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INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

IPCC Expert Meeting on Mitigation, Sustainability and Climate Stabilization Scenarios

Addis Ababa, Ethiopia
26–28 April 2017

Meeting Report

Edited by:
Priyadarshi R. Shukla, Jim Skea, Renée van Diemen, Elizabeth Huntley, Minal Pathak, Joana Portugal-Pereira, Juliette Scull, Raphael Slade

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IPCC Expert Meeting on Mitigation, Sustainability and Climate Stabilization Scenarios

Addis Ababa, Ethiopia, 26 – 28 April 2017

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Preface

At the 44th Session of the IPCC (Bangkok, Thailand, 17-20 October 2016), the Panel agreed a proposal from the Co-Chairs of Working Group III and its Bureau for an *Expert Meeting on Mitigation, Sustainability and Stabilization Scenarios*. The Expert Meeting proposal specifically aimed to address issues contained in the proposal for a *Special Report on mitigation, climate stabilization scenarios and sustainability* made by the Government of Norway and the proposal for a *Special Report on decarbonisation and low carbon development* made by CAN International (IPCC-XLIII/INF. 7). The meeting was held in Addis Ababa, Ethiopia, from 26 to 28 April 2017 hosted by the United Nations Economic Commission for Africa (UNECA) and the Africa Climate Policy Centre (ACPC).

The Expert Meeting directly addressed challenges raised in the WG III Co-chairs' contribution to the Chair's Vision Paper for the IPCC Sixth Assessment Report AR6. The Meeting was particularly timely as the Scoping Meeting for the AR6 occurred the following week, also in Addis Ababa. This enabled recommendations from the Expert Meeting to have a significant impact on the scoping process. This report summarises the conduct of the Expert Meeting and the wealth of recommendations it generated for three audiences: the AR6 Scoping Meeting; the IPCC leadership; and the scientific communities upon which the IPCC relies.

We would like to thank UNECA and ACPC, particularly its Director Fatima Denton, for hosting the meeting in Addis Ababa. The meeting could not have succeeded without the guidance of the members of the Scientific Steering Committee. We thank the Committee and all the participants in the meeting who contributed to a constructive and fruitful dialogue. Finally, we thank the Technical Support Unit of the IPCC Working Group III, who provided professional support for the preparation, execution, and summary of the Expert Meeting.

Prof. Priyadarshi R. Shukla
IPCC WG III Co-Chair

Prof. Jim Skea
IPCC WG III Co-Chair

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Summary and Recommendations

The Expert Meeting was convened to meet two needs. The first is the need to assess the linkages between high-level climate stabilization goals and scenarios, and the practical steps needed in the short- and medium-term to make the realization of these goals possible. The second is the need to anchor climate responses firmly in the context of development needs.

To address these challenges, the Expert Meeting had several objectives:

- To open the "black box" and explain what insights models/scenarios can provide and their limitations;
- To unpack the "feasibility" of scenarios across different dimensions;
- To link modelling across scales and disciplines;
- To link the top-down and the bottom-up by identifying indicators that are explicit or implicit in model reporting ;
- To identify approaches for managing scenario perspectives in the AR6 process; and
- To develop recommendations for communicating scenarios effectively to policymakers.

The Expert Meeting was concerned primarily with the assessment of scenarios and models within the Working Group (WG) III contribution to the IPCC Sixth Assessment Report (AR6), and linkages with other strands of literature relevant to climate change mitigation. However, following guidance from the Panel, the Meeting also engaged representatives of WGs I and II, covering respectively the physical science of climate change, and impacts, adaptation and vulnerability.

The Expert Meeting produced recommendations directed at three audiences. The first was the AR6 Scoping Meeting, which took place in Addis Ababa directly after the Expert Meeting from 1 May 2017 until 5 May 2017. To ensure that these recommendations were considered during the scoping process, the Co-Chairs of Working Group III (WG III) presented the recommendations to participants on the first day.

The second set of recommendations was directed at the IPCC scientific leadership and WG III authors. These recommendations focus on the assessment of scenarios, their communication, and their interface with other forms of scientific investigation.

The third and final set of recommendations was directed at the scenario/modelling community and other scientific communities. These recommendations include useful lines of research that could enhance the contribution to the assessment of climate mitigation options, in the context of sustainable development, and communicate effectively with policymakers.

The meeting used presentations, plenary debates and focused breakout group (BOG) discussions to test ideas and develop recommendations. The recommendations below start with a number of cross cutting suggestions before describing the detailed recommendations that were developed and discussed in the BOGs.

Key Recommendations for the AR6 Scoping Meeting

- Establish a cross-Working Group BOG on scenarios within the AR6 scoping meeting.
- Suggest a separate forward-looking chapter on the medium-term (up to 2030-2040?) and the long-term (2100).
- Propose a chapter structure that allows mitigation responses to be connected across different scales (e.g. international, national, cities).
- Do not feel bound by the AR5 structure: be bold about identifying cross-cutting topics and possible chapter structures.

Key Recommendations for the IPCC

- Establish a cross-Working Group contact group for scenarios during the AR6 cycle.
    - Consider establishing authorship roles during the AR6 that cuts across chapters and Working Groups.
    - Consider writing a scenario chapter that is common to all three Working Groups.
- Document the treatment of scenarios across all three IPCC in a single location.
- Hold cross-Working Group discussions on best practices for model intercomparison projects (MIPs).
- Hold cross-Working Group discussions on best practices for presentation and communication of scenario ranges.
- Select authors with a wide-range of expertise, and authors that can enhance integration across Working Groups.
- Start discussions of the Synthesis Report early to promote coherence across the WGs, and to identify the accompanying scenario requirements
- Determine how the IPCC will use the Shared Socio-Economic Pathways (SSPs).
- Establish a clearer distinction between 'assessment' and 'research', and communicate this distinction to the authors.
- Establish a cross-chapter contact group within WG III on scenarios and modelling.

Key Recommendations for research communities

- Enhance communication between different scenario modelling groups.
- Establish a scenario database that includes relevant scenarios from a variety of sources.
- Find a common language in which different research communities can understand each other.
- Enhance transparency by being more explicit about assumptions, trade-offs, and uncertainties in scenarios.
- Identify gaps in knowledge in integrated assessment models.
- Unpack the concept of 'feasibility'.
- Link IAMs with finer scale models that represent infrastructure more explicitly.
- Ensure different tools and models are used for the purpose they are most appropriate for.
- Broaden the range of people (including social scientists, businesses and other stakeholders) involved in the design of storylines that feed into the scenarios.
- Bottom-up research communities could enhance efforts to self-organise, and build capacity on modelling for under-represented regions.

1. Introduction

Background

This Expert Meeting was proposed by the IPCC Working Group (WG) III Co-chairs to prepare for the assessment of climate mitigation scenarios at the start of the IPCC Sixth Assessment Report (AR6) cycle. The WG III Fifth Assessment Report (AR5) had provoked responses regarding the heavy use of global integrated assessment models (IAMs), the reliance of mitigation pathways on potentially controversial technologies, such as biomass with carbon capture and storage (BECCS), with land use implications, and the perceived lack of transparency around models and their underlying assumptions.

A proposal from the Norwegian government for an IPCC *Special Report on mitigation, climate stabilization scenarios and sustainability* (IPCC-XLIII/INF. 7) articulated some of these concerns. The proposal for this Special Report was not adopted but the Panel decided that the content of all unsuccessful proposals should be addressed during the AR6 cycle. The Expert Meeting, and its input to the IPCC AR6 scoping, partly fulfils that decision.

The Expert Meeting is also consistent with the overall aspirations off the WG III Co-chairs for AR6, expressed in three challenges set out in the WG III contribution to the IPCC Chair's Vision Paper:

- to achieve a better synthesis between higher-level "whole system" perspectives derived from, for example, global integrated assessment models (IAMs) and grounded, bottom-up insights into technologies and other approaches for reducing emissions.
- to make greater use of social science disciplines, in addition to economics, especially for gaining insight into issues related to lifestyle, behaviour, consumption, technological choices and socio-technical transitions; and
- to link climate change mitigation better to other agreed policy goals nationally and internationally (e.g. the Sustainable Development Goals - SDGs).

The Expert Meeting directly addressed all three challenges.

Purpose and preparation for the Expert Meeting

The WG III Co-chairs intended the Expert Meeting to address two needs:

- the need to assess the linkages between high-level climate stabilization goals and scenarios on the one hand and the practical steps needed in the short- and medium-term to make the realisation of these goals possible; and
- the need to anchor climate responses firmly in the context of development needs.

The WG III Co-chairs believed that these challenges should be addressed at the start of the AR6 cycle and, in particular, that the Expert Meeting should be held in advance of the AR6 Scoping Meeting in order to inform its deliberations. Addressing these challenges also has the potential to have an impact on the production of the other IPCC reports, in particular the IPCC Special Report on Global Warming of 1.5°C.

Following agreement by the Panel to the Special Report (Decision IPCC/XLIV-7), a Scientific Steering Committee (SSC) was formed comprising individuals with a range of relevant scientific skills, related not only to modelling and scenarios, with a balanced composition in terms of regions, gender and developed /developing countries. The membership and work of the SSC are described in Annex 1. The mandate of the SSC was:

- To recommend to the IPCC WG III Bureau, which had final sign-off, a list of participants in the Expert Meeting following IPCC principles and procedures;
- To prepare the agenda for the Expert Meeting;
- To prepare the necessary documentation to inform the Expert Meeting; and
- To prepare a document describing the outcomes of the Expert Meeting to be transmitted to the Secretariat for transmission to the Panel and for publication.

The SSC agreed on the following objectives for the meeting:

- To open the "black box" and explain what insights models/scenarios can provide and their limitations
- To unpack the "feasibility" of scenarios across different dimensions
- To link modelling across scales and disciplines
- To link the top-down and the bottom-up by identifying indicators that are explicit or implicit in model reporting
- To identify approaches for managing scenario perspectives in the AR6 process
- To develop recommendations for communicating scenarios effectively to policymakers

60 people were invited to the meeting of whom 47 finally attended. Participant selection is described in Annex 2 and the participant list, including TSU and Bureau members, is shown in Annex 3. Participation reflected a wide range of scientific skills not restricted to scenario building and modelling, as a key objective was to link these activities to practical action. The list included representatives from the UNFCCC, the government and business sectors and, as advised by the Panel, participants from the WG I and II communities.

Structure and outputs of the Expert Meeting

The SSC decided that the meeting should work towards concrete recommendations directed at three audiences: the IPCC scientific leadership and IPCC report authors; the scenarios/modelling community and other scientific communities whose work is assessed by IPCC; and, specifically, the succeeding IPCC AR6 Scoping Meeting. The recommendations were to be grouped under six themes:

- Sustainable development, co-benefits and trade-offs;
- Scenario "feasibility";
- The assessment of Model Intercomparison Projects (MIPs) and the use of marker scenarios;
- Communication of scenarios;
- Modelling across scales and scientific disciplines; and
- "Governance" and management of scenarios in AR6.

During the meeting, a seventh set of recommendations was generated on social science perspectives relevant to the demand side. All seven sets of recommendations were generated in Breakout Groups (BOGs), and endorsed by consensus in plenary sessions.

In order to reach the final recommendations, the meeting was divided into eight sessions of plenaries and breakout group discussions, a summary of which is presented in Table 1 below. A full Agenda is provided in Annex 4. As participants came from very diverse backgrounds, the plenary sessions consisted of short presentations intended to bring everyone up to speed, and included Q&A/discussion elements. The abstracts of all presentations are in Annex 5 and the PowerPoints are available at: [http://www.ipcc-wg3.ac.uk/]. The plenary presentation sessions covered:

- The IPCC AR6 cycle and the UNFCCC context;
- Global scenarios and the AR5;
- National and global perspectives post-AR5;
- Transitions and sectoral modelling; and
- Climate mitigation and development from a bottom-up perspective.

Table 1: Expert Meeting Structure

Session 1	Global scenarios and the AR5
Session 2	National and global perspectives post-AR5
Session 3	Transitions and sectoral modelling; First Breakout Group session: free flowing discussion
Session 4	Climate mitigation and development from a bottom-up perspective; Second Breakout Group session
Session 5	Report back and preliminary drafting of recommendations
Session 6	Taking stock; third Breakout Group session: methods and research protocols
Session 7	Feedback and third Breakout Group session continued: process and communication
Session 8	Final Plenary: crafting the recommendations

There were three sets of Breakout Groups (BOGs). BOG 1 was deliberately open in character, with randomly selected participants responding to the scenario/modelling presentations presented during Plenary Sessions 1, 2 and 3. The purpose of the BOG was to have a free flowing discussion about the treatment of scenarios in AR5 and to brainstorm any issues, challenges and opportunities associated with the treatment of scenarios in AR6. These ideas were then presented in plenary and formed a starting point to discussions in subsequent BOGs, which were intended to develop responses and solutions.

BOG 2 addressed scenario development and lessons that could be learned from bottom-up perspectives building on the presentations in Plenary Session 4. Self-selected participants focused on three topics: i) land use, ecosystem services and biodiversity; ii) social change, institutions and policies; and iii) infrastructure, technology development and lock-in. In relation to these topics, participants discussed what additional elements might be considered in developing scenarios/mitigation pathways. The groups explored challenges such as how to incorporate cross-cutting issues, how to develop scenario storylines that align mitigation with other policy goals and sustainable development, and how to incorporate framing elements.

Following the stock-taking Plenary Sessions 5 and 6, BOG 3 focused on developing recommendations in six thematic areas that were selected to build on the earlier discussions and taking into consideration all of the issues, challenges and opportunities raised. Participation was again self-selecting. Annex 6 describes the flow of the Expert Meeting and the guiding questions provided to each BOG in more detail.

The following sections of this report documents discussions and outputs from BOG 3, which resulted in the recommendations of the Expert Meeting.

2. Sustainable development, co-benefits and trade-offs

BOG Facilitator: Diana Ürge-Vorsatz
BOG Rapporteur: Franck Lecocq

Overarching discussion

This BOG discussed ways in which the AR6 could assess the linkages between climate mitigation and wider development needs. The discussions highlighted that while previous IPCC cycles had attempted to address these linkages, the framing of the assessments were typically climate-centric and focused on co-benefits. The BOG participants suggested that the AR6 should consider moving on from the co-benefit framing, and make sustainable development as an overarching analytical framework. In such a framework climate action and its impacts could be assessed on a more equal footing with development priorities, and the key question would become how to mainstream mitigation concerns into a large range of 'non-climate' policies. It was also highlighted that sustainable development is a broader concept than co-benefits, and that assessments should cover multiple objectives. It was noted that there have been several developments globally since the AR5 that provide new starting points for assessment. The signing (in 2015) of the 2030 Agenda for Sustainable Development and the Paris Agreement were identified as particularly important developments that will generate new literature and frameworks for analysis.

Recommendations for the AR6 Scoping Meeting

- The AR6 should consider a framing that starts with sustainable development.
  Whilst previous assessment cycles attempted to address sustainable development, these reports had climate-centric framings. The AR6 could use sustainable development to frame the questions addressed by the various chapters in the report. It should report both on how different sustainable development pathways affect the climate, as well as how climate action impacts different components of sustainable development. This could also include an assessment of the implications of the Sustainable Development Goals (SDGs) on climate and climate policy.
- The AR6 should explore how to embed mitigation concerns into broader policy sets.
  Sustainable development is broader than co-benefits, and while examining the co-benefits of climate policies is very useful, policymakers have multiple objectives when decisions are made. These other objectives influence the way in which mitigation and adaptation are achieved. This also broadens the set of policies that the AR6 should consider: it should not restrict itself to 'climate' policies (e.g., carbon taxes, emissions trading schemes, etc.), but explore how mitigation objectives can be mainstreamed in a broader set of policies that may be aimed primarily at other goals (e.g., urban planning and land taxation policies to influence the shape of cities, demand for transport, and ultimately GHG emissions). At the same time, climate actions will impact on other policy domains and core development objectives, so discussion of multiple impacts (referred to as co-benefits and adverse side-effects in AR5) still remains important in a development framing.
- The assessment should consider a wide range of narratives and scenarios on sustainable development
  Different perspectives exist on what constitutes a 'sustainable development pathway'. While the Shared Socio-Economic Pathways (SSPs)[1] are a useful tool and outline five different development paths, further different narratives on sustainable development are also needed. In particular, SSP1 which has been given the title "sustainability" should not be construed as *the* normative vision of what sustainable

[1] SSPs consist of a narrative outlining broad characteristics of the global future and country-level population, GDP, urbanisation projections. They are intended to help climate change analysts preparing policy analysis by ensuring that model results are compared against a consistent baseline.

development should be, but as one possible path. From a methodological point of view, the SSPs provide more information relevant to discuss sustainability than the previous scenario families developed as part of the IPCC Special Report on Emission Scenarios SRES.

Recommendations for the IPCC

- Consider linkages between WG II and WG III.
  The link between sustainable development and climate action (mitigation and adaptation) is also very pertinent to the WG II assessments. Coordination between the two WGs would result in a more comprehensive analysis.
- Ensure that author groups include experts with a wide range of relevant skills.
  Development economics was identified as a particularly important field of expertise from the perspective of this discussion that has often been missing from author teams in the past.

Recommendations for research communities

More literature is needed on:

- The implication of climate change action on other development goals. This includes the synergies and trade-offs in the context of scenarios, and also under which conditions climate action and development goals can be jointly addressed. Further literature on these interactions in the context of the SDGs and the Paris Agreement implications will be pivotal.
- How to embed climate change considerations into broader, multi-objective policy packages.
- The transitions required to reach other sustainable development goals, and how to embed climate change concerns into these goals.
- Exploration of sustainable development and climate change action at different scales.

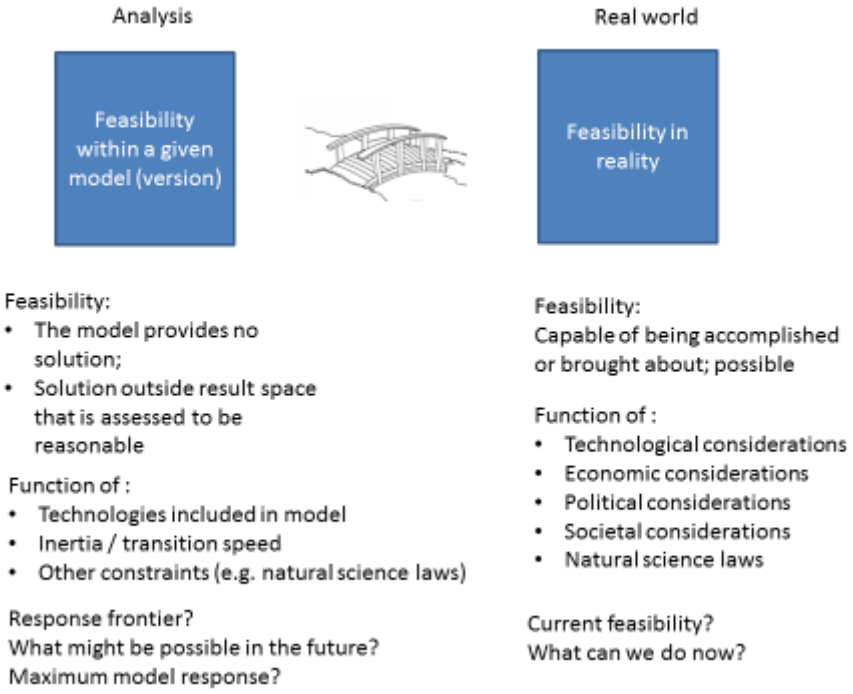
3. Feasibility

BOG Facilitator: Detlef van Vuuren
BOG Rapporteur: Raphael Slade

Overarching discussion

Feasibility is a very slippery word used differently in the real world and by modellers. It is important to recognise that what is possible in models may not be possible in the real world (and vice versa). The word feasibility is troublesome because it can be considered binary or conditional, it also has many different dimensions for example time and scale aspects which may be further characterised in terms of lock-in, or technical vs economic potential. Figure 1 below depicts some of the differences between how feasibility is used within models and how feasibility is interpreted in the real world. It is important to recognise that feasibility assessment requires value judgements. Social and political processes determine how much governments are willing and able to spend, whereas engineering disciplines may assess the technical opportunities and risks. For these reasons feasibility presents a communications challenge. Many options can only be realised if resources are committed. It may be easier to frame the discussion in terms of effort and risk. For many actors the debate around feasibility centres on creating (or removing) options that they may later want to use.

Figure 1: Feasibility in a model vs feasibility in reality



Recommendations for the AR6 Scoping Meeting

- When developing and assessing scenarios for the AR6 it is necessary to integrate a broad set of characteristics across WG III, i.e. the assessment should go beyond simple cost or GHG emission metrics.
- The AR6 should evaluate opportunities to make progress in short to near term. The Paris Agreement could be used as a framing to get going.

Recommendations for the IPCC

- Feasibility needs to be elaborated, explained, and a strategy developed for communication. Feasibility guidance is required and should be included in early chapters – (including elaborating on the short and long term dimensions of feasibility).
- It may be better to frame the discussion in terms of effort required/conditions necessary – thereby limiting the use of the word "feasibility" unless it is directly associated with a specific context.
- To help communicate scenarios it would be useful to consider scenario "archetypes" characterised in terms of the amount of technology required, investment needed, etc. In this way intervention scenarios can be characterised in terms of options and limitations.
- It would be useful to engage with the business community etc. to understand how the concept is used. For example, more rapid deployment and larger installations implies increased cost and hence reduced feasibility.
- Case studies and success stories are important to demonstrate what is possible.

Recommendations for research communities

- When elaborating and explaining feasibility the community needs indicators of effort level, and to be explicit about technology assumptions.
- Understanding feasibility is a science in itself. The community should be producing papers on this.
- Authors of papers should be encouraged to be specific on assumptions, and to use the Shared Socioeconomic Pathways (SSPs) to discuss feasibility.

4. Model Intercomparison Projects and marker scenarios

BOG Facilitator: PR Shukla
BOG Rapporteur: Joeri Rogelj

Overarching discussion

This group discussed how the results of large-scale Model Intercomparison Projects (MIPs) could be best used to the benefit of IPCC assessments. It was clarified that MIPs are exercises in which multiple modelling teams run the same experiments under a harmonised set of assumptions, or following a well-defined modelling protocol. These exercises are carried out to explore structural and parametric differences between models with the aim to ultimately derive insights that are as robust as possible. Markers, on the other hand, are single scenarios that are specifically selected because they represent certain scenario aspects particularly well or clearly. The discussion in this BOG focused on clarifying the strengths and weaknesses of the current approaches, and how they can be tailored to rise to the challenges facing the IPCC Sixth Assessment cycle. There was broad agreement that both MIPs and marker scenarios have an important role to play in providing insights for the IPCC assessments.

Recommendations for the AR6 Scoping Meeting

- Discuss best practices of MIPs across IPCC Working Groups.
  Several research communities have a long-standing experience with the IPCC and analysis of large-scale MIPs. Others, however, have only recently started or have yet to start. Discussions across Working Groups should ensure that best practices in the use of MIP data are consistently applied throughout the AR6.
- Discuss presentation and communication of scenario ranges.
  MIPs produce large amounts of data often showing a spread of results around a central value. However, the variation in such ranges is driven by a variety of factors, which can be very diverse in nature. Understanding how scenario ranges from MIPs can be interpreted, presented and communicated is essential to capitalize on the insights of MIPs for policymaking.
- Synthesis Report discussions should start early on in the Scoping Meeting.
  Keeping the ultimate end product of the Synthesis Report – as well as the accompanying scenario requirements to achieve such a synthesis – in mind from the beginning can avoid strong divisions and differences in foci between Working Groups.

Recommendations for the IPCC

- MIPs insights should be complemented with markers.
  MIPs inform the overall uncertainty and robustness of results for a specific sector or region. Markers, on the other hand, illustrate internal scenario dynamics and can provide more detailed information to other chapters. Marker choices and the reasoning behind these choices should thus be clearly documented. At the same time, factors underlying uncertainty ranges should be made explicit. These insights can be used as a means to derive statements of confidence, following the IPCC uncertainty guidelines. The framework of the Shared Socioeconomic Pathways (SSPs) already provides published marker scenarios which can be used in this context: However, markers should not be restricted to SSPs, and should be selected based on them being fit for purpose.
- Appropriate use of scenarios and scenario selection.
  Scenario selection should be encouraged based on a transparent set of criteria. Such scenario selection should include clearly articulated research questions, take into account the scenario design (for

example, whether the scenario represents a stylized perturbation of the model or aims at exploring the impact of specific policy choices), and needs to be well aware of the appropriateness of the underlying model to answer or inform the research question. The ultimate aim of such exercises is to be able to show how characteristics differ across sub-categories of scenarios.

- Encourage cross-Working Group and cross-chapter collaboration.
  Areas where communication is required between various models or approaches can be identified to facilitate comparison. For example, defining where sectorial or regional models overlap with global models allows for a comparison of modelling results at a finer scale.
- Ensure balanced representation of robust insights in the SPM.
  Develop strategy to ensure robust insights from all contributing lines of evidence, global, sectorial, and regional alike, reach the Summary for Policy Makers (SPM).
- Maintain a scenario database for the assessment.
  Given the large amount of scenarios and data from a large variety of sources, maintaining a database for the assessment is the only way to ensure full documentation and transparency of the assessment.

Recommendations for research communities

- National/sectoral modelling teams should experiment.
  Research communities which have little to no experience with MIPs are encouraged to experiment and develop MIPS within their communities to better understand inter-model variations and the robustness of results.
- Enable easy categorisation.
  Studies should consider allowing easy categorisation of the scenarios used. This could be, for example, by starting from the SSPs to inform consistent sets of socioeconomic drivers. This could, however, equally be by indicating how a study's scenario assumptions compare to the SSPs, or how they fundamentally differ.
- Data transparency should be strongly encouraged.
  Open access data and open source modelling tools should be encouraged across all modelling communities.
- Model evaluation and diagnostics.
  More work should be carried out on model evaluation and diagnostics which can help understand differences between models and hence make it easier to interpret the results from MIPs so that they can become more useful.
- Research on how ranges and markers can be communicated is needed.
  Ranges from MIPs and details from markers provide complementary information. Work on understanding how such ranges and markers can be presented and communicated in the most appropriate way would enable effective communication of rather complex issues.
- Develop linkages between approaches.
  Integrated models should explore how linkages with other modelling approaches can be provided. This could be achieved, for example, by incorporating more sectors or dimensions, or by providing specific tailored outputs that map on the domains of more specialised models.

5. Communications

BOG Facilitator: Øyvind Christophersen
BOG Rapporteur: Raphael Slade

Overarching discussion

There are important issues around the transparency and communication of scenarios that need to be addressed, in particular for users outside the modelling community. Communications underpin the credibility of the reports and should be targeted to specific audiences; a multi-level, multi-pronged approach is necessary. Using narratives could provide an important part of a communications strategy.

Not everyone is good at communications and this should be recognised (and potentially training should be provided). Authors should be aware that IPCC communicates to policy advisors (rather than directly to Ministers) – Ministers will hear about IPCC through conventional media. Authors also need to accept that there will always be times when their work is misrepresented, but they should "enter the fray" rather than stop trying to communicate. In some cases, IPCC has incorrectly been regarded as an advocating body which is something that needs to be tackled.

The communication of uncertainty presents particular challenges which need to be addressed. This includes being transparent about the process for assigning expert judgement. I.e. the analytical framework needs to be clear. There are also communication challenges around Shared Socioeconomic Pathways (SSPs). Currently, it is unclear whether SSPs can be developed into an effective communications approach.

Recommendations for the AR6 Scoping Meeting

- Start thinking about narratives now. Authors need to consider the story the science can tell.

Recommendations for the IPCC

- Clarity and transparency of analytical framework underpins communications, but it is important to recognize that there is more to transparency than providing a data table – it is also about demonstrating how value judgements were made.
- Unpack uncertainty in underlying reports (distinguish between expert judgement, and pseudo-quantitative approaches. Authors should be explicit about how judgments have been made).
- The IPCC should be very cautious about assigning probabilities to scenarios or to social processes and priorities. It is not possible to tell society if aspirations are likely or unlikely.
- IPCC should go back to its roots and say: "this is what the science tells us…" which is preferable to saying "the IPCC says…".
- Where there is a lack of knowledge this should be acknowledged.
- Planning communications needs to start today; the community needs to work on storylines, and network of journalists to be ready for five years' time. Outreach activities that include report authors could be extended.

Recommendations for research communities

- Researchers should be engaged in communication.
- Be open with data. This helps demonstrate transparency and builds trust.

6. Modelling across scales and scientific disciplines

BOG Facilitator: Roberto Schaeffer
BOG Rapporteur: Detlef van Vuuren

Overarching discussion

This BOG discussed how to develop scenarios across different temporal scales (short-, mid- and long-term), spatial scales (local, regional and global), and disciplines (function, purpose). In the academic literature there are a wide range of models describing a variety of outcomes which depend upon the applied scale of analysis. This can potentially result in contradictory conclusions. Scaling methods and alternative scale definition are important in dealing with this problem. Discussions in this BOG clarified that model scales differ in terms of parameter extent, temporal resolution, and spatial coverage rate. Participants discussed different scaling methods needed to homogenise results, including secondary data extrapolation, upscaling (aggregation) and downscaling (disaggregation), and technical coefficients derived from simulation models. Improved integration of scaling frameworks would be helpful to overcome the limitations of Integrated Assessment Models (IAMs) and sectorial models and reduce the cumulative uncertainty due to the use of different scales across modelling exercises. The discussion in this BOG focused on identifying limitations of current approaches and how to overcome them.

Recommendations for the AR6 Scoping Meeting and IPCC process

- SSP framework may be applied to organise scenarios across WGs.
- SSPs may also be used to harmonise scenarios across WG III chapters (among others because there will be a lot of literature based on them).
- Work not related to SSPs should also be assessed to address specific policy questions.
- Use existing tools already developed to link across temporal, geographic and sectoral scales and disciplines (also developed in other communities).
- Literature on the integration of bottom-up and short-term scale modelling results with the long-term results from IAMs needs to be further explored.

Recommendations for different research communities

- Map different scenarios and integrating concepts in research communities beyond the existing circle of IAM practitioners.
- Develop literature on scenario definition starting from a storyline design.
- Conduct studies that link mitigation scenarios with social adaptation pathways across different scales.
- Improve the SSP framework to bridge the gap between large and small spatial scales and group literature scenarios.
- Develop further studies to clarify which models are more suitable to answer different questions.
- Develop different temporal scales in IAMs to address different purposes (short-mid-term guidelines for Nationally Determined Contributions versus long-term).
- Organise workshops for stakeholder analysis on societal goals to design backcasting assessments to evaluate the implications of those goals.

7. Scenario Governance

BOG Facilitator: Jan Fuglestvedt
BOG Rapporteur: Katherine Calvin

This BOG discussed scenario "governance" for the Sixth Assessment Report. Participants identified the objective of this governance to ensure consistency, coherence (integration), and communication of scenario use throughout the AR6. In this context, "scenario" was defined to encompass different scales, sectors, and dimensions.

Several options for governance were considered. The first two options pertained to the full AR6 cycle, including the special reports and Synthesis Report. These options were a cross Working Group team on scenarios, and shared authorship across Working Groups and chapters. A third option discussed was to include a cross Working Group chapter on scenarios. This chapter could include methodology for use of scenarios, integrated analysis, limitations, etc. Such a chapter would appear in all three Working Group reports, either as identical versions or incremental chapters (i.e., each working group's version would include additional information relevant to the group). The participants did note that such an option would pose some logistical challenges (e.g., the chapter would need to be approved by one Working Group's plenary). The fourth option was to include an integrative section on scenarios in the Synthesis Report. Such a section would need to be designed at an early stage in the process to ensure that the individual Working Groups include the necessary material in their reports. The final option was a cross-chapter team within an individual Working Group that linked sectors, regions, etc. through scenarios. Importantly, participants thought that regardless of which option was chosen a single team/group was needed to ensure consistency. Given these options, BOG participants developed a list of recommendations for the AR6 scoping meeting and for the IPCC Bureau.

Recommendations for the AR6 Scoping Meeting

- Participants of this BOG thought that a cross-Working Group Breakout Group focusing on integrating recommendations from the expert meeting was necessary. This group could consider the options listed above in detail.
- A similar recommendation was made for the WG III scoping; that is, participants suggested an internal breakout on scenario integration within the WG III scoping meeting. The focus on WG III was due to the experts included in the expert meeting and the BOG and not a reflection of needs in other Working Groups.
- Integration needs to be included in the chapter objectives and structure in order to have it included in the final report.
- The ability to think beyond an individual chapter was identified as an important criterion for selecting CLAs of chapters including integration.

Recommendations for the IPCC

- Information about potential authors' "integrative expertise" should be solicited as part of the author nomination process.
- Cross-Working Group teams need "champions" with clear responsibilities.
- The IPCC Bureau should facilitate engagement across Working Groups by inviting participants from other groups (e.g., CLA/LA or co-chairs) to join calls or lead author meetings.

8. Consumption, lifestyles and services (a social science perspective on demand)

BOG Rapporteurs: Joyashree Roy and Felix Creutzig

Overarching discussion

During the course of the Expert Meeting a seventh informal Breakout Group (BOG) was formed by several participants motivated by a perceived need to give greater emphasis to energy service and demand-side solutions, and in particular those aspects that would benefit from greater representation of emerging social science literature compared to previous IPCC reports. Whilst previous research has focused on energy supply mitigation options, there is a growing literature on energy services and changing pattern of demand for these services and multiple ways to manage this demand. This research provides an alternative perspective on how to leverage reductions in primary energy demand. Demand-side mitigation options are also closely entangled with equity, questions of multidimensionality of human well-being and sustainable development.

Recommendations for AR6 scoping meeting

- A stand-alone chapter in the AR6 report to synthesise and communicate consumption and lifestyle driven issues should be considered.
  Such a chapter might include an analysis of human well-being from an end-use/service perspective. The chapter would include knowledge from behavioural psychology to explain consumer behaviour, and behaviour towards output and services. Such studies could examine how consumer behaviour changes, and transitioning options from a consumer perspective. The chapter would bring together studies on end-use service delivery compatible technologies, and their costs and mitigation potentials that goes beyond sector-specific costs and opportunities. The mitigation opportunities specifically will capture cross-sectoral mitigation potentials. The chapter could examine de-scaled technological learning, as well as options for multi-level governance.

Recommendations for IPCC

- Systematically assess the emerging social science literature and case studies that are applicable to the scale and nature of the decisions being made.
  This BOG identified a need to improve the way mitigation options were evaluated and communicated to policy makers as well as decision makers at different scales (e.g. including the household/individual level). Assessing the literature related to these different levels of decision making could help.
- Highlight demand-side options as supplementary and as short-term entry points for climate action with long-term transformative impact.

Recommendations for research communities

- Find a common platform for communication across different social science disciplines.
  Several social science disciplines were highlighted as providing useful perspectives on consumer behaviour. These include: social anthropology, traditional sociological approaches, psychology, cognitive sciences, behavioural economics, a service approach to human well-being, sustainable development studies, and innovation and transition studies. It would be beneficial for these disciplines to find a common platform for communication, including a common understanding of semantics, to strengthen a coherent research agenda, and by this establish a platform for high-level messages and input to assessment processes.
- There is a need to build scenarios from the bottom-up.
  These scenarios would start with energy services and link to consumption and lifestyles.

Annex 1: Background Information

At the 44th Session of the IPCC (IPCC-44) (Bangkok, Thailand, 17-20 October 2016), the Panel considered a proposal from the Co-Chairs of Working Group III and its Bureaux for an Expert Meeting on Mitigation, Sustainability and Stabilization Scenarios.

The Expert Meeting specifically aimed to address issues contained in the proposal for a Special Report on mitigation, climate stabilization scenarios and sustainability made by the Government of Norway and the proposal for a Special Report on decarbonisation and low carbon development (including on 1.5°C-warming scenarios) made by CAN International (IPCC-XLIII/INF. 7).

It was agreed to include 30 journeys for this meeting in the forecast budget for 2017, allowing CHF 140,400 for the Expert Meeting.

The Co-Chairs of Working Group III formed a Scientific Steering Committee consisting of experts in the fields of mitigation, climate stabilization scenarios and sustainability. Its members are:

- Priyadarshi R. Shukla, Indian Institute of Management Ahmedabad, India
- Jim Skea, Imperial College London, UK
- Mercedes Bustamente, University of Brasilia, Brazil
- Leon Clarke, Pacific Northwest National Laboratory, US
- Michel Colombier, Institute for Sustainable Development and International Relations, France
- Fu Sha, Climate Technology Centre and Network, China
- Jan Fuglestvedt, CICERO, Norway
- Stuart Haszeldine, University of Edinburgh, UK
- Yemi Katerere, CGIAR, Zimbabwe
- Peter Newman, Curtin University, Australia
- Keywan Riahi, IIASA, Austria
- Roberto Sanchez-Rodriguez, El Colegio de la Frontera Norte, Mexico
- Taishi Sugiyama, the Canon Institute for Global Studies, Japan
- Diana Urge-Vorsatz, Center for Climate Change and Sustainable Energy Policy, Hungary

The Scientific Steering Committee met seven times by conference call (21 December 2016, 23 January 2017, 10 February 2017, 21 February 2017, 2 March 2017, 15 March 2017, 10 April 2017). The mandate of the SSC was:

- To recommend to the IPCC WG III Bureau a list of participants in the Expert Meeting.
- To prepare the agenda for the Expert Meeting.
- To prepare the necessary documentation to inform the Expert Meeting.
- To prepare a document describing the outcomes of the Expert Meeting to be transmitted to the Secretariat for transmission to the Panel and for publication.

The Expert Meeting was held on Wednesday 26 April 2017 to Friday 28 April 2017 in Addis Ababa. A total of 60 participants attended the meeting. A full break-down of the participant selection is provided in Annex 5.

The cost of the meeting for the IPCC totalled CHF 56,590 consisting of travel support for invited experts, members of the Steering Committee, members of the Bureau, and Secretariat staff. This is summarised in Table 2 below.

Table 2: Costs of the Expert Meeting

16 invited experts (developing countries/economies in transition)	CHF 39,154
1 member of the Scientific Steering Committee (developing countries/economies in transition)	CHF 3,203
4 eligible Bureau Members	CHF 10,135
1 Secretariat staff	CHF 1,909
Miscellaneous	CHF 3,900

Annex 2: Participant Selection

Participants to the Expert Meeting were selected following a process consistent with the IPCC policies and procedures.

The expert selection process occurred in four stages:

Stage 1 – Identification of experts
Members of the Scientific Steering Committee (SSC), members of the WG III Bureau, and the Co-Chairs of WG I and WG II were invited to identify up to 12 individuals who they believe could make a useful contribution to the Expert Meeting. In addition to the names of individuals, members were asked to provide information on the areas of expertise of each individual. This included expertise in three broad groups in line with the meeting themes: scenario/modelling, sectors and cross-cutting areas. This was done in order to ensure a broad range of expertise was present at the meeting, which was about the interface between modellers and individuals with sectoral and cross-cutting expertise. A total of 132 experts were nominated and compiled into a list by the WG III TSU.

Stage 2 – Evaluation of candidate's expertise
SSC members identified priority participants by identifying six high priority and six secondary priority participants to the meeting. Their voting was consolidated by the WG III TSU.

Stage 3 – Identifying and filling major gaps
The SSC identified key gaps in expertise, regional representation, and gender balance. Suitable candidates to fill these gaps were proposed by the SSC with support of WG III TSU.

Stage 4 – Invitations and reserves
A total of 60 invitations were issued on 1 March 2017. A reserve list of 30 experts was identified. If an expert was unable to accept the invitation to the Expert Meeting, a participant was selected that would ensure a similar balance of expertise, regional representation and gender.

Participant list

A total of 47 experts accepted invitations to attend the Expert Meeting. In addition, 7 Bureau Members attended the meeting. Of the total 54 participants, 44% were from developing countries and countries with economies in transition, and 56% were from developed countries. 26 nationalities were represented. 76% of the participants were males and 24% were female. The break-down of participants across a number of criteria is shown in Figures 2 through 4. Table 3 provides a break-down of participants by WMO region and expertise. The full list of participants who attended the meeting is provided in Annex 3.

Figure 2: Percentage of participants from developed and developing countries (including economies in transition)

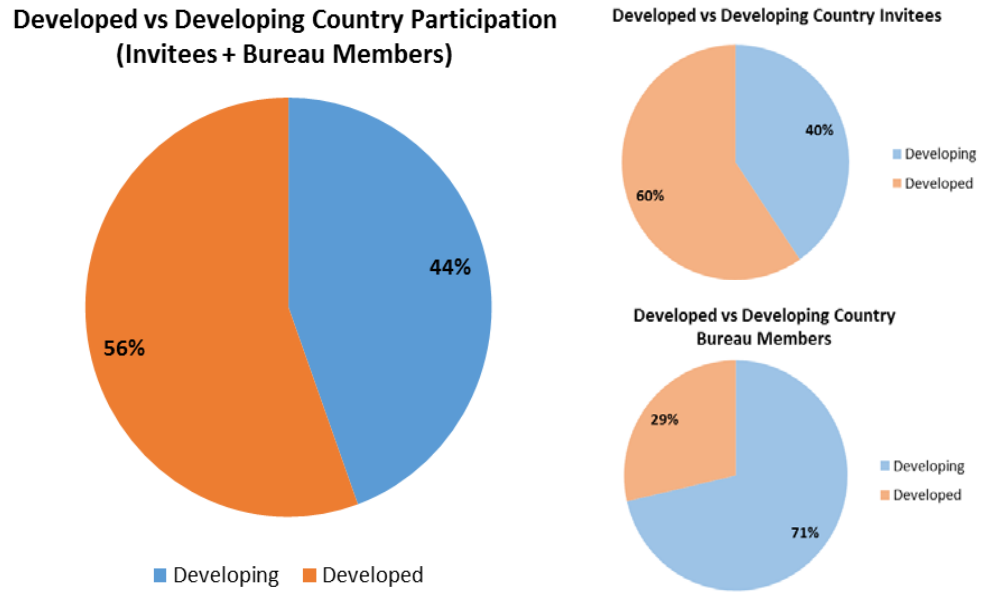


Figure 3: Distribution of participants across WMO region (based on citizenship)

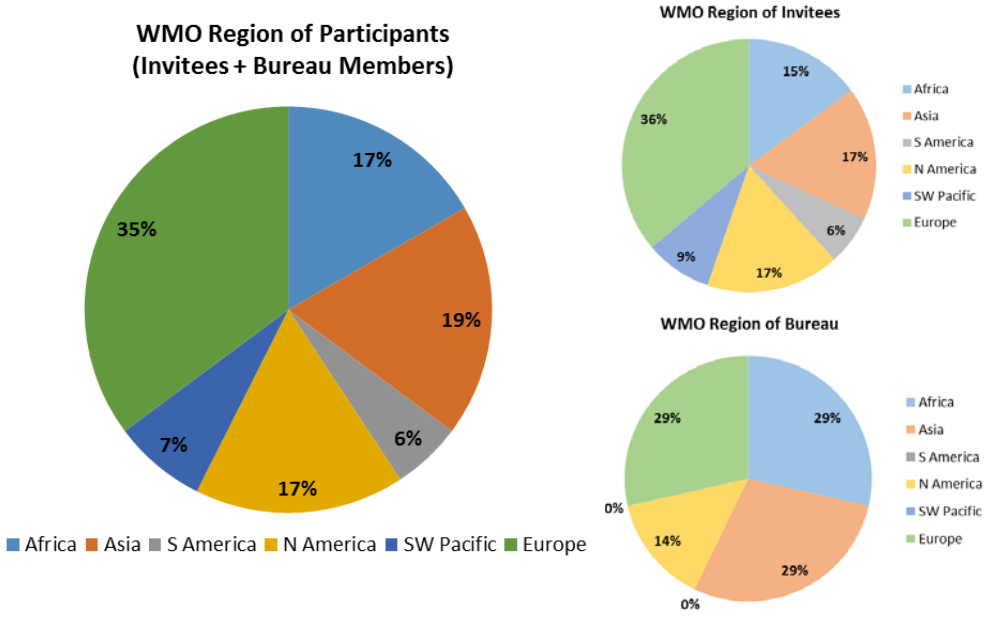


Figure 4: Gender balance of participants

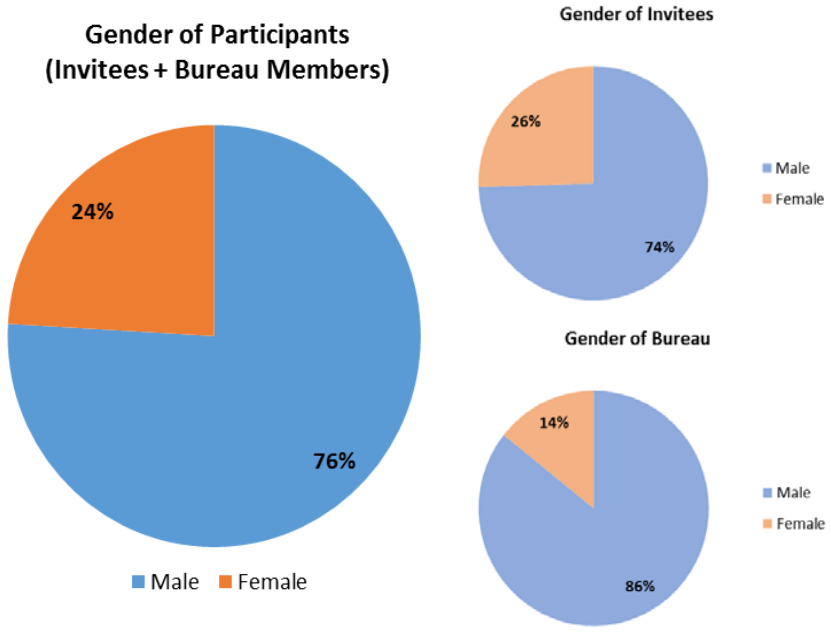


Table 3: Distribution of participants by WMO region and expertise

	Skills	Africa	Asia	S America	N America	SW Pacific	Europe	Total
Models and scenari	Global IAMs	0	2	1	3	0	9	15
	National/regional	2	4	2	1	0	6	15
	Sub-national	0	1	1	0	1	1	4
	Sectoral	1	3	1	2	0	5	12
	MIP participation	0	2	1	3	0	5	11
	Scenario building including SSPs	0	0	0	3	2	8	13
Sectors	Energy system	2	5	1	2	2	9	21
	Urban/rural systems and settlements	0	2	0	2	1	4	9
	Buildings	0	0	0	1	0	2	3
	Transport	0	2	1	1	0	4	8
	Industry	0	3	0	2	0	3	8
	AFOLU	4	0	2	1	0	5	12
	Food systems	2	0	0	0	0	3	5
X-cuts	Links to the SDGs, e.g. poverty eradication, food security	3	2	2	2	1	8	18
	Ecosystem services, biodiversity impacts	3	0	2	0	0	2	7
	Governance and institutions	1	2	1	1	0	7	12
	Technology and innovation	1	5	1	4	0	9	20
	Finance	1	2	0	0	0	5	8
	Human behaviour and consumption	1	1	0	1	1	3	7
	Societal transitions	1	1	0	1	2	7	12

Annex 3: Participant List

Selam Kidane ABEBE
Legal Research Group
ETHIOPIA

Mustafa BABIKER
Saudi Aramco
SAUDI ARABIA

Xuemei BAI
Australian National University
AUSTRALIA

Malek BELKACEMI
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Joseph CANADELL
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CEEW
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Øyvind CHRISTOPHERSEN
Norwegian Environment Agency
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Fatima DENTON
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Subash DHAR
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Henri WAISMAN
IDDRI
FRANCE

Sumaya Ahmed ZAKIELDEEN
University of Khartoum
SUDAN

Annex 4: Agenda

Tuesday, 25 April 2017

14:00-17:00	Meeting registration (Delegate Registration Building – Gate 2)	

Wednesday, 26 April 2017

08:00-10:00	Meeting registration (Delegate Registration Building – Gate 2)	
09:00	Welcome and introduction: IPCC AR6 and the UNFCCC context (Conference Room 2)	Chair: PR Shukla
	• Welcoming remarks	Fatima Denton
	• Motivations for the expert meeting	Øyvind Christophersen
	• AR6 products and aspirations	Jim Skea
	• Government responses to the AR6 scoping questionnaire	Jim Skea / PR Shukla
	• Links to the UNFCCC (NDCs and the global stocktake)	Florin Vladu
09:30	SESSION 1: Global scenarios and the AR5 (Conference Room 2)	Chair: Nagmeldin Mahmoud
	The purpose of this session is to bring all participants up to speed on the contributions of integrated assessment modelling (IAM) to AR5, notably Chapter 6: Transformation Pathways. It will cover how the IAMs link to climate modelling and outcomes and summarise conclusions and recommendations arising from the 2015 Expert Workshop on scenarios and will include a government response to the AR5 scenarios work.	
09:30	Scenarios in WG III AR5: their scope, their presentation and their use	Leon Clarke
09:50	From emissions to climate: the role of reduced complexity climate models	Jan Fuglestvedt
10:00	Report on the IIASA Scenarios Workshop 2015	Keywan Riahi
10:10	Scenarios in WG III AR5: a government adviser's perspective	Fu Sha
10:20	Scenarios in WG III AR5: a business perspective	Brian Flannery
10:30	Discussion	
11:00	Break	
11:30	SESSION 2: National and global perspectives post-AR5 (Conference Room 2)	Chair: Ramón Pichs-Madruga
	The purpose of this session is to bring all participants up to speed on global scenario work subsequent to AR5. This will cover the subsequent use of IAMs, bottom-up approaches based on the aggregation of national analyses and progress with the shared socio-economic pathways (SSPs). Presentations will include 1.5°C Scenarios related new work and how 1.5°C SR can complement AR6.	

11:30	National climate policies, sustainable development and policy experiences	Roberto Schaeffer
11:45	The Shared Socio-Economic Pathways (SSPs): progress and use	Brian O'Neill
12:00	IAM scenarios subsequent to AR5: interpretation and extensions	Elmar Kriegler
12:15	The trouble with negative emissions	Glen Peters
12:30	Discussion	
13:00	Lunch break	
14:30	SESSION 3: Transitions and sectoral modelling (Conference Room 2)	Chair: Taishi Sugiyama
	The purpose of this session is to provide participants with information on projects relating high-level modelling to other perspectives and work on sectoral approaches	
14:30	Transition and initiative-based learning: the PATHWAYS project	Detlef van Vuuren
14:45	An energy sector case study (IEA)	Eric Masanet
15:00	Modelling urban and sectoral systems	Diana Ürge-Vorsatz
15:15	Modelling climate and land use	Katherine Calvin
15:30	Discussion	
16:00	Break	
16:30	BREAKOUT GROUP 1: Re-Setting the Agenda	

The purpose of this session is to allow all participants to react to the presentation of all of the scenarios/modelling work presented. Randomly selected groups should have free-a flowing discussion of what they've heard and address some specific questions. The approach is intended to be diagnostic. There will be subsequent opportunities to develop solutions and responses.

- *Reconciling different approaches for consistent communication to policymakers*
- *Assessing and communicating 'feasibility' of pathways to policymakers*

Communication of findings and transparency of scenarios storylines and model databases

	BOG 1a Facilitator: Fu Sha (Large Briefing Room)	BOG 1b Facilitator: Keywan Riahi (tbc) (CAUCUS 1)	BOG 1c Facilitator: Jim Skea (Small Briefing Room)
18:00	Report back (Conference Room 2)		Chair: Jim Skea / PR Shukla
18:30	End of day 1		

Thursday, 27 April 2017

09:00	SESSION 4: Climate mitigation and development from a bottom-up perspective (Conference Room 2)	Chair: Diana Ürge-Vorsatz

The purpose of this session is to receive the views of domain experts, who will in general not be modellers, as to what key elements and insights from their domain should ideally be addressed in large integrative models and scenario exercises with the motivation of addressing "realism", "feasibility" and links to wider development agenda (c.f. SDGs). Questions:

- *Do the SSPs and mitigation pathways capture all the essential elements of possible socio-economic developments? What elements are missing?*
- *Have the biodiversity and ecosystem service dimensions of mitigation pathways been adequately captured? Are they realistic? How could they be better covered?*
- *Is the scale and rate of change of technology deployment implied by mitigation pathways credible? Are there constraints?*

09:00	Land use, ecosystem services and biodiversity	Cheikh Mbow
09:25	Social change, institutions and policies	Navroz Dubash
09:50	Infrastructure, technology development and lock-in	Arnulf Grübler
10:15	Discussion	
11:00	Break	
11:30	BREAKOUT GROUP 2 Scenario development: learning from bottom-up perspectives	

Thematically differentiated, self-selecting BOGs are charged with building on the presentations in Session 4 to develop recommendations for scenarios developers and modellers as to what additional elements might be considered in developing scenarios/mitigation pathways. Challenges include:

- *Elements of scenario storylines and modelling approaches to align mitigation and development (SDGs)*
- *framing elements (e.g. uncertainly, risks and co-benefits)*
- *Cross-cutting issues (technology, finance, carbon price, policy instruments etc.)*

	BOG 2a: Land use, ecosystem services and biodiversity Facilitator: Cheikh Mbow (Large Briefing Room)	BOG 2b: Social change, institutions and policies Facilitator: Ramón Pichs-Madruga (CAUCUS 1)	BOG 2c: Infrastructure, technology development and lock-in Facilitator: Leon Clarke (Small Briefing Room)
13:00	Lunch break		

14:30	BREAKOUT GROUP 2 continued		
	BOG 2a: Land use, ecosystem services and biodiversity (Large Briefing Room)	BOG 2b: Social change, institutions and policies (CAUCUS 1)	BOG 2c: Infrastructure, technology development and lock-in (Small Briefing Room)
15:30	Break		
16:00	SESSION 5: Report back and preliminary drafting of recommendations (Conference Room 2)		Chair: Jim Skea / PR Shukla
16:00	Report on IPCC expert meeting on communications		
16:20	Feedback from BOGs		
17:00	Review of BOG recommendations and general discussion		
18:00	End of day 2		

Friday, 28 April 2017

09:00	SESSION 6: Taking stock and final breakout groups (Conference Room 2)	Chair: Diriba Korecha
09:00	Re-cap from the Scientific Steering Committee	
09:15	Discussion	
09:30	BREAKOUT GROUP 3a: Methods and research protocols	

The purpose of these self-selecting BOGs is to develop recommendations in three broad areas which may, in practice, overlap. The recommendations should relate to methods and approaches to assessments as conducted by IPCC and also methods and protocols associated with the underlying research activity on which IPCC might draw. There are therefore two audiences for the recommendations, which should be explicitly identified:

a) IPCC authors and scientific leadership;

b) Scientific communities generating literature relevant to IPCC.

It will be helpful for each BOG to consider indicators that will assist with communication between communities: sustainable development (BOG 3ai); policymakers (BOG 3aii); and researchers addressing different scales (BOG 3aiii).

BOG 3ai: Sustainable development, co-benefits and trade-offs Facilitator: Diana Ürge-Vorsatz (Large Briefing Room)	BOG 3aii: Feasibility Facilitator: Detlef van Vuuren (CAUCUS 1)	BOG 3aiii: MIPs and marker scenarios Facilitator: PR Shukla (Large Briefing Room)
Linking climate mitigation with wider development needs • Climate mitigation and sustainable development • Links to the SDGs • Relevant SD indicators • Co-benefits, co-costs/risks and trade-offs • "Nexus" (land/water/ food) implications	Unpacking the "feasibility" of scenarios across different dimensions: • Technical feasibility • Lock-ins • Cost/financing • Social acceptance • Speed and scale of adoption • Impacts on ecosystem services/biodiversity • Indicators of feasibility	• The use of marker scenarios to facilitate deep-dive analysis of possible mitigation pathways • The balance between MIPs/markers in terms of exposition • Linking MIPs/markers: context/uncertainties

11:00	Break	
11:30	SESSION 7: Feedback from the BOG 3a (Conference Room 2)	

12:00	BREAKOUT GROUP 3b: Process and communication		
	The purpose of these self-selecting BOGs is to develop recommendations that focus on IPCC processes and the communication of scenarios, including aspects related to transparency.		
	BOG 3bi: Transparency and communication Facilitator: Øyvind Christophersen (CAUCUS 1) • Opening the black box: how to explain what models can do and limitations • Following up recommendations of IPCC Expert Meeting on communication • Use of IPCC uncertainty language as applied to scenarios	BOG 3bii: Scenario "governance" during AR6 Facilitator: Jan Fuglesvedt (Small Briefing Room) • Cross-WG teams on scenarios • Authorship across chapters and WGs • Cross-chapter working – scenarios and sectors Cross-chapter working – scenarios and x-cutting chapters (policy, finance etc.)	BOG 3biii: Modelling across scales and scientific disciplines Facilitator: Roberto Schaeffer (Small Briefing Room) Linking modelling across scales and disciplines: • IAMs/global models • Regional/national models • Sub-national (state/city) • Sectoral models • Natural/social sciences • The role of scenarios • Indicators for linking modelling at different scales
13:00	Lunch break		
14:30	SESSION 8: Final Plenary: Crafting The Recommendations (Conference Room 2)		Chair: Jim Skea / PR Shukla
14:30	Feedback from Breakout Groups 3b		
14:45	Break		
15:00	Plenary refinement of recommendations: BOGS 1, 2, 3a and 3b		
17:00	End of workshop		

Annex 5: Abstracts

Session 1

Scenarios in WG III AR5: their scope, their presentation and their use

Leon Clarke

This talk will discuss the scenario efforts that were attempted in WGIII of AR5 and lessons for the next assessment. WGIII included not only a robust assessment of long-term, multi-sector, and typically global scenarios from integrated assessment models in Chapter 6; it included as well a cross-chapter process for linking across sectoral chapters and broader, multi-sector analyses. In addition, WGIII authors worked extensively with WGI and to some degree WGII authors in the synthesis of various scenario efforts in the overall AR5 synthesis report. This talk with reflect on the successes in these processes and the areas where new efforts or processes would be helpful, with a particular emphasis on the internal WGIII process for linking across chapters, and hence across sectors and scales.

From emissions to climate: the role of reduced complexity climate models

Jan Fuglestvedt

The presentation will discuss the different purposes, perspectives and approaches traditionally used by WGI and WGIII, and the role that reduced climate models (that are calibrated to full climate models) play in bridging global climate goals and the emission pathways generated by Integrated Assessment Models (IAMs). The IAMs have different structures and use different climate modules, and mitigation targets are formulated in different terms, e.g. radiative forcing or CO2-equivalent concentration by the end of the century or as total cumulative CO2 emissions. The presentation will also briefly discuss prospects for better integration and communication of scenario work and results across the IPCC Working groups.

Report on the IIASA Scenarios Workshop 2015

Keywan Riahi

No abstract available.

Scenarios in WG III AR5: a government adviser's perspective

Fu Sha

This presentation will start from matching the key issues cared by policy makers or affecting decision making process, such as priority of policy objectives, time frame, cost-benefit, feasibility, etc., with the key messages delivered by scenarios in WGIII AR5, such as carbon budget and pathway, cost, co-benefit, etc. Then, the presentation will try to identify some kind of gaps in scenario study in WGIII AR5, which not only limited to study itself but also the way presenting or communicating findings, such as how to deliver more concise, accurate and transparent information to policy makers.

Scenarios in WG III AR5: a business perspective

Brian Flannery

IPCC scenario efforts frame consideration of climate change. Business participates with the research communities and uses the experience to inform public engagement and internal deliberations. Companies have sponsored IAM research and experts interacted to share information, e.g., on energy supply and demand, and technology and policy options. Involvement informs company views and demeanor, e.g., on policy and corporate citizenship, and internal consideration of strategy, research and, more recently, risk management and resilience.

These long-term scenarios are inappropriate for business planning: this requires far more economic and market detail, temporal resolution, and timely updates. ExxonMobil, for example, develops detailed annual energy and

economic outlooks that provide a planning basis across the organization. Plans guide future operations and major investment decisions that alter future technical capacity.
It would be helpful if AR6 were in a better position to assess how the future unfolds under the Paris Agreement. This would require the research communities to develop tools—more akin to energy outlooks than long-term scenarios—that generate reference cases that incorporate NDCs through 2030. Understanding would benefit from scrutiny, perhaps in workshops, of experts from government, business, academia and think tanks to explore implications for managing climate risks.

Session 2

National climate policies, sustainable development and policy experiences

Roberto Shaeffer

Economy-wide emissions reductions do not ensure that short-term action will contribute meaningfully to long-term decarbonisation goals. In this sense, climate policies have to be designed in such a way as to simultaneously contribute to non-climate objectives, so as to allow for broad coalition of supporters in the short, medium and long terms. Having this perspective as a background, this presentation will focus on national level modelling, drawing attention to links with climate policies and policy experiences. Having the CD-Links project as a reference, the presentation will call attention to the importance of national-level-scenario modelling, given the much higher resolution of national models as compared to global Integrated Assessment Models (IAMs), but emphasizing the importance of a dialogue between these two levels of modelling, if one really wants to anchor climate responses in the context of development needs. Given that post-AR5 the United Nations Sustainable Development Goals (SDGs) now provide an agreed framework for exploring climate responses, this new framework asks for global, regional, national and even subnational climate scenario modeling and policies.

The Shared Socio-Economic Pathways (SSPs): progress and use

Brian O'Neill

Recently the international climate change research community has developed a new set of five alternative visions of future societal development at the global level. These Shared Socioeconomic Pathways (SSPs) describe broad trends in societal change that can be combined with future projections of climate change in order to investigate possible climate change impacts as well as mitigation and adaptation response options. The SSPs are likely to underpin a wide range of climate change research and are also being used to investigate broader questions of sustainable development. They describe various aspects of society thought to be important determinants of adaptation and mitigation capacity, including demographics, economic growth, technological change, governance, and institutions, in both quantitative and qualitative terms. The SSPs have served as the basis for a set of scenarios of future energy use, land use, and emissions developed with integrated assessment models. These SSP-based scenarios will be used to drive global climate model simulations for assessment in AR6. SSPs are also already being used in a variety of impact, adaptation and mitigation studies, and are being extended to provide more detailed information for specific sectors and at the regional or spatially explicit scale.

IAM scenarios subsequent to AR5: interpretation and extensions

Elmar Kriegler

No abstract available.

The trouble with negative emissions

Glen Peters

In October 2016, together with Kevin Anderson, I published a Perspective in Science on negative emissions. We called negative emissions a "moral hazard", because if they failed to work at the scale in emission scenarios, future generations would bear the consequences. In this presentation, I want to talk more about the background

of the paper. Why was there even space, in a high-profile journal, for non-IAM researchers to write such an article? To me, the answer is clear. Outside of the IAM community there is very little understanding of IAMs and their findings. There is too much focus on headline results, and too little discussion of the details and consequences. Users external to the IAM community are demanding details, but the supply of information is not coming from the IAM community in a user-friendly format. This says a lot about how IAMs and scenarios are used and communicated. I will conclude with a few small steps, that could potentially make a big change in the way IAMs and scenarios are perceived by the broader research and user community.

Session 3

Transition and initiative-based learning: the PATHWAYS project

Detlef van Vuuren

No abstract available.

An energy sector case study (IEA)

Eric Masanet

The energy sector accounts for two-thirds of global GHG emissions, and therefore plays a decisive role in achieving global climate objectives. IEA energy technology outlooks and scenarios provide policy makers with robust guidance on technology pathways, policy actions, and investment needs for meeting climate ambitions, as well as a means of tracking progress toward policy objectives. This presentation will first highlight the IEA's approach for constructing and modelling long-term energy technology scenarios at national/regional scales, focusing on the use of technology-rich energy systems models that leverage multiple IEA resources--including IEA statistics, technology roadmaps, market reports, Policy and Measures Databases, and extensive energy technology expert collaborations—and on how modelling insights are translated into policy advice. Next, recent IEA scenario results for long-term "below 2 degree" technology pathways will be presented to illustrate the amplified scale and pace of energy system transformations necessary to meet increased climate ambitions, including key findings and policy insights, and with an emphasis on the critical role that demand-side energy technologies and policies must play in the transitions.

Modelling urban and sectoral systems

Diana Ürge-Vorsatz

While integrated assessment models and other whole-economy provide the pillars and backbone of mitigation scenarios, sectoral and other bottom-up models complement these in essential ways. These may include providing more fine-grain and concrete details on implementation, feasibility, costs and benefits, as well as spatially and stock-wise high resolution on the scenarios. The talk provides the bird's eye view on urban and sectoral scenarios, and how these might complement/challenge sectoral information in IAMs. It emphasises the importance of viewing sectoral emissions both in a direct and indirect emission accounting. It reviews comparisons of IAM sectoral scenarios with those from the sectoral/bottom-up literature, mainly based on AR5. The talk concludes with a call for significant advances to be made in sectoral scenarios and their coupling/harmonization with IAMs, especially in urban systems where the bottom-up scenario literature is among the most limited.

Modelling climate and land use

Katherine Calvin

There is a broad literature describing efforts to model climate and land. Some of this literature develops estimates of future land use and land cover change (LULCC), while other articles explore the influence of land on climate or of climate on land. Different models are used depending on the particular question asked. In this

presentation, we describe modelling efforts to estimate future LULCC at global, regional, and local scales. First, we describe the use of global Integrated Assessment Models to develop global LULCC scenarios. We include a description of the structure and assumptions made in different IAMs, as well as how scenarios are implemented in these models. Next, we provide examples of efforts to produce regional and local LULCC scales, using different types of models. For each model type, we provide a list of strengths and weaknesses.

Session 4

Linking climate scenarios to humanized landscapes

Cheikh Mbow

To address likely climate challenges for the future, land managers need scenarios and models that assess risk and impacts of climate on various productive systems. A daunting challenge of current knowledge is whether we are asking the right questions to climate models and if we are using the models' outputs adequately to target the right land interventions for better land use, ecosystem services and biodiversity. The modelling community and users of model outputs all need to do some adjustments to improve the applicability of models. One of the issues of land use, modellers struggle to include advanced social systems scenarios (e.g. SSP) to respond to the demand of information for land management. Another aspect is related to limited considerations of the cross-scale interactions, including teleconnections and their local feedbacks that often limit the projections relevance to local realities. The challenges are many but largely related to suitable methods and metrics to convert socioeconomic scenarios and general policy options to specific changes in model's input parameters (e.g., how a particular land system or land policy changes the demand for particular types of land resource distribution and ecosystem behaviour). This presentation will give few highlights on the importance of coupling socioeconomics, climate and environment, to improve the analysis of the impacts of various socio-economic pathways and policy options in the context of climate change. The main articulation around context specific molder of land use change should influence current and future development of climate models and scenarios.

Social change, institutions and policies

Navroz Dubash

Attention to development and climate mitigation linkages from a bottom-up perspective presents several challenges to large integrative models. First, how mitigation and development links are conceptualised – co-benefits versus alternative pathways -- can affect how they are modelled. Second, issues of scale are central to the discussion – the national perspective, which IAMs often miss, allows representation of how development priorities are politically prioritised and context specific trade-offs. Third, important social considerations, notably distribution and provision of jobs, are only imperfectly captured. Fourth, while there is a growing literature on a limited set of co-benefits, notably energy security and air pollution, there is far less progress on many social indicators and other, non-air resources such as land and water. Fifth, the complementarities/trade-offs across multiple objectives may differ from country to country depending on context. This places emphasis on the process through which through which national scenario development occurs. Sixth, by contrast to a co-benefits approach, a 'pathways' approach helps draw attention to large scale socio-economic transitions countries face, such as urbanization, cooking energy transition, demographic transition and so on. These, in turn, help drive consideration of inter-sectoral linkages that are often neglected in large integrative studies. Finally, modelling across climate and development is challenged by the reality of national institutions and policy frameworks, which tend to focus on single sectors and outcomes, to the relative neglect of linkages, whether complementarities or trade-offs.

Infrastructure, technology development and lock-in

Arnulf Grübler

Rapid and deep decarbonisation is required for meeting climate targets well below 2°C. The urgency of rapid transformation is further amplified by increasing evidence that many so-called “negative emission” technologies are more a convenient modelling artefact than a practical long-term climate solution that can be scaled to the levels as illustrated in model derived scenarios. Rapid transformation however faces significant obstacles, often summarized under “carbon lock –in”. The presentation reviews and summarizes the determinants of technological and infrastructural lock-in. Recent theoretical and empirical advances in our understanding of the determinants of technological transitions are also presented that suggest effective strategies for exiting lock-in. These include in particular greater emphasis on decentralized, granular end-use practices and technologies that offer tangible consumer surplus and SDG co-benefits as opposed to the traditional large-scale, lumpy and capital intensive supply-side “climate mitigation only” investments that have traditionally dominated scenarios and modelling of deep decarbonisation.

Annex 6: Meeting Flow

The Expert Meeting was divided into eight sessions.

Sessions 1, 2 and 3 consisted of a series of keynote presentations. Session 1, 'Global scenarios and the AR5' intended to bring all participants to the Expert Meeting up to speed on the contributions of integrated assessment modelling (IAM) to AR5, notably Chapter 6: Transformation Pathways. It covered how the IAMs link to climate modelling and outcomes, and summarised conclusions and recommendations arising from the 2015 Expert Workshop on Scenarios. It also included a government response to the AR5 scenarios work.

Session 2 was on 'National and global perspectives post-AR5' and consisted of a series of presentations to inform participants on global scenario work subsequent to AR5. This covered the subsequent use of IAMs, bottom-up approaches based on the aggregation of national analyses, and progress with the shared socio-economic pathways (SSPs). Presentations included 1.5°C scenarios related work, and how the Special Report on Global warming of 1.5°C can complement the AR6.

Session 3: Transitions and sectoral modelling provided participants with information on projects relating high-level modelling to other perspectives and work on sectoral approaches. Abstracts of the talks given can be found in Annex 5.

Session 3 was followed by the meeting's first set of Breakout Groups (BOGs). The purpose of these BOG sessions was to allow participants to react to the presentations from Sessions 1 through 3. Participants were randomly divided into three different BOGs. Participants were provided with the following guiding questions:

- What are the biggest issues, challenges, and opportunities associated with the successful treatment of scenarios in AR6?
    - If you could change one thing about the way scenario work is being conducted, what would it be?
    - What steps can be taken to improve understanding of scenarios, models and related findings?
    - Are there other topics (not on the current agenda) you recommend we pick up during this week?

Session 4: Climate mitigation and development from a bottom-up perspective started with three presentations on land use, ecosystem service and biodiversity; social change, institutions and policies; and infrastructure, technology development and lock-in. They aim of these talks was to highlight the key elements and insights from their domain that should ideally be addressed in large integrative models and scenario exercises.

This session was followed by BOG 2 on scenario development: learning from bottom-up perspectives. These BOGs were thematically differentiated with the intention of building on the presentations to develop recommendations for scenarios developers and modellers as to what additional elements might be considered in developing scenarios/mitigation pathways.

BOG 2a on land use, ecosystem services and biodiversity was provided with the following guiding questions:

- Incorporating insights from (non-modelling) research on land use, ecosystem services and biodiversity into IAMs, other models and associated scenarios
    - Which quantitative indicators are suitable for assessing climate, land, ecosystem services and biodiversity (e.g. SDGs 'Clear Water and Sanitation', 'Climate Action', 'Life on land and below water')?

    - Which elements could be covered by qualitative narratives?
- Linking land use and biodiversity modelling to IAMs (e.g. uncertainly, risks and co-benefits)
    - Which methodologies are available to link multi-dimensional bottom-up/GIS analysis in IAMs and other models?
    - How can climate and land use approaches be linked consistently?
- Identify possible cross-cutting issues
    - Which linkages exist (e.g. technology, finance, carbon price, policy instruments, etc.)?
    - How strong are linkages?

BOG 2b on social change, institutions and policies was provided with the following guiding questions:

- Incorporating insights from (non-modelling) research on social change, institutions and policies into IAMs, other models and associated scenarios
    - What is meant by social science (economists, sociologists, anthropologists, philosophers…)? Which social sciences should/should not be more involved with IAM community?
    - Which indicators are suitable to include social change, institutions and policy impacts in IAM scenarios? What elements could be covered by qualitative narratives?
- Framing the social dimensions
    - How can co-benefits between social change, institutions and policy design and mitigation/adaptation be considered?
    - How can risks linking social change and mitigation/adaptation be considered?
- Identify possible cross-cutting issues
    - Which linkages exist (e.g. technology, finance, carbon price, policy instruments, etc.)? How strong are the linkages?

BOG 2c on infrastructure, technology development and lock-in was provided with the following guiding questions:

- Incorporating insights from (non-modelling) research on infrastructure, technology development and lock-in into IAMs, other models and associated scenarios
    - What quantitative indicators are suitable for assessing infrastructure, technology development and lock-in (e.g. 'Affordable and clean energy', 'Industry, innovation and infrastructure', 'Sustainable cities and communities', 'Responsible consumption and production')?
    - What elements could be covered by qualitative narratives?
- Linking modelling of infrastructure, technology development and lock-in to IAMs (e.g. uncertainly, risks and co-benefits)
    - Which methodologies are available to design scenario storylines and technology portfolios?
- Identify possible cross-cutting issues
    - Which linkages exist (e.g. innovation support, finance, carbon price, policy instruments, etc.)?
    - How strong are the linkages?

Participants were asked to report back on their discussions during Session 5, which served as a preliminary drafting of recommendations.

Session 6 and Session 7 consisted of a set of six BOGs. The purpose of the six BOGs was to develop recommendations for methods and approaches to assessments as conducted by the IPCC, and also methods and protocols associated with the underlying research activity on which the IPCC might draw. Specifically, each BOG was charged with drafting recommendations for the IPCC, recommendations for the AR6 Scoping Meeting, and recommendations for research communities.

Each BOG was also provided with a list of suggested topics to discuss. These are shown in Table 4.

Table 4: Suggested topics for discussion in BOG3a and BOG3b

BOG3ai: Sustainable development, co-benefits and trade-offs	BOG3bii: Feasibility	BOG3aiii: MIPS and market scenarios
Linking climate mitigation with wider development needs: - Priority SD indicators - Climate mitigation and sustainable development - Links to SDGs - Co-benefits, co-costs/risks and trade-offs - "Nexus" (land/water/food) implications	Unpacking the "feasibility" of scenarios across different dimensions: - Technical feasibility - Lock-ins - Cost/financing - Social acceptance - Speed and scale of adoption - Impacts on ecosystem services/biodiversity - Indicators of feasibility	- The use of market scenarios to facilitate deep-dive analysis of possible mitigation pathways - The balance between MIPs/markers in terms of exposition - Linking MIPs/markers: context/uncertainties
BOG3bi: Transparency and communication	**BOG3bii: Scenario "governance" during AR6**	**BOG3biii: Modelling across scales and disciplines**
- Opening the black box: how to explain what models can do and limitations - Following up recommendations of IPCC Expert Meeting on communication - Use of IPCC uncertainty language as applied to scenarios	- Cross-WG teams on scenarios - Authorship across chapters and WGs - Cross-chapter working – scenarios and sectors - Cross-chapter working – scenarios and x-cutting chapters (policy, finance etc.)	- IAMs/global models - Regional/national/subnational models - Sectoral models - Time scales - Indicators for linking modelling at different scales - SSPs applied at different scales

Session 8 was the final plenary of the Expert Meeting. During this Session, participants were asked to report back from the final set of BOGs. The recommendations drafted by each BOG were discussed and refined in plenary.