Workshop on GHG Stabilization Scenarios

National Institute for Environmental Studies
Tsukuba, Japan, January 22-23, 2004

Summary Report

The Workshop on GHG Stabilization Scenarios was held at the National Institute for Environmental Studies (NIES), Tsukuba, Japan from January 22nd to January 23rd 2004. The workshop was co sponsored by NIES and the Stanford Energy Modeling Forum. The schedule of the workshop and the list of participants with their affiliations are appended.

Dr Shuzo Nishioka, Executive Director, NIES and Mr. Yasuo Takahashi, Ministry of the Environment, through their address welcomed the participants to the workshop. They remembered the great work of Dr Morita and hoped that this workshop would help carry forward his work and dreams.

Dr Mikiko Kainuma, NIES, and Dr John Weyant, EMF, introduced the objectives of the workshop. Through her presentation she discussed the IPCC SRES and Post SRES works. She elaborated on the important lessons learnt from these exercises. They include that appropriate policy/technology options are different for different development paths and stabilization levels. However, robust technology options can be found across them. Also the timing of reductions is dependent on future development paths and stabilization levels and high emission path as well as low stabilization level would require early reduction. She also pointed out that most mitigation scenarios show the necessity for developing regions to start GHG reductions before 2040 in order to reach 550ppmv or lower stabilization levels or otherwise developed regions would be required to stop all GHG emissions, and in turn, the world economy would collapse.

Dr Kainuma then elaborated the main themes of the workshops, which included issues like the appropriate stabilization levels, down scaling of scenarios and the importance of feedback/collaboration among different modeling groups, which is essential for achieving integrated scenarios. Dr John Weyant added to the above, a few more issues for discussion during the workshop which included baseline assumptions, policy options

regarding carbon tax, technology diffusion, Non CO2 gases etc, assumptions for international trade in GHGs, burden sharing among countries, and feedbacks to consider. These presentations put the objectives of the workshop in perspective and set the ball rolling.

Before the presentations got to a start Dr. Kainuma also asked the participants to support the update of the IPCC scenario database to which Dr Morita had devoted much of his work. She also informed the participants of a special issue in Environmental Economics and Policy Studies in memory of Dr Morita and called for papers for this issue . The deadline for submission is January 2005.

The first day of the workshop consisted of the session on Integrated Assessment/ Climate Economic Modelers. Experts from all over the world presented on a wide range of issues on climate change. The outputs were from a wide range of models used for analyzing issues in climate change.

Session 1: Integrated Assessment/Climate Economic Modelers

Dr Y. Matsuoka, Kyoto University, made the first presentation in this session. He elaborated on the application of AIM family of models for carrying out GHG stabilization scenario analysis. He explained the Aim family of models in detail and presented his analysis on stabilization scenarios. An important assumption was the convergence approach for burden sharing. The results showed that drastic reductions would be required by developed countries (60-80% for 450ppm) compared to 1990 emissions. In the case of full scale carbon trading this would be about 60%. Dr Schlesinger, University of Illinois, raised the question that, since the Kyoto protocol is likely to fail, would a Kyoto like analysis be useful. Dr Matsuoka clarified that the analysis beyond 2012 was not totally dependent on assumptions involving successful implementation of the Kyoto Protocol.

A presentation on the multi gas analysis using the AIM/CGE (Asia) model was made by Dr Fujino. The model is currently under development and some preliminary results were presented. Results included anthropogenic GHG emissions for BAU, CO2 mitigation only and multi gas mitigation scenarios. Attempts are being made to link this model to the bottom up AIM/Enduse model for analyzing non-CO2 gas scenarios. After the presentation Dr Schlesinger remarked about the appropriateness of using radiative forcing of 4.5 W/m^2. However Dr Fujino explained that this analysis was carried out according to the assumptions prescribed by EMF.

Dr Jae Edmonds presentation focused on the role of technology in stabilization, using the MiniCAM model. He briefly explained the structure of the model and presented the refernce case (B2) scenario results which included emissions, concentrations, sea level rise and global mean temperature change. Through his analysis he showed that the inclusion of non-CO2 greenhouse gases in an analysis of greenhouse gas stabilization would have important implications. Also limiting the change in radiative forcing to 2^oC would imply stabilizing CO2 concentrations at 500 ppm. The cost analysis showed that improved technology portfolio could reduce the cost substantially—from $4.5 trillion to $1.5 trillion. Dr Schlesinger reiterated about the inappropriateness of using radiative forcing higher level of 4.5 W/m^2. However Dr Edmonds clarified that this level was used for the analysis because of its conventionality. Also while answering questions Dr Edmonds clarified that higher ocean heat uptake and its correlation with climate sensitivity had been considered for the analysis. Prof Shukla made a clarifying remark that reduction in costs from $4.5 trillion to $1.5 trillion implies interpreting the difference as an investment in R&D activities.

Dr Detlef Van Vuuren presented on the ongoing work stabilization scenarios at RIVM using the IMAGE 2.2 model. The presentation chiefly covered issues in modeling multi gas stabilization scenarios, which included whether scenarios be defined based on radiative forcing or temperature and in either case its implications. The analysis using the IMAGE 2.2 model (aiming for 4.5 W/m2 in 2150) showed that using GWPs, a considerable share of early abatement is in CH4/N2O and in the later years most of the

abatement needs to come from CO2. Also further analysis would focus on issues like the role of uncertainties, how changes in stabilization targets might change results, and also inclusion of land use/non Kyoto gases in the analysis. Dr Matsuoka enquired whether trading of carbon permits had been considered in the analysis. Dr Vuuren clarified that the analysis showed the emergence of groupings and LDCs sold permits to DCs. In an answer to a separate question he also pointed out that in the medium term SO2 emissions decrease in the DCs and increase in the LDCs. However in the long term they reduce in the LDCs too as a result of mitigation initiatives.

Dr Shukla, IIMA, presented on stabilization scenarios and its implications for India. He paid tribute to the work of Dr Morita whom he considered a friend and a great scientist. He then described the development of Indian scenarios along the lines of SRES. The presentation included the long-term energy emission scenarios for India for both the medium term and the long term. The presentation also included the implications of South Asian regional cooperation for stabilization. He emphasized the importance of policy actions with regard to technology portfolio, fair allocation of emission rights, linking development and climate change and designing multiple pathways. In the course of answering questions Dr Shukla clarified that there was decoupling of GDP growth and carbon emissions. Also to a question related to the technologies used in the transportation sector, he clarified that in the B1 scenario, strong public transport had been built in. Also CNG and fuel cells had been considered as technology options in the modeling exercise.

The post lunch session started with a presentation by Dr Mori, TUS. He presented on the Phoenix project under way at his institute. The project concerns Integrated Assessment of Global Warming Mitigation and Adaptation and the Development of Multi-regional and Multi-sector IAM. Details of the structure and the methodology were presented. The expected outcomes of the project include helpful information on the energy technology development strategies, preferable burden sharing scenario for carbon emission reduction and assessing industry policies for R&D in energy and environmental technologies.

Dr Jiang, ERI, presented on issues in modeling future scenarios in a fast changing and growing country like China. Through his presentation he clearly brought out the difficulties faced by modelers in accessing reliable data in an ever-changing economy. He also presented energy and emissions results for China for the medium term and mentioned that future work also included conducting studies for Beijing, Chongqing, Taiyuan, and Ningxia provinces. Dr Jiang also pointed out that it is important to prepare a twenty year national plan and think about a long term strategy (till 2050) for the country.

Using the GRAPE model (consisting of the energy, economy, landuse, impact and climate modules) Dr Kurosawa, IAE, presented his analysis for GHG mitigation. His analysis included F-gas also. The analysis traced the atmospheric concentration of HFCs, HCFCs, CF4, and SF6 over the past three decades. He pointed out that for long-lived GHGs that inspite of considerable reductions, the concentration levels are expected to remain the same over the long run. Also through his analysis he showed that the co-benefit of CO2 mitigation for the energy sector is not small. Lessening the dependency of fossil resources in the energy system will be helpful for the reduction of CH4 and N2O. Including non-CO2 GHG abatement measures in the energy sector would relax climate impacts. Also additional non-CO2 GHG abatement efforts are required in the agriculture sector.

Dr Richels, EPRI, presented on the issues of uncertainity, timing, costs and technology in stabilizing long term temperature. Using the MERGE model he covered issues pertaining to the range and likelihood of temperature change over the 21st century in the absence of climate policy, the impact of technological expectations on the least-cost emission pathways for stabilizing global-mean temperature, the potential value of a technology rich energy future, and the need to focus on stabilizing temperature rather than concentrations. In response to queries regarding the appropriateness in the use of the right range of temperatures, raditaive forcings, he reiterated that the framework of analysis is more important as sensitivity analysis can be carried out over a range of numbers.

The post tea session included presentations and open discussion for the first session. Dr Chesnaye, USEPA, presented on the experiences from EMF 21, in addressing non-CO2 gases and sinks in GHG scenarios. The presentation included giving a detailed outline of the EMF 21 study underway and the initiatives on the data development front for Non-CO2 GHGs and sinks. The results included comparisons of GHG emissions trajectories developed by the various modeling teams that form a part of EMF 21. He also discussed the importance of sinks in sequestration. He pointed out that a landuse and integrated assessment workshop is planned in spring/summer this year with ABARE and RIVM.

Dr Nakicenovic's presentation focused on the alternative paths towards stabilization and the challenges ahead for new scenarios. He paid tribute to Dr Morita and remembered the work they had done together. He presented the SRES scenarios in great detail and also discussed some recent results regarding emission paths for global CO2 for scenarios like A1B-550 when mitigation options like demand reduction, fuel switching and CO2 scrubbing and removal are introduced. Dr Nakicenovic emphasized that there is deep uncertainty and limited knowledge is available on the feasibility and costs of future technologies. He pointed out that it is essential to consider downscaling and its limitations. The modeling community should include all GHGs and particulates in multigas baseline scenarios and the role of additional GHGs and particulates need to be considered in stabilization scenarios. Dr Edmonds agreed with the importance accorded to scenarios and pointed to the importance of thinking on stabilization cases as a community. Dr Nakicenovic felt that modeling forums like EMF provided the right opportunity for modelers to come together.

The presentations were followed by an open discussion. The major topic was with regard to ides for new stabilization scenarios. Dr Yohe felt it was important to think about how long-term temperature targets are to be determined and how mid term corrections can be made. Also it is important to discuss the transaction costs in terms of allocation of emission targets. Dr Nakicenovic reemphasized that analysis show that action would be required to be taken in the next few decades. Dr Richels pointed out that it is important to

think about moving from concentration to temperatures in addressing stabilization and also thought should be given to an optimal hedging strategy.

Session 2: Climate Modeling

The second day of the workshop started with the session on Climate modeling. Climate modelers from different parts of the world using a variety of climate models presented their analysis. Dr Akira Noda, MRI, using the MRI-CGCM, made the first presentation of the day. The presentation included downscaling with MRI regional climate models and earth system modeling for the carbon cycle and chemical mass transport. The analysis included surface air temperature trends over the next century, spatial patterns of global warming and natural variability bith due to El Nino and CO2 increase, and simulations of tropical cyclones. The presentation also detailed the climate modeling at MRI using the earth simulator which is considered to be the best in the world. In the course of answering questions Dr Noda suggested that his team is also planning to get multiple simulations for the same state. To a separate question on El Nino he pointed out that many models have predicted El Nino like climate change. If El Nino like change is true then sea to air flux is reduced. This change would then be related also to stabilization issues.

Dr Cubasch, ZEDAT, Presented on the European project for climate change modeling named ENSEMBLES. The presentation reviewed the Third Assessment Report results and discussed the new developments. Prominent among the new results discussed were the PDF of temperature change simulated with the Hadley Centre model and the PDF of climate projection. The presentation also outlined the experiments being conducted for the fourth assessment report. The final part of the presentation covered details on the ENSEMBLES project, which is a five-year project, funded by the European Commission and has eight research themes. The project is expected to get underway by April 2004. During the course of answering questions, Dr Cubasch expressed his reservations regarding how open IPCC would be to changes in stabilization paths. Dr Forest, MIT, queried about the extent of data and computing that team has ready for AR4. Dr Cubasch was of the view that it is important not only to have computing power but also adequate

manpower. He explained that the project was set up for research for five years and most of the fund had to be used for policy analysis and not for fundamental research.

Dr Schlesinger, University of Illinois, presented on climate sensitivity, uncertainties involved and the learnings. Through his analysis Dr Schlesinger showed that the IPCC misinterpreted the findings of the Charney report and that the there is only a 50% likelihood that ? T2x (climate sensitivity) lies within 1.5° to 4.5°C. He also showed that to reduce the uncertainty in climate sensitivity it requires reducing the uncertainty in the radiative forcing, not only by aerosols, but also by the Sun and volcanoes, and that the observed warming during 1856-1990 was mostly human induced. With respect to learning over time he pointed out that The uncertainty in climate sensitivity due to climate noise can be reduced by learning over time, that is, by performing future estimations using longer observational records, and it is quite likely that the formulation and negotiation of policies to abate human-induced climate change will, for the foreseeable future, continue to be made against a backdrop of deep uncertainty. He reiterated the importance of focusing not only where we end, but also how we can begin and the need to develop near term hedging strategies.

Dr Chris Forest, MIT, presented on stabilization and global climate policy in a multi gas world. The aim of the research was to examine the issues involved in current discussions of stabilization policy given a multi-greenhouse gas world. In the analysis –using the EPPA model, a CGE model - the CO2 only scenario and the GHG trade scenarios were considered. The analysis showed that stabilization of carbon dioxide concentrations can be met at reasonable costs. However, these costs will be much less if trading is allowed between all gases. Additionally, an all-gas policy is much more effective than CO2 only policies on the two-century scale and uncertainty in costs and uncertainty in impacts should be incorporated into the determination of appropriate targets. Dr Richels pointed out that it is also important to go beyond GWPs to analyze trade. Dr Kurosawa queried on the natural emissions of each gas and whether feedback between natural emissions and climate change has been considered. The modeling effort in fact did take this into consideration according to Dr Forest.

After a short tea break Dr Wigley, UCAR, presented on overshoot pathways to CO2 concentration stabilization. He presented on the revised carbon cycle model and why constructing new stabilization profiles are important. He elaborated that new stabilization profiles are important because there are new baseline no-policy scenarios, there are improved carbon cycle models, and these models now account for climate feedbacks on the carbon cycle. The presentation then discussed overshoot possibilities and its consequences on temperature and sea level. His important conclusions included that Climate feedbacks lead to substantially lower emissions requirements to meet any given stabilization target and It seems likely that overshoot pathways would reduce mitigation costs much more than they would increase climate-change damages – unless there are non-linearities that lead to much larger damages if thresholds are passed. Dr Nakicenovic observed that most stabilization curves peak before 2100 and hence there is not much time to buy. Also Dr Richels remarked that it is important to consider what buys time in the 550 ppm case because most costs are frontloaded for mitigation. In the shorter term mitigation would be a political challenge while in the longer term it would be a technological challenge.

The next presentation was by Dr Nozawa, CCSR/NIES, who presented on climate change experiments with a high-resolution climate model. The presentation discussed the current experiments, the results and the future plans. The interesting presentation detailed how the modeling exercise was successful in locating typhoons. In the course of answering questions Dr Nozawa remarked that though the model was successful in locating typhoons, the total located during the period 1979-1998, was only about one fourth of the observed during the same time period. He also pointed out that the model was capable of reproducing daily precipitation frequency.

Dr Kheshgi, EMREC, presented on the objectives of the stabilization scenarios, the consumer of the scenarios, and what is it that needs to be stabilized and the targets and the uncertainties involved. He opined that currently there is very little ability to make probabilistic forecasts of climate limiting determination of safe levels of greenhouse

gases. Also it is important to assume substantial management of plants and soils, which the models do not at present. Dr Kheshgi was in favor of transparency in the whole process of considering and ascertaining stabilization paths. Dr Weyant also emphasized the importance of stabilization targets. He reiterated that while it is good to consider long-term targets, it would also be beneficial if the uncertainties involved with such an exercise were also considered. However Dr Nakicenovic was of the view that in certain cases long-term issues were easier to comprehend than short term. He cited that it would be easier to figure out say the future of a Hydrogen economy, than the future of electricity sector reforms.

This presentation was followed by an open discussion. Dr Yohe pointed out that long term stabilization should not only motivate decision makers to look at long term issues but also mid term corrections. He also advised modelers to look at issues such as intertemporal discount rates. Dr Mori suggested that there was a need for a road map that would outline the development of various mitigation technologies like carbon free technologies. In his view this was important because policy makers demand figures like the level of investments required in R&D in say in the next ten years.

Session 3: Impact Modeling

The post lunch session on the second day was dedicated to Impacts modeling. Dr Takahashi, NIES, made the first presentation. The presentation gave a detailed overview of the Impact study under the AIM project and its relation to the stabilization scenarios. The presentation started with a brief introduction to the Aim/Impact model. The model covers impact on sectors like water, agriculture, health and natural vegetation. Results from various studies on these sectors were presented. The presentation also discussed how new stabilization scenarios affect climate impact assessment. Dr Takahashi also pointed out the need improve the procedure to develop climate scenarios for impact assessment. The socio economic and other assumptions for each stabilization scenario should be in a format suitable for impact assessment. He concluded by pointing out that advanced procedure for developing climate scenarios might be needed for considering

stabilization scenarios in impact assessment and that impact assessment modelers wish for more spatially detailed socio-economic factors assumed in each stabilization scenario. Also the AIM team is developing a new tool for bridging impact assessment results and policymakers.

Dr Kram, RIVM, presented the ongoing work on climate impacts using the IMAGE 2.2 model. He briefly explained the structure of the model and how it used in conjunction with other sector specific modules for impact assessment. The sectors for which detailed results were presented included land-use, nitrogen loading of coastal waters, water, air quality and biodiversity. Through analysis it was clearly shown that increased pressure on the land use system affects ecosystems and LU emissions and there were compounded effects from simultaneous (multiple) environmental stress on ecosystems. The results also indicated consequences for water availability across different world regions. The modeling exercise also captured loss of vegetation and species by type. The post presentation discussion pointed out that though the modeling results show some species likely to disappear in one region, they may however be surviving in other regions. Dr Pant questioned whether interaction between habitat loss, climate change, nitrogen change were considered in the case of species loss. Dr Kram responded that this interaction in fact had been taken into account. Dr Mori pointed out that while there was a possibility that some vegetation types reduce, others may increase. It is also important to consider the role of glaciers and melting of snow in providing additional water resources.

The post tea session started with a presentation by Dr Gary Yohe. He presented on synthesizing GHG stabilization with impacts and adaptation. Through his presentation and analysis he argued that while analysis of mitigation should focus on cost-effectiveness, the ability to make mid-course corrections, and implementation uncertainty, analysis of adaptation should focus on understanding the roles played by the various determinants of adaptive capacity and the antecedents of robust options. Also adaptation must be included in any assessment of what may or may not be accomplished by mitigation in terms reducing the likelihood crossing critical impact thresholds and the

degree to which mitigation complements adaptation in reducing those likelihoods must be explored with full recognition of associated uncertainties in the outcome of mitigation.

The last presentation of the day was by Dr Pant, ABARE. The presentation traced the global emission paths of CO2 under the SRES A1 growth path. The additional assumptions for three scenarios developed included, emissions efficiency improves globally by 2.5% per year, emission intensity of non-OECD regions catches up the intensity of OECD 2000 by 2040 and maintain EEI at 2.5% pa and Non-OECD regions delay until 2020 and then maintain EEI at 2.5% pa. The important observations included that irrespective of the eventual technological path a 2.5% pa reduction in emission intensity is necessary to attain atmospheric concentration level of CO2 below 1000ppmv by 2100, given SRES A1 growth path, 1.5% pa reduction in energy intensity and 0.5% pa reduction in emission intensity has been historically observed (IEA 2002) – implies some additional action is required, taking into account thermal efficiency limits, emission intensity reduction via carbon capture, sequestration and cleaner technologies appear necessary, as a rough guide – reduction in emission intensity at a rate higher than the economic growth rate will lead to decline in total emissions and delayed action by any party adds to the burden.

A final workshop wrap up discussion followed the last presentation of the day. Dr John Weyant set the ball rolling by acknowledging that the group assembled had in fact done well to meet the objectives of the workshop. The group present was a good mix of modelers representing all major regions of the world. He also suggested that there was a consensus to look at long-term scenarios in greater detail. EMF 21 would be a good forum to look at stabilization sensitivity runs. However building the necessary database for such runs is the main challenge ahead. Dr Richels felt that the meeting was in the right direction and was a merger between the earlier EMF workshops and the Snowmass conference. He felt that such integrated kind of workshops have great benefits. A lot can be learnt from projecting baselines as it ‘flushes out’ various insights and the work done in the future would be useful for AR 5. He remarked that the center of gravity is towards the 550 ppmv scenario. Also it is essential to consider whether certain paths can be

considered without taking into account the large R&D expenditure that would be required to tread on that particular path. He also felt that modelers may work on a range of reference scenarios. Dr Edmonds felt that it is important to build on the foundations of EMF 21. The lessons from SRES are before us and the modelers could update these results with better knowledge/information that is now at hand. He also felt that IPCC may however not have intentions of creating new baseline scenarios. Dr Nakicenovic asserted the need for greater participation and thus the question of standardization. Some groups may only be able to model future emissions but may not be able to do climate modeling or look into adaptation issues. He also suggested that it would be desirable that groups start working towards AR 4. Dr Kram felt that it was not necessary to discus the baseline scenarios all over again. It was essential to aim for consistency across scenarios and WG I and WG II are geared to use SRES like scenarios. Dr Shukla felt that IPCC should be in charge of scenarios, as it would lend more credibility and sanctity to the entire process. This would be important from the developing country perspective. Dr Chesnaye felt that IPCC calling for scenarios would make funding modeling efforts in developing countries much easier. Dr Kainuma pointed out that the AIM team is in the process of updating data including the driving forces. Dr Wigley felt that it is essential to consider whom these exercises are benefiting. He said he is looking forward to AR 5 and modelers should start working towards it. He also felt that there were no adequate stabilization scenarios for climate modelers to work with for AR 4 and hence it is essential that relevant work be compiled targeting AR 5.

The workshop was then declared closed by Dr Kainuma. She thanked all the participants for making the workshop a very successful one and wished that this New Year would prove fruitful to all in their endeavors.

(By Dr. Rajesh Nair)