Executive Body, twenty-eighth session
Geneva, 13 – 17 December 2010
Agenda item 5 of the provisional agenda
Informal document No. 5

TFIAM / EC4MACS workshop on uncertainty treatment

3-4 November, 2010

Report by the Chair of the Task Force

I. INTRODUCTION

1. This report describes the results of the workshop on uncertainty treatment of integrated assessment of air pollution and climate strategies organised by the Task Force on Integrated Assessment Modelling and the EC4MACS-project, held from 3 to 4 November 2010 at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. The presentations made during the meeting and the reports presented are available at: http://gains.iiasa.ac.at/index.php/tfiam/past-tfiam-meetings.

2. Sixty experts attended, representing the following Parties to the Convention: Austria, Belarus, Belgium, Czech Republic, Croatia, Finland, France, Ireland, Italy, Netherlands, Serbia, Spain, Sweden and The United Kingdom of Great Britain and Northern Ireland. Also the Expert Group on Techno-Economic Issues (EGTEI), the Network of Experts on Benefits and Economic Instruments (NEBEI), the Co-operative Programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe (EMEP), the EMEP Centre for Integrated Assessment Modelling (CIAM), the EMEP Meteorogical Synthesing Centre-West (MSC-W), the Coordination Centre for Effects (CCE), the World Health Organisation (WHO), the European Commission, the Institute for Environmental Sustainability of the Joint Research Centre of the European Commission, the European Environmental Bureau (EEB), CONCAWE, and the Union of the European Electricity Industry (EURELECTRIC) were represented. A representative from the Executive Body of the Convention and the UNECE-secretariat also attended.

3. Mr. R. Maas (Netherlands) chaired the meeting.

II. OBJECTIVES OF THE MEETING

4. The purposes of the workshop were:

- To review the main sources of uncertainty in integrated assessment modelling;
- To identify approaches for treating uncertainties and for risk management strategies in the context of the revision of the Gothenburg Protocol;
- To discuss possibilities for improved communication of uncertainties to decision makers.

5. The meeting was reminded of insights gained from earlier workshops on uncertainties in integrated assessment modelling. A main lesson learnt at the TFIAM-uncertainty workshop in 2002 was that policy makers, in contrast to scientists, are less interested in detailed quantitative statistics about uncertainties, but rather in robust strategies that do not significantly change due to changes in uncertain model elements. A systematic approach to uncertainties was considered important for establishing confidence in model results. Such an approach should differentiate between the reducible and the irreducible uncertainties. For the most significant sources of reducible uncertainties, it should determine by how much further scientific effort could increase the robustness of the models. For irreducible uncertainties, sensitivity analyses should be conducted for different assumptions. These should be made explicit and, where they significantly influence the model outcome, alternative scenarios should be explored.

6. The 2010 workshop of the Network of National Integrated Assessment Modellers (NIAM) re-iterated the importance of sensitivity analyses to explore the effects of possible systematic biases that might emerge from missing data, model simplifications, incomplete scientific understanding and assumptions about the future.

III. WHAT DO WE WANT TO KNOW ABOUT UNCERTAINTIES?

Perspectives from stakeholders and decision makers

7. Different stakeholder groups share concerns about uncertainties, although with different perspectives. Industrial stakeholders emphasized their interest in avoiding regret investments, especially of expensive policy measures. Particular concerns relate to a too narrow scope of sensitivity analyses (e.g., if limited to energy scenarios with rather similar assumptions on future economic development), too short time scales that do not fully grasp the dynamics of the turnover of the capital stock, and too limited consideration of alternative hypotheses for health impacts of different components of particulate matter.

8. In contrast, non-governmental environmental organisations are concerned about insufficient health and environmental protection from modelled emission control strategies. These could results from too pessimistic assumptions on achievable emission reductions, e.g., due to limited consideration of the potential offered by technological progress, the ongoing renewal of capital stock, and behavioural changes.

9. To bridge these concerns and to develop robust strategies, decision makers are faced with three basic questions: Is there confidence in (1) the basic science (Is there a problem?), (2) the size of the effect (How big is the problem?), and (3) the effectiveness of policy measures (What is the risk that policy measures prove to be wrong or insufficient later on?).

10. Integrated assessment modelling offers a good framework for identifying critical elements of uncertainty, translating them into policy risks, and developing risk management approaches.

11. The workshop identified key uncertainties that are crucial for the development of robust policy conclusions. These include basic uncertainties about the future economic development; the effectiveness of energy, transport and agricultural policies assumed in the baseline; possible changes in meteorological conditions due to climate change; the impacts of pollution on human health and the environment; and the effectiveness and costs of abatement options (e.g., for road transport and agriculture).

12. Good communication between integrated assessment modellers, stakeholders and decision makers on uncertainties and policy risks was considered to be important, both at the national and the international scale. Uncertainty analysis should not be placed at the end of the assessment process, but should form an integral part of the workplan for modelling and policy development. Ideally, a wide range of scenarios needs to be investigated that cover broad ranges of the indicators and parameters that are uncertain, with established priorities.

IV. CLASSIFICATION OF UNCERTAINTIES AND RISKS

13. A variety of classifications of the types of uncertainties have been proposed in the scientific literature, and different approaches to identify and manage risks have been developed.

14. The approach used in the Netherlands distinguishes uncertainties in data, in model structures and in expert judgements, as well as biases due to the chosen system boundaries and the choice of output indicators. Some uncertainties could be reduced by more research, but uncertainties due to input variability, lack of knowledge or recognised ignorance will always remain to some extent, and have to be taken into account in the decision making process.

15. When stakes are high and scientific knowledge is ambiguous, a good process for managing scientific uncertainties should acknowledge ignorance in understanding and provide tolerance towards opposing perspectives. In such cases the available information on uncertainties should be considered as an asset. Translated into associated policy risks, the knowledge of existing uncertainties make important contributions to the policy process.

16. Thus, extended peer review on knowledge inputs, dedicated space for dissident views and regular reviews and revisions of science and policy strategies are key

elements of the approach to uncertainties adopted in the Netherlands. The Netherlands Environmental Assessment Agency has institutionalized best practices in uncertainty communications through guidance documents and specific courses.

17. The UK hazard assessment methodology (HAZOP) emphasizes the importance of side-effects of policy measures. Integrated assessment modelling can systematically explore such side effects that are often overlooked.

V. REVIEW OF UNCERTAINTIES OF MODELLING ELEMENTS

18. The workshop reviewed key uncertainties of the various model elements, and how they would influence the robustness of overall policy conclusions from the integrated assessment modelling.

19. Key uncertainties in scenarios of future energy use (e.g., those developed with the PRIMES model) originate both from continuous modifications of historical statistical data (as they influence the modelled future behaviour of the different actors) as well as from assumptions about future driving forces (e.g., macro-economic development, energy world market prices, technological progress). In retrospect, baseline energy scenarios developed over the last decade changed because of (i) different prospects on economic development, (ii) more optimistic assumptions on technological development (e.g., on carbon capture and storage, electric vehicles), and (iii) new legislation on climate change. However, the extent to which new legislation will effectively change the future development is uncertain, and thus the assumption of successful implementation of existing policies can be seen as a systematic bias in baseline projections.

20. Along the same line, agricultural projections (e.g., those developed with the CAPRI-model) prove sensitive towards policy initiatives that are assumed in these projections. As in the model the assumed effectiveness of legislation – and thus the basic response of agricultural actors to policy interventions - is based on expert judgement, agricultural baseline projections are strongly influenced by the current perception among European Community experts. Experience shows that expert perception is often dominated by the current status and by very recent events with a tendency to underestimate the potential for significant and structural changes in the longer term. Along these lines, current baseline projections in CAPRI do not consider potential disruptions of historic trends, such as sudden changes in diets, agricultural subsidies, or abandoning of overfertilisation.

21. The transport sector, as modelled by the COPERT model, provides a prime example of emission control regulations that have not fully achieved the desired outcomes. While earlier versions of the COPERT model employed the designed efficiency of NO_x-control measures, higher real life emissions have been observed for a.o. Euro-3 vehicles, inter alia as a consequence of different driving patterns in reality

as compared with the regulatory test cycle. For heavy duty vehicles, the SCR-equipment proved to be malfunctioning at low temperatures, leading at lower speed to 50% higher NO_x-emissions than estimated on the basis of the test cycle. While the effect on total national emission is estimated at a few percent, the effect on urban emissions and concentrations could be substantially higher, and represents a major area of uncertainty in projections of emissions and local air quality.

22. Atmospheric dispersion models embody a vast array of scientific understanding of physical and chemical processes, although they will always remain an incomplete representation of reality. Obviously, new scientific research is constantly improving much of this understanding while opening new questions. Thus, the EMEP model which provides quantifications of atmospheric dispersion characteristics to the GAINS integrated assessment is constantly being updated to incorporate recent scientific findings.

23. The source-receptor relationships incorporated in GAINS have been derived from an EMEP model version of 2006, and the EMEP model has been updated in several respects since then. Model intercomparison - as performed under Eurodelta and the Task Force on Measurement and Modelling - is a key method of uncertainty assessment in atmospheric models. Model intercomparisons show that grid average depositions from the original model as well as from updated versions are generally well within the range produced by other models. Given the uncertainties related to the quality and representativeness of available deposition monitoring data, it is difficult to unambiguously establish the superiority of different model versions. Thus, the workshop concluded that the source receptor matrices derived from the 2006-model version could still be used for integrated assessments for the revision of the Gothenburg Protocol.

24. Scientific progress was also made in quantifying the sensitivity of ecosystems towards acidification and eutrophication. In addition, national focal centres provided critical loads estimates with finer spatial resolution, so that at the moment the European critical loads database holds approximately 1.3 million data points. With all these refinements, however, the current map of critical loads does not differ significantly from the one used 10 years ago, which provides a sense of robustness of these estimates. The robustness had been further enhanced by analyzing the implications of empirically determined critical loads, which provides an independent alternative methodological approach. One remaining area of uncertainty in this area is the environmental consequences of exceedances of critical loads and the establishment of deposition-response relationships leading ultimately to a quantification of effects.

25. Numerous new studies have focused on the quantification of health impacts from air pollution. While earlier studies showed health impacts of short-term ozone episodes, new research suggests an association between premature mortality and long-term ozone exposure. Thus, health impacts from ozone would be systematically underestimated by analyses that rely only on short-term time series studies, as was

done by the GAINS model before. The workshop recommended exploring this aspect through ex-post analyses.

26. For particulate matter, despite a large body of new scientific studies, uncertainties prevail about the relative toxicities of the various components. The assumption of equal toxicity should be considered as a cautious approach, although the implications on cost-effective mitigation strategies should be further explored in targeted sensitivity analyses. However, the holistic perspective of the multi-effect approach that combines health and vegetation concerns is seen as a practical and powerful way to minimize overall uncertainties of strategies that include multiple pollutants.

27. An additional source of uncertainty is related to the limited spatial resolution of European wide atmospheric models. As also local measures could reduce population exposure at the sub-grid scale, integrated assessment should develop methodologies that could provide robust assignments of effective policy actions at the local, national, international and inter-continental scales.

28. In addition to the uncertainties in the previous parts of the causality chain, cost-benefit analysis faces uncertainties in the valuation of impacts. Current estimates relate about 90% of the economic damage to health effects, mainly determined by the valuation of mortality. Five percent of total damage is estimated for crops and five percent from damage to materials. However, these estimates are incomplete as there is no accepted method yet to estimate the damage of air pollution to ecosystem services and cultural heritage. It was recommended to focus sensitivity analysis on alternative assumptions for the valuation of mortality and abatement costs.

VI. HOW TO INCREASE THE ROBUSTNESS OF POLICY?

29. Experiences from the UK demonstrated that recent government projections were mainly focussed on alternative trajectories towards politically desired low emission pathways, although these pathways represent only a fraction of the full uncertainty margin that was derived by Monte-Carlo analysis. As such a narrow focus could entail business risks for investments in the energy sector, it was recommended to consider a broader range of baseline scenarios, including cases with potential policy failures.

30. A study for Belarus highlights a large variability in the costs of abatement measures across different plants within the same sector. It was recommended to base policy strategies not only on average unit abatement costs, but consider the probability distribution.

31. It was found that a solid understanding and quantification of uncertainties provides certainly useful information for policy negotiations. However, as many

uncertainties are genuinely irreducible, there is an interest on how these unavoidable uncertainties could be managed in order to derive robust policy conclusions. One option, which was not explored at length in the past, would provide increased flexibility in the implementation of cost-effective emission control agreements.

32. Future emission targets, if expressed in absolute ceilings, suffer from uncertainties in current emission inventories. Current emission estimates of particulate matter showed much larger uncertainties than estimates for SO_2 and NO_x. These uncertainties could be quantified based on methods recommended in the emission inventories guidebook. In the future, satellite observations could provide additional means to confirm suggested trends in emissions, although it will remain a challenge to derive absolute levels of emissions with such techniques.

33. Within the UN-Framework Convention on Climate Change relative emission reduction targets (%) have been accepted as a way to handle uncertainties in greenhouse gas emission inventories at the time when the agreement is signed. This provides Parties with more time to refine their estimates, but requires elaborate validation procedures to avoid biased corrections. As emission estimates of particulate matter are similarly uncertain, this model could be adopted for a revised Gothenburg Protocol too. Alternatively, newly detected emission sources or significantly modified emission factors for known sources could be excluded from agreed emission ceilings, as to not discourage parties from further improvements of their emission inventories.

34. In order to deal with uncertainties due to economic and meteorological fluctuations, emission ceilings could be set for the average of consecutive three years, instead of one single target year.

35. Target setting with GAINS could possibly give more robust results when the gap closure approach was based on (more certain) base year values, rather than on uncertain target year projections including current policies.

36. It was recommended to explore the implications of different energy and agriculture baselines including a hypothetical no-policy case, a more ambitious climate policy case and a case with distinctively different consumer preferences, possibly induced by economic incentives.

37. In recent negotiations, emission ceilings for various pollutants have been negotiated based on a series of cost-effectiveness analyses with the GAINS model. While environmental targets for the different effects have been agreed upon by the Parties, reductions for different pollutants have been determined based on information on mitigation costs that depend crucially on the assumed baseline economic development. However, these aspects are associated with considerable uncertainties

38. CIAM presented an exploratory analysis of to what extent Parties could swap emission reductions between different pollutants in the same country without compromising environmental integrity. This would provide some form of flexibility to Parties to adjust ex-post for, e.g., a different economic development once a set of emission ceilings has been agreed upon while safeguarding the originally envisaged environmental improvement. Analysis with the GAINS-model showed space for pollutant swapping within a country through well-defined 'exchange rates' that are derived from information about atmospheric dispersion and environmental sensitivities. Pollutant swapping would not necessarily have to be executed via complex emission trading systems, but could be performed by national redistribution of emission reduction efforts according to country-specific exchange rates that could form an integral part of the agreement on emission ceilings. The design of this specific flexibility would however have certain limitations. For example, NO_x would not be 'swappable' given its impact on the various effects in the process. Exchange rates should be established in a conservative manner to ensure that agreed health and ecosystems targets are met.

39. In general participants welcomed the analyses for of different options for providing more flexibility for compliance with emission ceilings, although potential legal challenges would need further exploration.

40. The workshop concluded that acceptance of results of integrated assessment models will be enhanced not only through stakeholder involvement, model transparency, and enhanced sensitivity analyses, but also by exploring suitable arrangements that provide flexibilities in implementing agreed policies.

VII. CONCLUSIONS

41. While the workshop offered a long list of uncertain elements in integrated assessment modelling, this should not lead to the conclusion that current modelling tools are not useable in a policy context. In general the data base, the modelling framework and the methods to develop targets were considered fit for purpose of providing robust information for air pollution abatement strategies. In particular, experts confirm their confidence about the harmful impacts of air pollution on health and ecosystems, and that there is scope for cost-effective improvements.

42. Scientific knowledge will develop further and will most likely provide new answers, but also create new questions and uncertainties. A regular review of data and knowledge was recommended. Uncertainty analysis by integrated assessment modellers could provide directions to future national and international research programs to tackle salient sources of uncertainty.

43. It is important to establish confidence that no important environmental problem is overlooked and that suggested costly policy measures would not be regretted later. Sensitivity analysis can help to establish the robustness of policy strategies. Sensitivity analyses should not be done at the end of the policy process. Sufficient resources would be required to ensure that sensitivity runs accompany scenarios made during the whole process.

44. Priority should be given to analysing a broader range of baselines with time horizons extending beyond 2020, including cases with more ambitious climate policies as well as with policy failures. Furthermore, sensitivity analyses should address implications of alternative hypotheses about the toxicity of different species of particulate matter, of higher real life emissions of vehicles and of new information on the potentials and costs for ammonia abatement.

45. Communication with decision makers will be essential for building trust in messages from scientists, to improve on the communication of uncertainties and to manage resulting policy risks.

46. The workshop concluded that the robustness of emission-ceilings based strategies could be enhanced by creating more flexibility in achieving the emission ceilings, including possible mechanisms to adjust for different economic developments, relative reduction targets for uncertain sources and procedures to deal with new sources and significantly revised estimates for emissions from known sources.

47. Participants of the workshop were invited to provide the Chair and the secretariat in writing their further input to the discussion on uncertainty treatment and the development of an extended list of elements for further research and uncertainty analysis. From this list, priorities within the available time schedule and resources should be selected.

VIII. PROGRESS OF TFIAM-WORK

48. The revision of the Gothenburg protocol is envisaged to be agreed upon in December 2011, so that the Working Group on Strategies and Review should decide upon new emission ceilings by September 2011. CIAM is continuing its work on modelling short term climate forcers, and a report will be finalised in January 2011.

49. During its 47th session (August 30 – Sept 2) the Working Group on Strategies and Review requested the Task Force to explore additional options for target setting. CIAM would present a ‘hybrid option’ based on the options 3, 4 as well as 2 of the CIAM report 1/2010) at the 39th meeting of the Task Force in February 2011. CIAM

would analyse ambition levels between 25% and 75% of the gap between current legislation and maximum feasible reductions.

50. Country data of the target setting options developed thus far would be made available by end of November 2010.

51. During its next meeting the Task Force will identify abatement measures that would result in substantial further environmental improvements. The Task Force took note of the methodology developed by Italy to translate the emission limit values in the draft technical annexes as proposed by the Expert Group on Techno-Economic Issues. CIAM would work further with Italy to develop GAINS scenarios for each of the three ambition levels in the technical annexes.

52. The Task Force on Reactive Nitrogen had updated its estimates on ammonia abatement costs. Practical experience in a growing number of countries suggests that low efficiency manure storage options and spreading is becoming less expensive over time, while costs for high efficiency storage options are higher than previously estimated. CIAM will look at the possibilities to implement this new information in GAINS, but need to await outcomes of the discussion on the applicability of various options. However, the timeline of the Task Force on Reactive Nitrogen would not be in line with the planned development of the 'hybrid target setting options' by CIAM.

53. CIAM will make emission data available to the Working Group on Effects for the ex-post analysis of the environmental impacts of abatement strategies. While emissions for the baseline and the maximum feasible reduction cases are already available, after April 2011 a new set of emission scenarios will be made available that covers the range of ambition levels being discussed within the Working Group on Strategies and Review.

54. The Network of Experts on Benefits and Economic Instruments (NEBEI) would in collaboration with TFIAM-experts finalize the update of the guidance document on economic instruments. The workshop took note of a database of policy measures developed by Ireland and available at: www.policymeasures.com. Experts were invited to add information to this website.

55. The 39th meeting of the Task Force would be held in Stockholm, 23-25 February 2011 and the 40th meeting in Oslo, 18-20 May 2011.