

## **Rapporteur's Summary**

**R. Tol**

## **Rapporteur's Report on Session VII: How can IAMs research conclusions be applicable to both developing and developed countries?**

**Rapporteur: Dr Richard S.J. Tol**

Dr R. Richels, USA, discussed the 'Timing of Policy Responses and Cost Distribution'. He presented results of MERGE 3, which differs from the previous version of the model by its greater regional diversification (nine instead of five regions) and the inclusion of endogenous (instead of exogenous) technology diffusion. The model was applied to compute the cost of reaching various stabilization targets for the atmospheric concentration of carbon dioxide (450, 550, 650 and 750 ppm) under four scenarios (emission path according to WG1 or WRE; without or with internationally tradeable emission permits).

In all scenarios, developing countries follow business as usual emission for the next decades. In the 550 ppm case, emission entitlements are grandfathered in 2030 and subsequently linearly shifted to an equal per capita emission permit distribution in 2050 (according to 1990 population). Dr Richels concluded that allowing international trade in emission permits could cut global costs of meeting the 550 target into two, and that developing countries may benefit from such trade. Abating less in the next decades but more in the later ones could cut global costs to a third, but developing countries may suffer a net loss in this case. However, gains in the OECD are found to be sufficient to compensate developing countries.

Dr Richels continued by saying that emission reduction would reduce the price of oil on the world market. This would be beneficial for OECD countries (which are net importers of oil) but harm the former Soviet Union (a net exporter). The findings for the rest of the world are mixed (as there are net exporters and importers) and scenario dependent. Qualitatively, these findings are independent of the concentration stabilization target chosen. Quantitatively, costs are higher for lower targets.

Dr Richels concluded by stating that: (1) considerations of economic efficiency help reduce the costs of emission reduction; (2) postponing emission reduction increases climate change in the near future; (3) the higher the probability of a low target (450 ppm), the more carbon dioxide needs to be abated in the near future; and (4) he does not advocate a wait-and-see policy; rather, the optimal portfolio of climate policy should focus on research and development now, and on emission reduction later.

Professor Bolin wondered how robust or uncertain Dr Richels results are. Dr Richels answered that similar conclusions were found in 3 other models, while EMF/IPCC is convening a comparative analysis with 10-15 models.

Dr La Rovere questioned that technology development may be assumed endogenous. Dr Richels answered that he doubted that price signals induce research and development, although it may aid diffusion (as in his model). This issue is a great intellectual challenge. Market failures may be overcome through public/private cooperation. Current trends are not reassuring, though.

Prof. J. Parikh, India, spoke on 'Collective decision-making and north-south equity'. She argued that a proper analysis of climate policy include emission reduction costs, including joint implementation, as well as impacts, adaptation and compensation. Abatement costs should internalize all social and environmental externalities, including those of climate change. Discounting ought to be based on a liability exercise (instead of an evaluation of

investments) and economic development should be reflected through world average per capita income (so that OECD countries face economic shrink whereas developing countries face growth). A global policy should be set in a collective decisionmaking framework, with safe minimum standards (rather than cost-benefit analysis) as a starting point.

Emission entitlements should be set such that developing countries get their fair share in accumulated emissions. She continued with an analysis of India's carbon dioxide emissions, indicating that only 15% of emissions could be directly ascribed to consumption. She further pointed out that emissions vary widely between income classes, but that the top 10% in income in India is still well below world average emissions.

Dr Patwardhan asked how emissions should be shared internationally. Professor Parikh answered that this should be the outcome of a collective decision making process, respecting equity. She expressed her hope that Kyoto would lead that way, since with each additional year of wait-and-see the USA would consume more of India's need for future emissions.

Professor J. Alcamo, Germany, treated 'Safe Emission Corridors'. The concept of a safe emission corridor emerged out of an iterative process between the IMAGE team and a selected of climate negotiators and other stakeholders. This analysis tries to reconcile short term (up to 2010) emission targets with long term (up to 2100) climate goals, so that landing is safe. The result is a corridor of global emissions. If actual emissions up to 2010 are in the corridor, long-term targets can be met without reducing emissions too fast in later years. The lower bound of the corridor is determined by the maximum rate of emission reduction in the earlier decades. The upper bound of the corridor is determined by the climate targets and the maximum rate of emission reduction in later decades. The long-term climate goals are inspired by Article 2 of the Framework Convention on Climate Change but are still open to debate.

Professor Alcamo derived the following insights from the analysis. The stricter the long-term targets, the greater the downward deviation from business as usual scenario. The stricter the targets, the smaller the corridor. The higher emissions in the near future, the less flexibility for future emissions. The safe corridor applies to global emissions. If developing countries are allowed to emit as under a business as usual scenario, Annex I countries will have to reduce their emissions soon. For the medium corridor, OECD emissions in 2010 should be between 64 and 105% of 1990 levels. Professor Alcamo concluded with stating the following limitations to his analysis: (1) the chosen climate indicators (level and rate of global mean temperature and sea level) are not adequate; (2) sulphate aerosols matter but are not included; (3) uncertainty about for example the climate sensitivity matters, but cannot be included in IMAGE; (4) economic considerations matter but economic models are too immature to give meaningful insights; and (5) although the target rate of temperature change lies well above the current rate, strict targets are common in environmental policy. Various questions were raised: (1) Can this analysis accommodate uncertainties? (2) How are targets in 2100 uniquely tied to targets in 2010? (3) How much international cooperation is required to make this work? (4) What do sulphate aerosols do to the regional distribution of climate targets? (5) What is the justification for assuming that developing countries will be able to substantially cut their emissions in the future? (6) How sensitive are the results to the maximum rate of emission reduction? (7) What is the basis of the assumed maximum rate of 2% per year? (8) Would it not be sensible to add a restriction that emission paths should be smooth?

Professor Alcamo answered as follows: (1) Decision makers are sufficiently intelligent to do uncertainty analyses themselves. IMAGE cannot do uncertainty analysis. (2) A finite set of emission paths were generated. The results follow from selecting those that meet all constraints. (3) All emission paths are smooth.

Professor K. Yamaji spoke of the 'Role of Technology in Climate Change'. Six types of technologies are available to influence the causal chain from human needs to the impact of climate change: (1) dematerialization; (2) emission efficiency improvement; (3) decarbonization; (4) sequestering; (5) geoengineering; and (6) adaptation. This talk focused on points 2-4, using the Dynamic New Earth 21 model. DNE21 is a ten region model that performs intertemporal cost-minimization of emission reduction over the next century, so as to meet carbon dioxide concentration targets. The model is a (semi-)partial equilibrium market of the energy market, with considerable detail in energy technology. Supply of energy carriers is given and elastic. Nuclear power is exogenous. Demand for secondary energy commodities is given and elastic in some scenarios. Compared scenarios are business as usual, stabilization at 550 ppm with elastic demand and 1% autonomous energy efficiency improvement per year, and stabilization at 550 ppm with inelastic demand and 1.5% AEEI/year. Under Business as Usual Scenarios [BaU], coal is the dominant energy source. Under the second scenario, gas takes over the role of coal while renewables and carbon sequestration and recovery play a larger role. Under the third scenario, the carbon backstop technology and renewables are the dominant energy source. It is found to be optimal to postpone stricter emission reduction to the second half of the next century.

Professor P. Wibulswas, Thailand, discussed 'Technical changes in developing countries', focusing on energy sources in Southeast Asia, and Thailand in particular. The role of biomass is large at present but, while growing in absolute terms, it is decreasing in relative terms. Incineration of waste may be a further source of energy, but is not competitive at current technologies and prices. Similarly, biomass plantations (e.g., replacing cassava's failing exports) are not competitive. Hydropower has been expanding rapidly over the last decade. Further expansion is hampered by environmental concerns and the required replacement of populations. Alternatives are medium and small scale hydropower generation, and large hydropower in lightly populated parts of Malaysia. Biomass and hydro cannot meet growing demand while Thai gas reserves are exploited at their maximum. Gas imports are hampered by the lack of deep sea-ports, and environmental concerns about digging these. Imports per pipeline from Myanmar are politically constrained. Installing nuclear power is constrained by public acceptance and political stability. In the short-term, expansion of biomass seems the preferred option, taken up in the medium term by hydropower. For the longer term, nuclear power may be viable, provided that preparations are made.

Professor Wibulswas wondered whether IAMs are capable of including such issues, or the environmental consequences of large hydropower.

Professor Dowlatabadi, USA, treated 'Decision making under uncertainty'. He argued for evolutionary modelling, since the problem is characterized by limited determinism, imperfect knowledge, labile values, and blunt policy instruments. He first illustrated this type of modelling with impacts of and adaptation to sea level rise. Over the years, estimated costs of sea level rise have fallen considerably, due to lowered estimated of sea level rise and inclusion and perfection of adaptation. Including storms, however, damages go up again, perhaps by a factor of 5. The stochastic nature of storms prevents decision makers to make perfect forecasts, and leads them to sometimes overreact and sometimes underreact. Depending on the actual storms that occur, sea level rise may have negative as well as positive impacts, although the mean is negative. If, in addition to sea level rise, the storm regime becomes less severe, potential (low-probability) benefits of sea level rise disappear. A similar adaptive decision maker is considered in the latest version of the ICAM model. Given the uncertain characteristics of the climate and energy systems, policy should be evaluated as to their influence on a smooth and relatively certain indicator. Emissions were found to be erratic, and temperatures highly uncertain. Only the concentration of carbon dioxide was

found to meet both criteria. Given the many assumptions in the model, Professor Dowlatabadi concluded that the best policy today would be a carbon tax of \$15.

Dr Grubb stressed that valuing and aggregating impact estimates of climate change is an inherently ethical issues which should be solved by adhering to juridical practices in international relations. He wondered about the influence of culture in model-design, reminding that US-based economic models assumed that decision makers want to maximise current assumption in an environment without limits. 'Old world' model design may be more suited for a world with limits and precautionary decision makers.

Vice-Minister A. Sugandhy, from Indonesia urged that integrated assessment models be designed in close cooperation between modellers and policy makers. He wondered whether current modelling practice has progressed sufficiently far to be used in Kyoto, e.g., with respect to sectorial detail.

A Chinese participant then remarked that if models are sufficiently certain, they should be used throughout the world. If not, developed countries should perform more research. Models that represent particular countries best should be used there.