Low mitigation scenarios since the AR4 – Global emission pathways and climate consequences

Bill Hare (PIK, CA), Michiel Schaeffer (Wageningen University, CA), Malte Meinshausen (PIK)
Overview

• AR4 Scenarios
• Lower Scenarios
• Post AR4 – Lower Mitigation Scenarios
• Climate consequences and risk of exceeding temperature limits
• Conclusions
IPCC AR4 lowest stabilization range – 445-490 ppm CO₂ equivalent

<table>
<thead>
<tr>
<th>CO₂-equivalent Stabilization level (2005 = 375 ppm CO₂-eq)</th>
<th>Global Mean temperature increase at equilibrium (°C)</th>
<th>Global average sea level rise at equilibrium from thermal expansion only</th>
<th>Year global CO₂ emissions need to peak</th>
<th>Reduction in 2050 global CO₂ emissions compared to 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>445 – 490</td>
<td>2.0 – 2.4</td>
<td>0.4 – 1.4</td>
<td>2000 – 2015</td>
<td>-85 to -50</td>
</tr>
<tr>
<td>Scenario category</td>
<td>Region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annex I</td>
<td></td>
<td></td>
<td></td>
<td>-25% to -40%</td>
</tr>
<tr>
<td>Non-Annex I</td>
<td></td>
<td></td>
<td></td>
<td>-80% to -95%</td>
</tr>
<tr>
<td>A-450 ppm CO₂-eq</td>
<td></td>
<td></td>
<td></td>
<td>Substantial deviation from baseline in Latin America, Middle East, East Asia</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>15-30% below business as usual (den Elzen and Höhne 2008)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Substantial deviation from baseline in all regions</td>
</tr>
</tbody>
</table>

**Source:** Top half of table from Table SPM.6 of the IPCC AR4 Synthesis Report Summary for Policy Makers (IPCC 2007) and lower half from Box 13.7 of IPCC WGIII (Gupta, Tirpak et al. 2007).
AR4 Fossil CO$_2$ reduction path for lowest scenarios

- AR4 Peak between 2000-2015
  - Six scenarios – two peak before 2010, 3 peak around 2010 and one peaks after 2010 and before 2020

- AR4 reduction by 2050 of 50-85% from 2000
  - Full range 43-89% for six scenarios.
Lower Scenarios: below 445 ppm CO$_2$ equivalent in 2100

- Nine scenarios – five Post AR4, 1 AR4, 3 AR4 revised
- Post AR4
  - IIASA/PBL Low scenarios IMAGE 2.6 W/m$^2$ scenario - revised from AR4
  - IIASA/PBL Low scenarios MESSAGE 2.6 W/m$^2$ scenario
  - ADAM Low Scenarios MERGE Model
  - ADAM Low Scenarios Poles Model
  - ADAM Low Scenarios REMIND Model
- AR4
  - AR4 IMAGE 2.6 W/m$^2$ scenario
- AR4 Revised Non-CO2 gases
  - AR4- Azar 350 ppm CO$_2$ - biomass energy carbon capture and storage –
  - AR4- Azar 350 ppm CO$_2$ - fossil fuel carbon capture and storage – Revised Non-CO2 gases
  - AR4- Azar 350 ppm CO$_2$ - no fossil fuel carbon capture and storage – Revised Non-CO2 gases
IMAGE and MESSAGE Scenarios Limiting GHG Concentration to Low Levels

• **Authors:** Shilpa Rao, Keywan Riahi, Elke Stehfest, Detlef van Vuuren, Cheolhung Cho, Michel den Elzen, Morna Isaac, Jasper van Vliet
  – International Institute for Applied Systems Analysis (IIASA), Austria
  – Netherlands Environmental Assessment Agency (PBL), Netherlands

• 450 ppm CO$_2$ equivalent stabilization scenarios - 2.6 W/m$^2$
  – Equilibrium temperature increase of ca 2.1ºC
  – IMAGE 2.6 updated from AR4
  – MESSAGE 2.6
IMAGE and MESSAGE Scenarios Limiting GHG Concentration to Low Levels

• Not attainable without negative emissions in energy sector – e.g. bio-energy with carbon capture

• Low levels attainable but **critically dependent** on several factors
  – Drastic, early and globally concerted mitigation and assumed that emission reductions implemented from 2013 and global peak by 2100
  – Rapid up-scaling and feasibility of large-scale bionergy, and availability of forest sinks
  – High rates of energy efficiency improvements
  – Availability of carbon capture and storage technologies
ADAM: First assessment of low stabilisation scenarios

- Investigated technological feasibility and implications of 400 CO₂ equivalent stabilization scenarios –(1.95 W/m²)
  - Equilibrium temperature increase of ca 1.6°C

- **Authors of the report:** Brigitte Knopf, Ottmar Edenhofer (PIK) (lead authors), Hal Turton (PSI), Terry Barker (4CM1R), Serban Scrieciu (4CMR), Marian Leimbach, (PIK), Lavinia Baumstark (PIK), Alban Kitous (Enerdata) (contributing authors)

- **Authors of the modelling results:** Lavinia Baumstark, Marian Leimbach (PIK, modelling with REMIND), Hal Turton, Bertrand Magné, Sokrates Kypreos (PSI, modelling with MERGE), Terry Barker, Serban Scrieciu (4CMR, modelling with E3MG), Alban Kitous, Elie Bellevrat (Enerdata, modelling with POLES)
ADAM Low Mitigation Scenarios - Models

- REMIND: Potsdam Institute for Climate Impact Research
- MERGE: Paul Scherrer Institute
- E3MG: Cambridge Centre for Climate Change Mitigation
- POLES: CNRS Universite Pierre Mendes, France
ADAM: Report on first assessment of low stabilisation scenarios – Conclusions

- All models can produce low stabilization targets
- Costs are moderate in all models
  - Ranging from cumulative gains of 1% of GDP to 1.7% losses compared to baseline to 2100
  - Lower to medium range of costs compared to AR4
- Technological flexibility is much lower compared to higher stabilization scenarios
  - Biomass, CCS, energy efficiency and demand side measures all play a very important role
ADAM: Report on first assessment of low stabilisation scenarios – Technology

- POLES, REMIND, MERGE models require biomass and CCS, to achieve low stabilization level
  - All below 450 ppmv CO$_2$e by 2100
    - MERGE ca 400 ppmv CO$_2$e in 2100 and declining quickly
    - REMIND ca 440 ppmv CO$_2$e in 2100 and declining slowly
    - POLES ca 440 ppmv CO$_2$e in 2100 and declining slowly
- E3MG has a different model set up
  - Early investment in energy efficiency policies stimulate global economy
    - Biomass and CCS not needed
  - Above 460 ppm CO$_2$e in 2100 and increasing slowly
## Lower Scenarios: Emissions summary

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>Peak year</th>
<th>Industrial CO₂ reductions in 2050 from 2000</th>
<th>Total GHG reductions 2050 from 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azar revised 350 ppm CO₂ stabilization with biomass energy carbon capture and storage</td>
<td>2010</td>
<td>45%</td>
<td>15%</td>
</tr>
<tr>
<td>Azar revised 350 ppm CO₂ stabilization with fossil fuel carbon capture and storage</td>
<td>2000</td>
<td>85%</td>
<td>50%</td>
</tr>
<tr>
<td>Azar revised 350 ppm CO₂ stabilization with no fossil fuel carbon capture and storage</td>
<td>2000</td>
<td>90%</td>
<td>50%</td>
</tr>
<tr>
<td>AR4-IMAGE 2.6 W/m²</td>
<td>2010</td>
<td>70%</td>
<td>50%</td>
</tr>
<tr>
<td>IIASA/PBL Low scenarios IMAGE 2.6 W/m² scenario - revised from AR4</td>
<td>no data</td>
<td>no data</td>
<td>50%</td>
</tr>
<tr>
<td>IIASA/PBL Low scenarios MESSAGE 2.6 W/m² scenario</td>
<td>2020</td>
<td>35%</td>
<td>5%</td>
</tr>
<tr>
<td>ADAM Low Scenarios MERGE Model</td>
<td>2010</td>
<td>85%</td>
<td>65%</td>
</tr>
<tr>
<td>ADAM Low Scenarios Poles Model</td>
<td>2010</td>
<td>75%</td>
<td>55%</td>
</tr>
<tr>
<td>ADAM Low Scenarios REMIND Model</td>
<td>2010</td>
<td>85%</td>
<td>65%</td>
</tr>
</tbody>
</table>
Low Scenarios - Global Fossil CO$_2$ reductions relative to 1990 (%)
## Lower Scenarios: Concentration, temperature and risk

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>CO$_2$e in 2100</th>
<th>$^\circ$C increase in 2100</th>
<th>Probability of exceeding 2$^\circ$C</th>
<th>Probability of exceeding 1.5$^\circ$C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azar revised 350 ppm CO$_2$ stabilization with biomass energy carbon</td>
<td>415</td>
<td>1.5</td>
<td>25%</td>
<td>75%</td>
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<tr>
<td>capture and storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azar revised 350 ppm CO$_2$ stabilization with fossil fuel carbon</td>
<td>410</td>
<td>1.3</td>
<td>5%</td>
<td>40%</td>
</tr>
<tr>
<td>capture and storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azar revised 350 ppm CO$_2$ stabilization with no fossil fuel</td>
<td>410</td>
<td>1.4</td>
<td>5%</td>
<td>45%</td>
</tr>
<tr>
<td>carbon capture and storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR4-IMAGE 2.6 W/m$^2$</td>
<td>445</td>
<td>1.6</td>
<td>30%</td>
<td>75%</td>
</tr>
<tr>
<td>IIASA/MNP Low scenarios IMAGE 2.6 W/m$^2$ scenario - revised from AR4</td>
<td>445</td>
<td>1.6</td>
<td>30%</td>
<td>75%</td>
</tr>
<tr>
<td>IIASA/MNP Low scenarios MESSAGE 2.6 W/m$^2$ scenario</td>
<td>440</td>
<td>1.7</td>
<td>50%</td>
<td>95%</td>
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<tr>
<td>ADAM Low Scenarios MERGE Model</td>
<td>405</td>
<td>1.4</td>
<td>15%</td>
<td>60%</td>
</tr>
<tr>
<td>ADAM Low Scenarios Poles Model</td>
<td>440</td>
<td>1.6</td>
<td>25%</td>
<td>90%</td>
</tr>
<tr>
<td>ADAM Low Scenarios REMIND Model</td>
<td>440</td>
<td>1.6</td>
<td>30%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Global Mean Temperatures

Temperature (°C relative to pre-industrial)

observations
Probability of exceeding 2°C
Probability of exceeding 1.5°C
2050 Fossil CO$_2$ reductions and risk of exceeding 2$^\circ$C
Conclusions

• Lower scenarios show
  – 2°C warming limit can be achieved with higher probability than shown for lowest category AR4 stabilization scenarios
  – Fossil CO$_2$ emissions peak before 2020
  – Fossil CO$_2$ emissions reduced 35-90% by 2050 from 2000 levels (6 out of 8 scenarios 70-90%)

• Further work is needed on higher probability pathways for that 1.5°C warming level
Thank you.
Further information
www.primap.org
www.climateanalytics.org
Our Aim: Synthesis of climate science, including its uncertainties, for informing international climate policy negotiations.