OMM
WMO
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
Working Group III: Mitigation of Climate Change
PNUE
UNEP

SUMMARY REPORT OF IPCC EXPERT MEETING ON

STABILISATION AND MITIGATION SCENARIOS

Copenhagen, Denmark, 2-4 June 1999

Authors: Kirsten Halsnæs, Rob Swart, Nebojsa Nakicenovic, Jae Edmonds and Mike Hulme

Organised by IPCC Working Group III,
Danish Energy Agency,
UNEP Collaborating Centre on Energy and Environment - Denmark

Supporting material prepared for consideration by the Intergovernmental Panel on Climate Change. This supporting material has not been subject to formal IPCC review process.

Summary Report of IPCC Expert Meeting On Stabilisation And Mitigation Scenarios

Published by: UNEP Collaborating Centre on Energy and Environment,
Risø National Laboratory, Denmark, 2000.

ISBN: 87-550-2702-4

Available on request from:

UNEP Collaborating Centre on Energy and Environment
Risø National Laboratory
P.O. Box 49
DK 4000 Roskilde
Denmark
Phone: +45 46 32 22 88
Fax: +45 46 32 19 99

Information Service Department, Risø, 2000

Foreword

The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO) in 1988 to undertake scientific and technical assessments relating to climate change. Currently, the IPCC is preparing its Third Assessment Report, covering the scientific aspects of Climate Change (covered by Working Group I), the potential impacts of climate change and options for adaptation (covered by Working Group II), and options for mitigation of climate change (covered by Working Group III). Approximately 500 experts from around the world are now assessing the scientific and technical literature in this context.

The long-term nature of the climate problem requires a scenario approach for analysis of climate change, its impacts, and response strategies. The IPCC Special Report on Emissions Scenarios (SRES) that is currently being finalised reports on new scenarios for GHG emissions and their socio-economic driving forces that do not consider additional climate policy initiatives over what has been agreed in the UN Framework Convention on Climate Change that entered into force in 1994. These scenarios are important as reference scenarios for analysis of response options to limit emissions of greenhouse gases. The SRES report re-iterates the recommendation from earlier IPCC reports that in order to reflect uncertainties in future socio-economic developments, a multiple baseline approach should be adopted when analysing climate change response options. Article 2 of the UNFCCC stipulates as the ultimate objective of the Climate Convention the stabilisation of GHG concentrations in the atmosphere at a safe level. To explore strategies that can lead to stabilisation of concentrations at several levels (in the absence of a decision on what constitutes a safe level), scenarios are particularly useful. After the completion of IPCC's Second Assessment Report, many scenario analyses have been performed by research groups around the world. These analyses are very diverse, in their objectives, time horizons and methods.

In order to facilitate the job for the lead authors of the chapter on mitigation scenarios in the TAR, an expert meeting on stabilisation and mitigation scenarios has been organised, from 2-4 June 1999 in Copenhagen, Denmark. The main goals were (1) to enable a broad discussion between experts on mitigation and GHG concentration stabilisation scenarios, (2) to make such long-term scenarios better accessible to TAR Lead Authors, and (3) to discuss the linkages between GHG mitigation scenarios and sustainable development. The usefulness of multiple baselines for analysis of climate response options, the desirability of placing climate change mitigation in a wider context of development, sustainability and equity, and the necessity for more and more detailed scenarios studies in developing countries, using tools and methods appropriate for those regions, were some of the main issues that were addressed.

In line with the prominent role that Denmark has played in both the climate policy area as well as in analytical work on long-term energy and GHG scenarios, the Danish government undertook the organisation of the meeting in Copenhagen. We would like to thank the Ministry of Environment and Energy, in the person of Minister Svend Auken. In particular we would like to acknowledge the strong support of Jesper Gundermann of the Danish Energy Agency for making the meeting happen. Kirsten Halsnæs and the staff of the UNEP Collaborating Centre on Energy and Environment at Risø we thank for their efficient organisation of the meeting. The meeting focused on an exchange of insights between the participants based on formal presentations. The formal presentations were based on written papers that have been published in international

journals or have been used as input to chapters in the Third Assessment Report. It has been decided not to include the papers in this summary report because they are already published in the international literature. However, the programme committee prepared this summary report on the basis of the discussions and plenary conclusions of the expert meeting with the intention to provide a number of policy-relevant a (but not policy-prescriptive) recommendation. We hope that these recommendations will inform networks of scientists from around the world with different regional, cultural and disciplinary backgrounds about new developments in climate change mitigation scenarios, and that the summary report will be used by the authors of IPCC's Third Assessment Report.

Professor Ogunlade Davidson and Dr. Bert Metz, co-chairs of IPCC Working Group III on Mitigation of Climate Change.

IPCC Expert Meeting on Stabilisation and Mitigation Scenarios

2-4 June 1999, Copenhagen, Denmark

Organised by IPCC WG III, Danish Energy Agency and UNEP Collaborating Centre on Energy and Environment - Denmark

Organising Committee

Jesper Gundermann, Danish Energy Agency
Berit Hansen, Danish Energy Agency
Kirsten Halsnæs, UNEP Collaborating Centre on Energy and Environment, Denmark
John Christensen, UNEP Collaborating Centre on Energy and Environment, Denmark
Jørgen Fenhann, UNEP Collaborating Centre on Energy and Environment, Denmark
Bent Sørensen, Roskilde University Centre, Denmark

Programme Committee

Dr. Bert Metz and Professor Ogunlade Davidson, Co-chairs of WGIII
Dr. Rob Swart, Head of TSU WGIII
Professor John Weyant, CLA Chapter 1, WG III
Dr. John Robinson, CLA Chapter 2, WG III
Dr. N. Nakicenovic, LA Chapter 2, WG III
Dr. T Morita, CLA Chapter 2, WGIII
Professor P. Shukla, CLA Chapter 8, WGIII
Dr. K. Halsnæs, LA, Chapter 7, WGIII.

Expert Meeting Programme

Wednesday 2 June

9.30 - 10.30	**Opening Session, Chair Professor Ogunlade Davidson, Co-chair IPCC WG III**
	Welcome address by Danish Minister of Environment and Energy Svend Auken
	Welcome address by Danish Organising Committee, Dr. John M. Christensen, Director of UNEP Centre, Risø National Laboratory, Denmark
	The scope of the IPCC scenario work and the Third Assessment Report, Dr. Rob Swart Head of Technical Support Unit IPCC WGIII
	General presentation of the SRES scenario work, Dr. N. Nakicenovic, Austria
10.30 - 11.00	Coffee break
11.00 – 13.00	**Presentation of Stabilisation Scenarios by Different Modelling Teams: General Results, Approach and Key Critical Assumptions, chair: Professor Ogunlade Davidson Co-chair IPCC WG III**
	General overview of the work building on the SRES approach, Dr. T. Morita, Japan
	Scenario work building on the SRES approach presented by various scenario groups (Alexander Sankovski, Keywan Riahi, Bert de Vries, Knut Einer Rosendahl, Kenji Yamaji, Kelun Jiang, Ton Manders)
	Low energy consumption scenarios, Professor Bent Sørensen, Denmark
13.00 – 14.00	Lunch
14.00 - 15.30	**Morning Session with Presentation of Stabilisation Scenarios continued, Chair: Dr. Mike Hulme**
	Results of the Energy Modelling Forum work, Dr. Jae Edmonds, USA
	Scenarios for developing countries, Professor E. La Rovere Brazil
	Other GHGs, Dr. J Fenhann, Denmark

15.30 – 16.00	Coffee break
16.00 - 18.00	**Scenario Session continued, Chair: Dr. Mike Hulme**
	Review of the qualitative scenario literature Dr. John Robinson Canada
	Comparative assessment of scenario results – why analysis differ, Dr. Jae Edmonds, USA
	Framework for assessing SRES, IS 92, EMF and other scenarios Dr. Hugh Pitcher and Dr. Jae Edmonds, USA
	Discussion

Thursday 3 June

9.00 - 11.00	**The Costs and other Social Impacts of Stabilisation Scenarios, Chair: Dr. K Halsnæs, Denmark**
	Development, equity and sustainability implications of the scenarios, Dr. Adil Najam, Pakistan
	The costs of alternative emission reduction targets and international flexibility mechanisms, Dr. R. Richels, USA
	The costs of alternative emission reduction targets and international flexibility mechanisms based on European modelling, Dr. J-C Hourcade, France
	Common but differentiated responsibilities: Assessment of costs and burden sharing under different scenarios and stabilisation targets, Dr. P. Shukla, India
11.00 – 11.30	Coffee break

11.30 - 13.00	**Technology Transfer and Diffusion, Chair: Dr. Jyoti Parikh, India**
	How to integrate technology transfer in a national and regional Development Equity and Sustainability (DSE) agenda, Dr. M. Monasinghe, Sri Lanka
	Main constraints and conflicts in implementing biomass scenarios, Dr. Irving Mintzer, USA
	Technology learning perspectives, Dr. Arnold Grübler and Dr. N. Nakicenovic IIASA
13.00 - 14.00	Lunch
14.00 – 15.30	**Implications of Stabilisation Scenarios, Chair: Dr. Bert de Vries, The Netherlands**
	Climate change impact indicators of stabilisation scenarios, Dr. M. Hulme, UK
	Stabilisation scenarios, Dr. Tom Wigley, USA
15.30 - 16.00	Coffee break
16.00 - 18.00	**Implementation Issues, Chair Dr. J. Robinson, Canada**
	Implementation aspects of technology transfer strategies, Dr. J. Parikh, India
	Implementation issues related to developing countries based on the UNEP country studies, Dr. K. Halsnæs, Denmark
	Further development of the Kyoto mechanism, Professor Ogunlade Davidson, IPCC
Friday 4 June	
9.00 - 10.30	**Presentation of Session summaries, Chair Professor O. Davidson** Dr. Mike Hulme, Dr. K. Halsnæs, Dr. Jyoti Parikh, Dr. Rob Swart and Dr. John Robinson
	General discussion

Summary of the Sessions

Presentation of Stabilisation Scenarios by Different Modelling Teams

Main Issues Discussed

The first part of this session summarised on-going stabilisation scenario work that build on the IPCC Special Report on Emission Scenarios (SRES) non-intervention scenarios. Nine modelling teams are participating in this process and seven different presentations were made. To achieve stabilisation of CO_2 concentration at several target levels requires a reduction emissions by 2100, depending on which SRES baseline scenario is chosen and which time profile of emission reduction that is followed. Following the overview of the stabilisation scenario work by T. Morita, the seven short presentations on specific modelling initiatives in this session were made by B. de Vries (IMAGE model); K. Riahi (MESSAGE model); A. Sankowski ASF model); Bollen (WorldScan model); K. E. Rosendahl (PETRO model); K. Yamaji (LDNE21 model), and K Jiang (AIM model). The scenarios developed by S. Mori (MARIA model) were reported by Morita.

The afternoon session started with four presentations on alternative or complimentary modelling activities relating to mitigation: end point/snapshot energy supply scenarios (Sørensen); the EMF stabilisation work (Weyant/Edmonds); a perspective on mitigation from Latin America (La Rovere); and mitigation of industrial gases (halocarbons etc., Fenhann).

The three concluding presentations provided more reflective discussions on why different energy models yield different quantifications (Edmonds); opportunities for using the SRES approach to explore uncertainties (Pitcher/Edmonds); and a preliminary appraisal of the qualitative scenario literature and how it differs from the quantitative database (Robinson).

Similarities and Differences in Approaches/Critical Assumptions

The WorldScan exercise looked at reasons for non-Annex I countries to join Annex I countries through trading under the A1 SRES world and the implications of early versus delayed action. Carbon trading was considered explicitly. The ASF and the PETRO models used carbon taxes to reduce emissions. The implications of the taxes on equity, revenue transfer, etc. are not well explored by these models. The PETRO model looked at the time-path of carbon tax values in order to explore when carbon-free technology becomes competitive under different SRES worlds. All these approaches consider the issue of timing in relation to the participation of non-Annex I participation in climate change mitigation. The ASF model here concludes that non-OECD countries gradually should begin the introduction of carbon taxes increasing proportionally to GNP per capita in order to achieve a stabilisation of the atmospheric CO_2 concentration at 550 to 750 between 2100 and 2150.

The IMAGE model is a global simulation model that has an Energy-Industry subsystem built around the following main assumptions: Energy consumption per GDP unit is following an u-shaped curve, autonomous energy efficiency improvements is included, and learning costs and technology learning are built into the model. The stabilisation scenarios by the IMAGE model assess the GHG emission decreases initiated by

regulation policies target to introduce technology promoting programmes, substitution to low GHG emitting fuels, and general energy efficiency improvements. These options are supported by carbon taxes and energy subsidy removal. The IMAGE stabilisation scenarios conclude that a stabilisation at 517 ppmv level in 2100 can be achieved with relatively low costs. A reduction of this concentration level down to 450 ppmv, however, requires a large effort in industrialised countries, and need to be supported by actions in developing countries in the last part of the 2100 century. The policy efforts include extensive biomass use, carbon taxes, and carbon removal technologies.

The MESSAGE model is an integrated energy system engineering and macroeconomic energy model that includes a detailed energy sector technology database. The model has been used to assess a CO_2 stabilisation scenario at 550 ppmv after 2100 based on the SRES scenarios. It is concluded that the stabilisation target can be met at modest costs (1.7% GDP reduction). The main policy option is fuel switching, but also energy demand reduction and CO_2 scrubbing and removal play a role.

The MARIA model is an integrated assessment model that included an energy sector sub-module that have been used to assess the role of biomass, nuclear power and other energy technologies in achieving CO_2 stabilisation based on SRES scenarios. It is concluded that the achievement of stabilisation targets like 450 ppmv, 550 ppmv, and 650 ppmv will require the introduction of large scale biomass use, nuclear power production, and carbon sequestration technologies.

The New Earth 21 model (DNE21) is a global energy optimisation model that includes detailed energy technology data and it is especially well suited to model supply side changes. The conclusions of the model runs for stabilisation targets around 550 ppmv in 2100 are that this will require a mixed energy sector approach combining energy conservation, fuel conversion options, large scale introduction of non-fossil fuels, and carbon disposal implemented at a large scale. Similarly to other models DNE21 concludes that developing countries need to be integrated in reduction efforts as soon as possible.

The Asian-Pacific Integrated Model (AIM) utilises a linked series of modular computer simulation with both top-down and bottom-up structure to predict a variety of outcomes and impacts related to climate change, developed by an international collaborative team comprised of Asian experts including Japan, China, India and Korea. AIM-based scenarios showed that a wide range of technology/policy packages is required in climatic policy for high-emission world, and early GHG reduction is also essential to avoid serious pressure on social development and technological progress in the second half of the 21st century. The AIM-based scenarios also suggested that integration between climatic policies and domestic policies could effectively reduce GHGs in developing regions for the next two or three decades.

One of the main differences between the scenarios and modelling work here presented is that some approaches intervene explicitly at a policy level (e.g. with carbon taxes), while others alter assumptions about the rate of technological change, fuel switching and/or technology penetration. This is related to the differences between top-down modelling approaches versus bottom-up modelling approaches that has been extensively considered in the IPCC Second Assessment Report on Social and Economic Dimensions. Different modelling approaches is also one reason why the distinction between intervention (imposed policy) and non-intervention (endogenous technological change) becomes blurred in these mitigation scenarios. Some approaches identify

explicitly how climate change mitigation is achieved (e.g. through reduced demand vs. fuel switching) and quantify the different contributions that are made, why others provide more aggregate economic cost results that arrive as the welfare loss generated by introducing carbon taxes. The ancillary benefits of mitigation measures (e.g. reduced sulphur) are also treated differently by different models.

Bent Sørensen's approach is somehow different than the above referred SRES based scenario work in the following areas: a) energy demand and supply scenarios are modelled with explicit global geography, and b) four alternative near "zero-carbon" futures by 2050 are envisioned and Sørensen's model is employed to determine the feasibility of each of these futures (unrelated to SRES). In this case, all technologies implemented already exist in commercial or near-commercial form. For industrial gases (not considered by most energy models), mitigation options are perhaps more clear-cut and Jørgen. Fenhann demonstrated a set of quantifications for mitigation in this sector using existing technologies (cf. Sørensen) and GWPs.

Emilio La Rovere presented a number of methodological conclusions based on climate change mitigation scenario work for developing countries. He emphasised that most models do not reflect the specific dynamics driving GHG emission in developing countries, and the recommendation was therefore to use scenario assessment approaches where policy makers and local experts can participate in studies on alternative development patterns and climate change policies.

The EMF approach was presented by Jae Edmonds on behalf of John Weyant. It involved an explicit energy model intercomparison project – six models were run to achieve a 550 ppmv stabilisation target given the IS92a baseline assessing the implied costs of different pathways to that target. The EMF work concluded that differences in modelling results primarily relate to the following issues:

1. Approach - Top-down versus bottom-up.
2. Trade - Direct and indirect effects.
3. Uncertainty and expectations.
4. Non-CO_2 greenhouse gases.
5. Sinks - Land use emissions.
6. Measurement of costs.
7. Ancillary benefits.
8. Endogenous technological progress.

John Robinson suggested that there exists a significant difference between qualitative and quantitative scenarios in the literature. Most emissions scenarios revolve around issues of economic development and/or environmental sustainability, whereas qualitative scenarios are more concerned with issues of governance, equity, security, - issues largely absent (although SRES storylines make reference to them) in quantified scenarios. Such narrative-bases scenarios thus offer a potential route to link these broader issues to the climate change policy arena.

Recommendations for Future Research

- The linkage between quantification (e.g. emissions numbers) and visualisation (e.g. stories) scenarios is made by SRES, but more work is needed. What do these future worlds really look/feel like? And if constructed, do the resulting three-dimensional pictures pass the authenticity test?

- There may be a rich and authentic scenario literature to tap into at national and regional rather than global scales. These may allow better representation of cultural diversity in views of the future.

- Some economy/energy models may not be well suited to conditions in developing countries – e.g. due to inadequate representation of the informal sector. This may need to be addressed through wider participation in the process of model development.

- Role of biomass and other GHG sinks (e.g. soils) in mitigation needs more consideration. There is a clear and important feedback here between climate change impact and mitigation policy and is one example (of several) where WGII/WGIII linkages need to be improved.

- Is there any scope for more formal/quantifiable uncertainty analyses regarding future emissions, or do we remain with alternative one-dimensional emissions paths where the selection of 'most likely' remains subjective?

Recommendations Concerning the Dimensions that Participants find Important to Address in Scenario and Modelling Work in Order to Improve the Utility to Policy-makers

- A real value of the SRES work is that it stresses the existence of multiple baselines (cf. IS92a which became a *de facto* standard even though it was not presented as such). This perspective should not be lost since it is fundamental to the way we need to think about climate policy.

- SRES scenarios highlight the difficulties in distinguishing between intervention/non-intervention and this is in keeping with reality. We are part of the future and the climate change debate has already shifted the (unknown) distribution of possible future worlds – we cannot go back.

- Ones choice of baseline scenario becomes very critical regarding any examination of mitigation options and their costs, and SRES makes this choice explicit. Given that we will never agree on baselines, can we agree on an optimal mitigation strategy that will cope will all possible outcomes?

The Costs and other Social Impacts of Stabilisation Scenarios

Main Issues Discussed

Adil Najam discussed how Development Equity and Sustainability (DES) issues can be integrated in climate change scenario work and recognised that the DES issues are difficult to define precisely. The models should try to integrate natural systems, social and human systems, and economic systems in order to assess where substitution of the different "capitals" is possible and where it is not. The analytical frameworks that can be applied in these areas include welfare optimisation approaches and resilience/vulnerability assessment approaches.

This general introduction to DES issues where followed by two economic modelling presentations by Jean-Charles Hourcade and Richard Richels who reported main results of studies about the costs of meeting stabilisation and other emission reduction targets for Europe, the USA and other regions leading up to a discussion about critical assumptions including technical change, timing and international flexibility in meeting emission reduction targets.

Priyadarshi Shukla highlighted a number of development and social implications of the new IPCC scenarios seen from the perspective of developing countries. The IPCC scenarios include a number of important assumptions about "development space" for developing countries as a consequence of the GHG emission projections of the scenarios. It should be recognised that all the scenarios assume relatively low GHG emission growth in developing countries. This means that the per capita emissions still in the future will be much lower in developing countries than in industrialised countries. Shukla emphasised that the IPCC scenario work should highlight and discuss the burden sharing issues related to the emission projections more explicitly and consider potential cost effective global carbon trading regimes. These regimes could be based on alternative emission permit allocation principles such as historical responsibilities, ability to pay, equal per capita emissions, and procedural equity.

Similarities and Differences in Approaches/Critical Assumptions

All the presentations emphasised that it is very important to integrate the assessment of DES issues as much as possible in formalised modelling and scenario work and to make a more precise definition of the quantitative aspects of DES that can be addressed in the studies.

There were a number of differences in what the experts recommended to include in this work. On one hand, the economic modellers primary suggested to include issues related to ancillary benefits of GHG emission reduction policies, which in particularly could include financial double dividends and income distribution issues. Jean-Charles Hourcade stated that European studies tend to conclude that the introduction of carbon taxes can generate a significant double dividend in particular due to the potential for reducing payroll taxes and decreasing unemployment. This benefit is not assessed to be very likely in studies for the USA.

Adil Najam and Shukla addressed a broader menu of DES issues than the ones included in the economic modelling studies. They emphasised that GHG emission scenarios should be related to broader work on sustainability issues in developing countries and it should be evaluated how climate change finance could support such broader policy objectives.

The general discussion focussed on a number of critical assumptions in the modelling work and in policy implementation. These included assumptions about technological development and backstop technologies, and the highly uncertain GHG emission projections for developing countries. A strong need for more information about distributional consequences of GHG emission reduction policies was stated. Such information was assessed to be very important in policy implementation. The information should include identification of gainers and losers of reduction policies and assessment of social groups that would be particularly vulnerable to climate change.

Recommendations for Future Research

- Operationalisation of Development Equity and Sustainability (DES) aspects in a way where they can be addressed in modelling and scenario work.

- Assessment of trade-offs and synergies between climate change policy objectives and DES objectives using welfare optimisation approaches as well as resilience/vulnerability assessment approaches.

- Comparative assessment of ancillary benefits of GHG emission reduction policies using different baseline definitions. This will also imply a clarification of scenario and cost concepts in relation to financial double dividend studies.

- Assessment of the implications on financial transfers to developing countries of different baseline definitions and emission permit allocation rules.

- The SRES scenario assumptions about low future GHG emissions in developing countries should undergo a critical assessment. The per capita emissions of the scenarios show convergence in relative terms in several of the cases, but not in absolute terms, which in reality could make the scenarios politically "infeasible".

Recommendations Concerning the Dimensions that Participants find Important to Address in Work on Costs and other Social Impacts in Order to Improve the Utility to Policy-makers

- Development of more understanding about relationships between sustainable development objectives and GHG emission reduction policies in a way can make and local decision makers and other people more interested in climate change policies.

- Discuss how developing countries can benefit from participating in GHG emission reduction policies if international climate change finance for example related to the Clean Development Mechanism can generate ancillary benefits in the host countries.

- Short- to medium time perspective of official national development programs should be linked to the time horizon of the IPCC scenarios in a way where policy makers can understand implications for policy making.

- A more realistic basis for policy implementation can be established if information is provided on distributional consequences of GHG emission reduction policies.

Technology Transfer and Diffusion

Main Issues Discussed

Mohan Munasinghe made a general introduction about how technology transfer for GHG emission reduction can be carried out as a part of a DES policy. Scenario studies should then undertake a systematic assessment of alternate development pathways and identify local and global environmental policies that meet DES standards. A number of

study results on how to integrate technology transfer in a national DES agenda for Sri Lanka were reported.

Irving Mintzer discussed main constraints and conflicts in implementing the specific biomass and renewable energy options included in the SRES scenarios. He concluded that the plausibility and consistency of assumptions in particularly for biomass and energy must be considered very carefully with respect to the narrative- as well as the quantified emission scenarios. Some areas seemed to be insufficiently addressed in the scenario work. This is for example the availability of adequate water for the large increases in biomass production that are assumed in some of the scenarios. The scenarios also need to be more closely related to institutional and social aspects that critical aspects in policy implementation.

Arnold Grübler and Nebojsa Nakicenovic reported results of technology learning studies, and concluded that assumptions about technological development and penetration are very important determinants for future and GHG emissions and reduction costs. Studies that have included endogenous technology learning tend to suggest more rapid and successful penetration of new, high cost technologies compared with studies with exogenous assumptions about technology development.

Similarities and Differences in Approaches/Assumptions

The presentations emphasised that technology transfer should be related to a general DES policy agenda, and that the implementation aspects of the technologies critically would depend on institutional and social aspects such as learning capacity, private sector development, national development objectives and conflicts or synergies with other sectoral development goals. The land use sectors should be considered in more detail to identify biomass development strategies that are not in conflict with agriculture and with rural development needs. It was also emphasised that detailed comprehensive national studies were needed in order to understand the dynamic aspects of technology development and GHG emission trajectories.

Assumptions about technological development and implementation seem to impose large uncertainties on GHG emission scenarios as well as on reduction potentials.

Recommendations for Future Research

- Development, sustainability and equity should be mapped onto the economic, environmental and social dimensions of sustainable development as a starting point for technology transfer studies.

- The plausibility and consistency of SRES assumptions (e.g. for biomass energy) have to be considered more carefully.

- The practical biomass potential that can be implemented should be studied in more detail including considerations about institutional capacity, land tenure and other social issues.

- The models and scenario studies should include endogenous learning aspects because these could be critical factors in the assessment of technology penetration and mitigation costs.

Recommendations Concerning the Dimensions that Participants find Important to Address in Work on Technology Transfer and Diffusion in Order to Improve the Utility to Policy-makers

- The integration of DES dimensions in climate change studies will establish a better link to the private sector and public policies that already to a wide extent are based on these objectives.

- Many developing countries are now at the start of alternate and divergent development pathways; systematic analysis of these pathways and their consequences can help decision making

Implications of Stabilisation Scenarios

Main Issues Discussed

Tom Wigley described new future climate results from a coupled ocean/atmosphere General Circulation Model for a "business as usual" policy and a parallel simulation in which CO_2 concentrations stabilises at 550 ppmv. It was concluded that the effects of a policy initiated now to reduce the build up of CO_2 over 2000-2100 by 50% may not be noticeable for 50 or more years, even at the global mean level. The effects of such a CO_2 reduction policy will take even longer time to be identifiable at regional level.

Similarities and Differences in Approaches/Assumptions

Tom Wigley concluded that regional scale climate effects of a CO_2 stabilisation policy are highly uncertain. Their quantification, even with a single model, requires running multiple simulations in order to separate out the response signal from the noise of natural variability. At present no climate modelling group is planning such experiments.

Recommendations for Future Research

- Modelling of regional scale climate change impacts of stabilisation policies.

- Quantification of the economic benefits of reduced climate change at regional scale.

Implementation Issues

Main Issues Discussed

The papers presented in this session all focussed on implementation aspects of GHG emission reduction policies in developing countries. Jyoti Parikh outlined a general framework for technology transfer that was suggested to be broad and that in addition to more specific technology issues should include sustainable trade practices, adaptation policy, and technological development, innovation and diffusion. Technology transfer should be based on the assessment of local needs and abilities, and should try to balance resource endowments and technology availability. The transfer process as such would then be defined as a complex process with many steps and relationships between local

manufacturers and imports. She said that if sustainable development is a focus of CDM or technology transfer, rather than a narrow focus on climate change alone, many new areas can be explored. For example in the former mass transit could also be considered, while the latter would deal with coal based projects first, which is not a development priority in the south.

Kirsten Halsnæs reported the results of a number of UNEP studies for developing countries leading up to a discussion about national benefits of implementing GHG emission reduction options in these countries. The studies have assessed financial costs and social costs of GHG emission reduction options related to individual projects and sectoral strategies. It was concluded that the inclusion of social cost aspects can have a major impact on cost-effectiveness ranking of GHG reduction project in developing countries. A number of energy options as for example biogas plants and solar water heaters have been assessed to have significant social welfare components in cases were they generate increased employment, raise the income of low-income families and/or reduce local air pollution. Other GHG emission reduction options related to end-use energy efficiency improvement in particularly generate social benefits through fuel or electricity savings. These options, however, can be difficult to implement because they often rely on decisions by many individual agents. There is still very little information about implementation policies for GHG emission reduction policies in developing countries and this impose a large uncertainty on mitigation costing results.

Ogunlade Davidson provided a general overview of the relationships between the Kyoto mechanisms and emission scenarios emphasising that the Kyoto targets were very small compared with stabilisation objectives. Specific technology transfer policies could be facilitated through financial mechanisms of the Kyoto Protocol, but they should be developed in the context of broader long term DES goals. These scenarios however need to be more specific and detailed in their representation of developing countries.

Similarities and Differences in Approaches/Assumptions

The presentations all emphasised a need for more detailed studies on developing countries as potential host countries for GHG emission reduction projects and tried to make generic conclusions about development impacts of different technology choice and project design. The UNEP study results suggested that more work should be done in relation to sectoral strategies in particularly for the power sector, because this sector will be far the most important GHG emission source in the future. A technology transfer strategy should therefore include these large emission sources in addition to the focus on small individual technologies (e.g. advanced renewable energy) that are dominant in many ongoing studies for developing countries.

Recommendations for Future Research

- The concept of technology transfer should be developed from primarily considering specific technologies to include sustainable trade practices, adaptation policies, and technology development, innovation and application aspects.

- Technology transfer studies should take the starting point in local needs and should include a wide menu of options. The focus should be on end-use needs rather than on technology supply.

- The role of industry is becoming more dominant in technology transfer; and more information is needed about how governments can play an enabling and accelerating role (policies like voluntary agreements, incentives for clean technologies, education/capacity building).

- Studies for developing countries that include an assessment of social impacts of GHG emission reduction policies can generate important information about how DES policy objectives and climate change policies can be combined.

- Implementation costs and policy options need to be more carefully addressed in studies for developing countries in order to establish a basis for sustainable GHG emission reduction policies in these countries.

- Stabilisation scenario work need to be linked to Kyoto targets and short time decisions if they are to be considered as relevant to DES perspectives of developing countries.

Recommendations Concerning the Dimensions that Participants find Important to Address in Work on Implementation Issues in Order to Improve the Utility to Policy-makers

- The technology transfer issues should be linked to the potential use of the Clean Development Mechanism as a financial option. The establishment of such a link has been tried before but failed because of political constraints; link will bring back involvement of developing countries in the operationalisation of the Kyoto mechanisms, but research in this area could help to establish a level playing field.

- Studies about social impacts of GHG emission reduction policies in developing countries could support the establishment of a capacity in developing countries for participating in the operationalisation of the Kyoto Protocol.

- Social cost aspects could be a use full policy criteria in cost effectiveness studies of GHG emission reduction options.

Concluding Plenary Session

This final session included a presentation of summaries of the sessions:

- Presentation of stabilisation scenarios by different modelling teams by Mike Hulme.
- The costs and other social impacts of stabilisation scenarios by Kirsten Halsnæs.
- Technology transfer and diffusion by Rob Swart.
- Implications of stabilisation scenarios by Mike Hulme.
- Implementation issues by Rob Swart.

The session additionally included supplementary presentations on stabilisation scenarios by Morita and Shukla, and a general statement about policy perspectives of the scenario work by Director Bill Hare, Greenpeace International.

Most of the conclusions presented in the session summaries are referred in the previous sub-sections on the sessions in this summary report. The following conclusions are therefore primarily reflecting additional observations by individual participants related to cross-cutting issues of the expert meeting.

It was stated by several participants that it is difficult to get an overview of the many assumptions behind the SRES scenarios and the related stabilisation scenarios on the basis of the draft IPCC Working Group III Special Report. More work to make the scenarios more transparent is therefore needed. This should include more explanations about the assumptions and mechanisms within the models and more detailed studies about technology implementation.

Morita agreed that an effort should be done to make the SRES scenario assumptions more transparent, and he presented his own priorities for further work. These activities included co-ordination and documentation of the stabilisation scenario work with regard to baseline definitions, trading regimes, timing of reduction efforts, policy instruments, and the treatment of ancillary benefits. Morita also found it very use full to make a comparative assessment of the SRES based stabilisation scenario work and the work of the Energy Modelling Forum (EMF).

Shukla criticised the models and the scenarios generated by these for being very unrealistic in their representation of developing countries. Models should go deeper into the driving forces in development as for example population growth, consumption patterns and living conditions of the rural population. The SRES scenarios do not give any specific guidance on how developing countries can participate in a transition to contribute to the achievement of stabilisation targets. Shukla finally emphasised that the future should be presented by a number of different alternative development patterns.

The need for multiple baselines was supported in general by several participants, but it was at the same time emphasised that more work should be done to describe the different worlds (including the linkage between qualitative and quantitative aspects) which in the SRES scenarios only have been sketched in a very preliminary form. Several participants were sceptical about the possibilities for linking qualitative and quantitative scenario assumptions in global work like the SRES scenarios and suggested that it maybe would be better to try to do more work in this area at a national basis. This could for example be done for developing countries where the energy sector and biomass issues should be addressed explicitly by local experts.

Ogunlade Davidson emphasised that several of the expert meeting sessions have concluded that it would be very use full if the DES aspects were built into more specific regional scenario models. This would on one hand make DES issues more concrete in relation to regional development issues and would also link the DES issues more to real policy making processes. IPCC should therefore support such regional modelling activities.

The modelling teams that have used the SRES scenarios as a basis for their stabilisation scenario work in general agreed that a very positive outcome of the SRES scenario approach was that inclusion of sustainable development perspectives in the scenarios has highlighted the difficulties of distinguishing between climate change intervention and non-intervention cases (baseline case and GHG emission reduction case). They found that this development was a benefit to policy makers based on the observation

that the international community is already in a process where climate change policies are implemented in particularly in industrialised countries.

This conclusion was questioned by other participants based on the argument, that it could be difficult for policy makers to use the SRES scenarios as a basis for decisions about GHG emission reduction policies, when the scenarios in general showed that future GHG emissions and climate change damages would be more dependent on very general political decisions about sustainable development issues than on climate change policies as such.

John Robinson replied that sustainable development policies could have major impacts on GHG emissions thus on climate impacts and adaptive capacity. Climate change policies therefore should therefore be linked to these policies. Perhaps we could foresee a day when IPCC would change scope to be an Intergovernmental Panel on Sustainable Development.

Bill Hare welcomed the SRES scenarios as a politically valuable new approach but asked for more clarity about the purpose of the scenarios in relation to political decisions. He would like to see more stabilisation scenarios that aimed at lower concentration levels such as 350 ppmv and 450 ppmv. The scenarios at the same time also should distinguish damages that could and could not be avoided given the current stock of atmospheric greenhouse gases. It would also be interesting to see the development of more sophisticated scenarios that are not focussing on stabilisation targets but go further on to specify "tolerable" damages based on detailed regional models that includes non-linearities and risk.

Finally it was generally emphasised by the participants that the uncertainty of the scenario results should be stated and assessed more explicitly. The recent scenario work has concluded that uncertainties in both socio-economic drivers and climate effects/impacts apparently are increasing. It is therefore a highly relevant to develop a framework for managing and presenting these uncertainties in a policy-relevant way.

Expert Meeting Participants

Nebojsa Nakicenovic
International Institute for applied systems analysis
Schlossplatz 1
A-2361 Laxenburg
Austria
Tel: +43 2236 807 411
Fax.: +43 2236 71 313
Email: naki@iiasa.ac.at

Keywan Riahi
International Institute for applied systems analysis
Schlossplatz 1
A-2361 Laxenburg
Austria
Tel.: +43 2236 807 491
Fax.: +43 2236 71 313
Email: riahi@iiasa.ac.at

Emilio La Rovere
PPE/COPPE/UFRJ
Rua General Mariante. 98/102
22221-100 Rio de Janeiro
Brazil
Tel.: +55 21 560 8995
Fax.: +55 21 290 6626
Email: emilio@ppe.ufrj.br

Deborah Herbert
Sustainable Development Research Institute
University of British Columbia
B5 – 2202 Main Mall
Vancouver, BC V6T 1Z4
Canada
Tel.: +1 604 822 8198
Fax.: +1 604 822 9191
Email: sdri@sdri.ubc.ca

John Robinson
Sustainable Development Research Institute
University of British Columbia
B5 – 2202 Main Mall
Vancouver, BC V6T 1Z4
Canada
Tel.: +1 604 822 8198
Fax.: +1 604 822 9191
Email: sdri@sdri.ubc.ca

John Christensen
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 46 32 22 88
Fax.: +45 46 32 19 99
Email: john.christensen@risoe.dk

Jørgen Fenhann
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 46 32 22 88
Fax.: +45 46 77 51 05
Email: j.fenhann@risoe.dk

Asger Garnak
Forum for Energy and Development(INFORSE
Landgreven 7
1301 Copenhagen K
Denmark
Tel.: +45 33 12 13 07
Fax: +45 33 12 13 08
Email: ag@inforse.org

Jesper Gundermann
Danish Energy Agency
Amaliegade 44
1256 Copenhagen K
Tel.: +45 33 92 67 83
Fax.: +45 33 92 68 67
Email: jgu@ens.dk

Tarjei Haaland
Greenpeace – Danmark
Bredgade 20. Baghuset 4
1260 Copenhagen K
Denmark
Tel.: +45 33 93 53 44
Fax: +45 33 93 53 99

Kirsten Halsnæs
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 46 77 51 12
Fax.: +45 46 32 19 99
Email: ucc-khal@risoe.dk

Anders Chr. Hansen
Roskilde University
Dept. of Social Science
P.O. Box 260
4000 Roskilde
Tel.: +45 46 74 21 68
Fax.: +45 46 74 30 80
Email: anders@ruc.dk

Jens Hesselbjerg
Danish Meteorological Institute
Lyngbyvej 100
2100 Copenhagen Ø
Denmark
Tel.: +45 39 15 74 50
Fax: +45 39 15 74 60

Anne Mette Jørgensen
Danish Meteorological Institute
Lyngbyvej 100
2100 Copenhagen Ø
Denmark
Tel.: +45 39 15 74 50
Fax.: +45 39 15 74 60
Email: amj@dmi.dk

Peter Laut
Institute for Physics and Applied Chemistry
Technical University of Denmark
Bygn 377, DK 2800 Lyngby
Tel.: +45 45255481
Fax: +45 45255480
Email: ifakpl@pop.dtu.dk

Henrik Meyer
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 46 77 51 62
Fax.: +45 46 32 19 99
Email: henrik.meyer@risoe.dk

Niels Meyer
Technical University of Denmark
Tel.: +45 45 25 19 30
Fax: +45 45 93 44 30
Email: Nim@ibe.dtu.dk

Naja Mikkelsen
Geological Survey of Denmark and Greenland
Thoravej 8
2400 Copenhagen
Denmark
Tel.: +45 38 14 21 35
Fax: +45 38 14 20 50
Email: nm@geus.dk

Kim Olsen
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 46 32 22 88
Fax.: +45 46 32 19 99
Email: kim.olsen@risoe.dk

Bent Sørensen
Energy & Environment Group
Roskilde University
P.O. Box 260
4000 Roskilde
Denmark
Tel.: +45 46 74 20 28
Fax: +45 48 14 44 97
Email: bes@ruc.dk

Finn Sørensen
Energy & Environment Group
Roskilde University
P.O. Box 260
4000 Roskilde
Denmark
Tel.: +45 46 74 20 28
Fax: +45 48 14 44 97

Jyoti Painuly
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 46 32 22 88
Fax.: +45 46 32 19 99
Email: j.p.painuly@risoe.dk

Morten Prehn Sørensen
Danish Energy Agency
Amaliegade 44
1256 Copenhagen K
Denmark
Tel.: +45 33 92 68 49
Fax.: +45 33 92 68 67
Email: mps@ens.dk

Arturo Villavicencio
UNEP Collaborating Centre on Energy and Environment
P.O. Box 49
4000 Roskilde
Denmark
Tel.: +45 33 92 77 51 48
Fax: +45 46 32 19 99
Email: arturo.villavicencio@risoe.dk

Walt Patterson
Royal Institute of International Affairs
10 st James´s Square
London SW1Y 4LE
England
Tel.: +44 171 957 5711
Fax.: +44 171 9575 710
Email: waltpattersn@gn.apc.org

Timothy Carter
Finnish Environment Institute
Box 140
FIN 00251 Helsinki
Finland
Tel.: +358 9 40300315
Fax.: +358 9 403 00390
Email: tim.carter@vyh.fi

Jean-Charles Hourcade
CIRED (Cnrs, Ehess)
45 bis avenue de la Belle-Gabrielle
94736 Nogent sur Marne
Cedex
France
Email: hourcade@centre-cired.fr

Joseph Alcamo
Center for Environmental Systems Research
Germany
Tel.: +49 561 804 3266
Fax: +49 561 804 7266
Email: alcamo@usf.uni-kassel.de

Jyoti Parikh
Indira Gandhi Institute of Development Research
General vaidya Marg, Goregaon
East Mumbai
400065 India
Tel.: +91 22 840 0919
Fax.: +91 22 840 2752
Email: jparikh@igidr.ac.in

Darshini Mahadevia
School of Planning
Centre for Environmental Planning and Technology
University Road, Navrangpura
Ahmedabad, 380 009
India
Tel.: +91 79 6302 470
Fax.: +91 79 630 2075
Email: darshini@satyam.net.in

P. R. Shukla
Indian Institute of Management
Ahmedarbad
380011 India
Tel.: +91 79 640 7241
Fax.: +91 79 642 7896
Email: shukla@iimo.hd.esnet.in

Kejun Jiang
National Institute for Environmental Studies
16-2 Onogawa
Tsukuba, 305-0053
Japan
Tel.: +81 298 50 2541
Fax.: +81 298 50 2541
Email: kjiang@nies.go.jp

Tsuneyuki Morita
National Institute for Environmental Studies
16-2 Onogawa, Tsukuba 305-0053
Japan
Tel.: +81 298 50 2541
Fax.: +81 298 50 2541
Email: t-morita@nies.go.jp

Kenji Yamaji
School of Engineering
University of Tokyo
7-3-1 Hongo, Bunkyo-ku
113 Tokyo
Japan
Tel.: +81 3 5841 6736
Email: yamaji@yamaji.t.u-tokyo.ac.jp

Goudou Dieudonne
Prime Ministers Office
HCBK
P.O. Box 13418
Sonara, Niamey
Niger
Tel.: +227 732 313
Fax.: +227 732 313
Email: kandadji@intnet.ne

Olusegun Adegbulugbe
Centre for Energy Research
Obafemi Awolowo University
Ile ife Nigeria
OLE-IFE, Osun state
Nigeria
Tel.: +234 36 233 638
Fax.: +234 36 233 638
Email: heptagon@nova.net.ng

Knut Einar Rosendahl
Statistics Norway
P.O.B. 8131 Dep.
N-0033 Oslo
Norway
Tel.: +47 22 86 49 54
Fax.: +47 22 86 49 63
Email: knut.einar.rosendahl@ssb.no

Ogunlade Davidson
University of Sierra Leone
PmB, Freetown Sierra Leons
Freetown
Sierra Leone
Email: ogunlade.davidson@risoe.dk

Mohan Munasinghe
University of Colombo
10 De Fanseka Place
Colombo 5
Sri Lanka
Tel.: +94 1 5002 89
Fax.: +94 1 580 822
Email: mmunasinghe@worldbank.org

Bill Hare
Greenpeace International
Keizersgracht 176
1016 DW
The Netherlands
Tel.: +31 20 52 36 268
Fax.: +31 20 52 36 200
Email: bhare@ams.greenpeace.org

Tom Kram
Netherlands Energy Research Foundation
P.O. Box 1
1755 ZG Petten
The Netherlands
Tel.: +31 224 564 427
Fax.: +31 224 563 338
Email: kram@ecn.nl

Ton Manders
CPB Netherlands
Bureau for Economic Policy Analysis
P.O. Box 80510
2906 GM The Hague
The Netherlands
Tel.: +31 70 338 3452
Fax: +31 70 338 350
Email: ajgm@cpb.nl

Rob Swart
TSU IPCC Working Group III
P.O. Box 1 3720
BA Bilthoven
The Netherlands
Tel.: +31 30 274 2639
Fax.: +31 30 274 4464
Email: rob.swart@rimv.nl

Bert de Vries
National Institute of Public Health and the Environment (RIVM)
3720 BA Bilthoven
The Netherlands
Tel.: +31 302 74 3533
Fax.: +31 302 74 4435
Email: bert.de.vries@rivm.nl

Mike Hulme
Climate Research Unit
University of East Anglia
Norwich NR4 7TJ
United Kingdom
Tel.: +44 1603 593162
Fax.: +44 1603 50 77 84
Email: m.hulme@uea.ac.uk

Devra Davis
World Resources Institute
10 6 st N,E.
Washington DC
USA
Tel.: +1 202 729 7600
Fax: + 1 202 729 7798
Email: devra@wrl.org

James Edmonds
Pacific Northwest National Laboratory
901 S Street, SW Suite 900
Washington DC 20024
USA
Tel.: +1 202 646 5200
Fax: +1 202 646 5233
Email: jae@pnl.gov

Adil Najam
Boston University
152 Bay State Road
Boston, MA 02215
USA
Tel.: +1 617 353 8910
Fax.: +1 617 353 9290
Email: anajam@bu.edu

Irving Mintzer
Pacific Institute for Studies in Development. Environment and Security
9514 Garwood
Silver Spring, Md
USA 20901
Tel.: +1 301 587 8714
Fax.: +1 301 587 8716
Email: irvingm@ibm.nct

Alexei Sankovski
ICF Consulting Group
1850 K-st., NW, Suite 1000
Washington, DC 20037
USA
Tel.: +1 202 862 1137
Fax.: +1 202 862 1144
Email: asankovski@icfkaiser.com

Michael Schlesinger
Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign
105 S, Gregory Ave.
Urbana, Illinois 61801
USA
Tel.: +1 217 333 21 92
Fax.: +1 217 244 4393
Email: schlesin@atmos.uiuc.edu

Tom Wigley
National Center for Atmospheric Research
P.O. Box 3000
Boulder, CO 80307-3000
USA
Tel.: +1 303 497 2690
Fax: +1 303 497 2699
Email: wigley@ucar.edu