALANCE and IMPACTS modules) were used for the emissions from the energy sector. Estimated changes in activity drivers and IPCC default CH_4 emission factors were used for the CH_4 projection for agriculture. The CASMOR model was used for the projection of carbon storage.
Iceland	Projections were prepared with Excel sheets based on assumptions and expert judgment.

Party	Methods and tools used for GHG projections
Italy	The scenarios of greenhouse gas emissions from the combustion of energy are drawn from the CEPRIG model (Emission Calculation and Policies for the Reduction of Greenhouse Gases), based on the system dynamics approach. The CEPRIG model formally elaborates statistical and/or econometric data, obtained by means of differential equations. These variables are modelled in conformity with statistic-econometric analyses, based upon the Italian energy history of the last 30 years. For comparison, MARKAL was also used for the energy sector.
Japan	Projections of CO_2 emissions from energy sources were primarily based on a general equilibrium model - the KEO model - which is integrated with an energy conservation factor model, and an electric power composition model. The validity of the integrated KEO model was tested using a regression analysis model. The integrated KEO model generated economic indicators, e.g., GDP, energy consumption, and integrated the effects of specific policy measures, e.g. a carbon tax. The regression analysis model employed in the NC2 was used to estimate CO_2 emissions from energy sources for the without measures projection of the NC3. A bottom-up approach and expert judgment were utilized to project CO_2 emissions from non-energy sources, CH_4, and N_2O.
Latvia	The projections were based on economic model simulations, and the results from these (economic growth, price levels, etc.) were fed into an energy system model simulation. The economic projections were based on a general equilibrium model (GEM). Energy projections were based on the energy system model MARKAL, a dynamic linear programming. Projections in the LUCF sector were made using a model developed by the Latvian State Forest Science Institute "Silava" using the database of the Forest Fund and expert judgment.
Liechtenstein	The projections were based on expert assessments, derived using analogies with Switzerland. The exception is transport where a detailed transport model was used.
Netherlands	Energy supply was modelled using the SELPE model, which makes it possible to model energy supply development that meets energy demand defined by the NEMO and SAVE models. The RIM+ and RIVM models (also known as the Environmental Information and Planning Model) were used to perform a consistent emission calculation by gas and by sector. In addition, the market simulation models GASTALE and POWERS were used to simulate the effect of energy market liberalization. Within the energy supply sector, specific models for refineries, electricity, CHP and renewables were used. Separate spreadsheet models were used for non-energy-related emissions, e.g. projections of CH_4 from landfills, livestock, application of manure and fertilizers in soils, N_2O from nitric acid production and the fertilizer industry, and fluorinated gases.
New Zealand	For the energy sector, SADEM was used plus five sectoral models. SADEM is a partial equilibrium model, which identifies market clearing prices through balancing energy demand and supply quantities. It contains quantitative demand models for industrial sector (petrochemicals, basic metals, forest products and transport other than land transport) and econometric models for sector called "other industry and commerce", land transport and residential sectors. At the supply side, five models are used to reflect interaction within the electricity system and gas supply system, as well as supply from coal, oil and renewables. For non-energy emissions, the projections were based on expert assessments. Technologies are presented in SADEM in detail at supply level, e.g. electricity and gas. In particular, new electricity technologies and fuels are chosen for the future fuel and technology mix through least-cost planning.
Norway	CO_2 projections are based on a macroeconomic model called MSG (Multi-Sectoral Growth). It is a general equilibrium model. An emission calculation module is included in MSG. Input data for the model come from sectoral studies. Projections for non-CO_2 emissions are based on information from the concerned sectors.
Poland	The aggregated 2002 emission scenarios were compiled using three main models: a macroeconomic general equilibrium model (CGE-PL), an energy demand simulation model(PROSK-E) and an energy supply optimization model (EFOM-PL). Three market penetration sub-models for (1) small CHP and RES, (2) electrical appliances and (3) building insulation and heating systems were linked to the main models. The general equilibrium model CGE-PL is used for a complex macro-scale analysis of long-term changes in the economic structure (i.e. production structure, changes in resource allocation and prices). Taking assumptions on both demographic developments in Poland and international economic growth rates as input data, the main results of this first modelling step are the GDP growth rates in individual sectors. In a second step, the energy demand simulation model PROSK-E calculates the trajectories for final and useful energy demand. In a third step, the energy supply optimization model EFOM-PL analyses the structural data for energy resources, including the supply of primary energy carriers, expenditures and costs of energy production, processing and distribution of primary energy carriers, marginal costs of emission reduction and optimum technological structure, primary and final energy balances.
Russian Federation	CO_2 projections of energy-related emissions were prepared with an aggregated single-equation formula linking the growth in emissions with the growth rates of the GDP, energy intensity improvements and the changes in the carbon intensity of energy supply.
Slovakia	The BALANCE and IMPACTS modules of the ENPEP package were used for energy-related emissions; the COPERT program was used for the emissions from transport. Expert judgment and assumptions were used for other emissions.
Slovenia	The MESAP model was used (a version modified in Slovenia to adjust to national conditions). Optimization was used only for the electricity module in MESAP; the rest was calculated using a scenario approach.
Spain	The projections in the NC3 were prepared in three stages: (1) final energy consumption was projected using the MED-PRO model, a bottom-up model from the MEDEE family which simulates final long-term energy demand disaggregated into five sectors (industry, transport, residential, services and agriculture); (2) energy required for transformation was evaluated (electricity and refining) applying several options on how energy demand would be met; (3) once the supply of primary energy had been estimated, the GHG emissions relating to these energy supply options were calculated.

Party	Methods and tools used for GHG projections
Sweden	The 3 approaches used were: (a) Economic-technical models for energy use (National Energy Administration) and energy supply (MARKAL) combined with analytical models for future transport demand (SIKA's passenger and goods transport model). (b) Spreadsheet models in which expert assessments of future changes in premises (activity data and emission factors) were made; emissions were quantified using the IPCC/UNFCCC methodology.(c) Statistical analyses and supplementary expert assessments.
United Kingdom	DTI Energy Model was used – a "top down" model made up of a set of interlocking models of final user energy sectors and the electricity supply sector. It contains 130 econometric equations; electricity supply is modeled at a plant-by-plant level. Spreadsheet model calculations were used for non-CO_2 emissions
United States	The National Energy Modeling System (NEMS) was used. This system uses a market-based approach that balances supply and demand with price competition between fuels and sectors. NEMS combines econometric and engineering or technical information in modules for fossil fuel supply, electricity generation, and a large number of categories of energy end-use including prices. Additional specialized models and spreadsheet calculations were used for gases from industrial processes, agriculture, wastes and carbon sequestration.
European Community	Two approaches are used in the EC for GHG projections: (1) summing the national GHG emissions provided by EC member states; (2) using a EC-wide model. For approach (2), energy-related CO_2 emissions were projected using the energy system model PRIMES; other emissions were projected based on estimates of activity levels and emission factors.

11. Table 2 illustrates the wide diversity of models and modelling approaches applied by Annex I Parties for the preparation of GHG projections. It proves that the requirements of the UNFCCC guidelines, relating to GHG projections, can be met with different methods and tools.

12. Notwithstanding the diversity of modelling approaches, some common methodological problems seem to exist. They were revealed either by modellers themselves in the national communications or by expert teams during in-depth reviews of national communications. The next section presents a list of such problems for consideration by the workshop.

III. Outstanding general and cross-cutting Issues

A. Reporting issues

13. ***Consistent definition of projection scenarios***: According to the UNFCCC guidelines, "… Parties shall report a 'with measures' projection… and may report 'without measures' and 'with additional measures' projections...". Most national communications complied with this requirement. The most typical deviation from the guidelines is the absence of a "with measures" scenario – instead, one or several scenarios with a different meaning were provided (such as "optimistic" or "pessimistic" scenarios, or "high" or "low" scenarios).

14. **The workshop may wish to identify whether there are any substantive, methodology-related problems behind the absence of a "with measures" projection in some communications and, if so, recommend action to address these problems.**

15. ***Transparent presentation of information on projections***: The UNFCCC guidelines require that "projections shall be presented on a sectoral basis, to the extent possible, using the same sectoral categories used in the policies and measures section" and "projections shall be presented on a gas-by-gas basis for the following greenhouse gases: CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 (treating PFCs and HFCs collectively in each case)". Another relevant requirement is that "Parties should include projections on a quantitative basis for the years 2005, 2010, 2015 and 2020. Projections should be presented in a tabular format by sector and gas for each of these years, together with actual data for the period 1990 to 2000 or the latest year available." Most Parties followed these requirements and were able to present information consistently and transparently, often using two sets of tables – one for projections by sector and one for projections by gas. However, some national communications revealed problems with the consistency and transparency of the presented information. The typical examples are incomplete coverage of gases in the projections (for example, projection of only CO_2), incomplete coverage by sectors (for example, projection of only energy-related emissions), and inconsistency between the projections presented by gas and the projections presented by sector (that is, the GHG total is different depending on whether the sum is taken by gas or by sector).

16. **The workshop may wish to identify options on how to resolve such transparency problems, for example, through the preparation of generic tables by gas/sector to be used in the next national communication.**

17. ***Consistency with the latest available GHG inventory***: The starting, historical point for GHG projections should be consistent with the latest available GHG inventory: "Emission projections shall be presented relative to actual inventory data for the preceding years. For the 'with measures' and 'with additional measures' projections, the starting point should generally be the latest year for which inventory data are available in the national communication". Often the starting point for projections was not fully consistent with the latest available inventory, mostly because of inventory recalculations conducted after the projections study had started. Another problem, observed in some communications, was that the breakdown of projections by sector differed from the breakdown used in the GHG inventory.

18. **The workshop may wish to identify the consequences of inconsistencies between GHG projections and GHG inventory and possible solutions.**

19. ***Availability of information on modelling approaches and key assumptions***: Some national communications presented information on projected GHG trends but did not describe the models, approaches and/or key assumptions used for the preparation of the projections, although the UNFCCC guidelines require that "in the interests of transparency, for each model or approach used, Parties should briefly… describe the type of model or approach used and its characteristics (for example, top-down model, bottom-up model, accounting model, expert judgment)" and "summarize the strengths and weaknesses of the model or approach used".

20. **The workshop may wish:**

(a) **To identify options on how projection models and modelling approaches could be best presented in national communications within the space limitations of these reports**

(b) **To identify the key assumptions and how these could be best presented in national communications.**

B. Methodological issues

1. Preparation of scenarios

21. ***"With measures" scenario***: According to the UNFCCC guidelines, "… Parties shall report a 'with measures' projection and may report 'without measures' and 'with additional measures' projections. A 'with measures' projection shall encompass currently implemented and adopted policies and measures." The two major challenges seem to have been (a) **the modelling of the impact of existing and adopted policies and measures on future GHG emissions** and (b) **the need to adequately reflect all national circumstances**, often very complex, that have implications for GHG emission levels.

22. ***"With additional measures" scenario***: Those Parties that reported information from this scenario used it as a means to identify the impact of possible additional measures on GHG emissions. The major methodological challenge here is how to integrate new policies and measures into projections, and the two most common modelling approaches were simulation (when the effects of new policies and measures are part of input data and the model reproduces these effects) and optimization (when the mix, timing and extent of implementation of policies and measures are determined by the model based on an optimisation technique).

23. ***"Without measures" scenario***: The particular methodological difficulty here is that this scenario should reflect a counterfactual situation that would have occurred, should no GHG-related measures had been implemented in the past. Such retroactive analysis is by no means easy. However, such a scenario

may provide (through comparison with the "with measures" scenario) valuable information on the overall efficiency of policies and measures implemented in the past.

24. **The workshop may wish:**

(a) **To exchange experiences on the major challenges in preparing the different scenarios, including the modelling of the impact of policies and measures on future GHG emissions and the approaches to adequately reflect national circumstances in the projections**

(b) **To identify whether any methodological guidance could be given to assist in the preparation of scenarios for the next national communication**

(c) **To summarize best practices in the preparation of scenarios and/or develop relevant recommendations**.

2. Key modelling problems

25. ***Incorporation of technological progress into projection modelling***: Technological progress has a major impact on the level of GHG emissions, but the integration of this factor into GHG projections is associated with certain modelling problems, such as making (and including into the models) consistent assumptions on the degree of technological progress in various branches of the economy, quantifying technological progress in accordance with modelling requirements, and identifying the link between the degree of technological progress and the modelled sets of GHG mitigation activities.

26. **The workshop may wish to review the techniques used to reflect technological progress in GHG projections and, if necessary, suggest relevant advice to Parties.**

27. ***Projection of macroeconomic costs and macroeconomic impacts of climate-related measures***: The UNFCCC guidelines do not require such projections. However, several Parties included estimates of macroeconomic costs and impact of climate-related measures on GDP, employment and other macroeconomic parameters in their national communications or presented such information during in-depth reviews. The main reasons for doing this are : (a) for those Parties that use macroeconomic models as part of their GHG projection study, macroeconomic implications can be estimated relatively easily; (b) the impact of climate-related policies and measures on macroeconomic parameters is an important policy issue.

28. **The workshop may wish to exchange information on how macroeconomic costs and macroeconomic impacts of climate-related measures have been modelled and on the lessons learned.**

29. ***Integration of cross-country factors, impacts on other countries, and international market developments into national GHG projections***: GHG projections required by the UNFCCC guidelines are by nature national. However, due to links between national economies national projections may depend on developments in other countries (in particular in neighbouring countries and/or among major export/import partners) and, on the other hand, policies and measures for GHG mitigation in a given country may have an impact on other countries (again, in particular in neighbouring countries and/or among major export/import partners). In general, such impacts cannot be evaluated accurately at a national level – models of regional or global scope may be better suited to the analysis of such issues.

30. **The workshop may wish to identify to what extent such factors are currently integrated into national GHG projections and whether any particular techniques could be used to model such factors at a national level.**

3. Uncertainties

31. *Methods for assessing the uncertainty in projected GHG emissions*: According to the requirement of the UNFCCC guidelines, the "sensitivity of the projections to underlying assumptions should be discussed qualitatively and, where possible, quantitatively". The uncertainties of the projected levels of GHG emissions are primarily due to the use of assumptions about future behaviour of multiple variables with impact on GHG emissions, to the uncertainty about the future effects of GHG-related policies and measures, and to the various inherent limitations of the models used. Understanding the level of uncertainty, if possible in quantitative terms, can provide valuable information for the discussions of climate-related policies and corresponding policy decisions. However, relatively few Parties attempted to evaluate the uncertainty of GHG projections. The methods used were sensitivity analysis, identification of ranges in key parameters and their impact on emissions, and the Monte-Carlo technique. The last option is particularly interesting (but rather demanding in terms of modelling effort) because it can provide quantitative estimates of uncertainty.

32. **The workshop may wish to identify options on how to model the uncertainty of GHG projections and how to improve uncertainty analysis and its presentation in the next national communications.**

4. Other issues

33. *Applicability and comparative advantages of various types of models*: Table 2 shows that Parties use various types of models and modelling techniques. In terms of model type, engineering bottom-up models, macroeconomic top-down models, and integrated (or hybrid) models have been used. In terms of modelling approach, one can mention accounting, simulation and optimization models (with linear or dynamic optimization). The wide range of model types is understandable, given the wide differences in national experiences with projections and the importance of using models that fit best into particular national circumstances of a country.

34. **The workshop may wish to consider the relative advantages and drawbacks of various model types and, if necessary, provide advice as to whether any particular modelling type could be particularly useful for a given aspect of GHG projection modelling within the requirements of the UNFCCC guidelines.**

35. *Possible means to facilitate comparability of national GHG projections*: National GHG projections provided by Parties in their national communications are based on various assumptions and different models. As a result, these projections are often not comparable across Parties.

36. **The workshop may wish to consider how the comparability of national GHG projections could be improved and to identify appropriate action in this regard.**

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