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A shortened summary of IPCC AR5 WGIII "Mitigation of Climate Change"

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Mitigation of climate change is "a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs)". This report summarises the findings of the IPCC AR5 mitigation report including details of recent changes in emissions and the characteristics of future mitigation pathways which reduce the probability of exceeding given levels of warming.

Headlines

- In the decade 2000-2010, global greenhouse gas emissions increased at a faster rate than in any of the three decades from 1970 to 2000.
- Future scenarios in which it is *likely*[1] (>66% probability) that warming will be kept under 2°C relative to pre-industrial levels are characterised by atmospheric CO_2-equivalent concentrations of 450 ppm in 2100.
    - Emissions pathways consistent with such concentrations have substantial GHG emissions reductions by 2050 enabled by large-scale changes in the energy system.
    - Many such scenarios have net removal of GHGs from the atmosphere in the later part of the 21st century, relying on carbon dioxide removal strategies which are not yet available at the scale required.
- Policies supporting mitigation goals do not stand in isolation but may have strong implications, both positive and negative, for achieving other goals (for example, goals related to human health, biodiversity, and the economy).
- The cost of limiting concentrations to a given level depends on the timeframe over which policies are developed and imposed, with costs increasing as mitigation is delayed.
    - Assuming cost-effective mitigation, reaching 450 ppm in 2100 entails consumption losses of 3% to 11% relative to a baseline in which consumption grows by 300% to 900%.

Recent Trends in GHG emissions

Human emissions of GHGs (greenhouse gases) rose throughout the period 1970—2010, and the highest rate of increase was in the decade 2000—2010. Greatest GHG emissions are for carbon dioxide (CO_2), nitrous oxide (N_20), and methane (CH_4). Total emissions are quantified in gigatonnes of CO_2 equivalent ($GtCO_2eq$), which is defined in WGIII as the amount of CO_2 that would have the same radiative forcing (see WGI for definition) over 100 years. Emissions reached 49 (±4.5) $GtCO_2eq$ in 2010, 76% of which was CO_2.

[1] The IPCC qualified uncertainty language appears in italics and is defined in 'Further Information'

The increases in GHG emissions can be partitioned by type (CO_2 from fossil fuels, CO_2 from land use, N_2O, CH_4) or sector. Partitioning by type, the majority (78%) of the increase in emissions has been from CO_2 from fossil fuels. Partitioning by sector, over the period 2000-2010, direct contributions to the increase were 47% from energy supply, 30% from industry, 11% from transport and 3% from buildings (*medium confidence*). The contributions of the buildings and industry sectors increase if indirect emissions are accounted for.

Changes in CO_2 emissions from fossil fuel combustion result from changes in population, the economy (GDP/capita), energy intensity of the economy, and emissions intensity of energy. In 2000–2010, increases in emissions due to population growth and economic growth were greater than emissions reductions from reduced energy intensity of the economy. The emissions intensity of energy has increased in recent years (after a long term decrease) due to an increase in the use of coal relative to other energy sources.

Consequences of future emissions pathways

In WGIII, there are many more emissions scenarios than considered in WGI. These are separated into **baseline scenarios,** in which no additional mitigation is imposed above that already in place, and **mitigation scenarios**, in which various levels and types of mitigation are assumed[2].

Mitigation scenarios can be characterised by the likelihood of warming relative to pre-industrial temperatures (before 1750) remaining below a given threshold, here 2^{o}C.

- *Likely:* About 450 ppm CO_2eq in 2100
- *More likely than not:* About 500 ppm CO_2eq in 2100; but likelihood reduces if concentrations temporarily exceed 530 ppm CO_2eq during the preceding period
- *More unlikely than likely:* About 530—650 ppm GtCO2eq in 2100
- *Unlikely:* More than 650 ppm in 2100[3]

In contrast, baseline scenarios reach 450 ppm GtCO2eq by 2030 and have 2100 concentrations of 750—1300 ppm GtCO2eq. In these scenarios, 2.5—7.8^{o}C warming relative to pre-industrial temperatures is expected. This range takes into account both the range of scenarios and of climate sensitivities (see WGI).

The implications of given levels of warming are discussed in the WGI and WGII summaries.

Characteristics of emissions pathways for mitigation

Emissions pathways leading to 450 ppm generally have a net reduction in emissions by 2050 and net reduction in atmospheric CO_2eq concentrations thereafter. These scenarios are characterised by large changes in the global energy system, including reduced demand and decarbonisation of energy supply leading to a substantial reduction in emissions by 2050. Most also rely on carbon dioxide removal technologies in the second half of the 21st century, and imply large shifts in investment patterns by 2030. Less stringent pathways, which are *more likely than not* to limit warming below 2^{o}C, have similar changes but over longer timescales.

Predicted 2020 emissions based on the 2010 Cancún pledges are not consistent with long-term strategies which are *as likely as not* or more likely to meet the less than 2^{o}C warming target. They are broadly consistent with *likely* keeping temperature change below 3^{o}C.

Policies which support climate change mitigation may have co-benefits or adverse side effects in areas as diverse as human health, the environment, energy and food security, productivity, livelihoods, sustainable development, and income equality. There are also relationships between mitigation and adaptation

[2] Approximately 300 baseline scenarios and 900 mitigation scenarios were assessed for WGIII.
[3] Comparing these scenarios to the RCPs in WGI, RCP2.6 is approximately 450 ppm by 2100 , RCP4.5 lies in the range 580—650 ppm, RCP6.0 is 720—1000 ppm and RCP 8.5 is >1000 ppm.

strategies, for example in the land use sector. In addition, effective mitigation requires international cooperation.

Mitigation is possible across all sectors (electricity generation and energy supply, transport, building, and industry, and agriculture and other land use), through a combination of demand change, uptake of new technologies, and policy measures. Specific measures for different sectors can be found in the full Summary for Policy Makers and for brevity are not discussed here.

A variety of economic policies can support mitigation in and across sectors. Cap and trade systems, where binding emissions of allowances are bought and sold, have had limited effects on emissions to date. In some countries, taxes have helped to partially decouple economic growth from emissions. Subsidies, regulation, and information measures have all been successful in some cases. Other elements include support of new technologies and the role of the private sector.

Mitigation policy requires value judgements based both on economic evaluation and concepts of justice and equity, in particular with respect to the role of countries at different levels of development.

Quantifying the total economic costs of limiting atmospheric GHG concentrations is challenging. Estimates depend on the specific choices leading to a given emissions pathway. Achieving substantial reductions over the next few decades reduces the long-term costs and challenges of reaching a given target, for example by avoiding commitment to energy-intensive technologies and emissions-intensive energy. Delaying reductions increases the reliance on technologies such as Carbon Capture and Storage (CCS), which is yet to be deployed on a large scale and is not market competitive, in the second half of the century.

Therefore mitigation is most cost effective if it begins immediately and if all technologies (CCS, renewables, nuclear power) are available. Under these assumptions, it is estimated that reaching 450 ppm CO2 by 2100 entails consumption losses by 2100 of 3% to 11% (median 4.8%) relative to the baseline (no mitigation). This is a reduction in consumption growth of 0.04 to 0.14 percentage points per year, relative to baseline annual consumption growth of 1.6% to 3%. These cost estimates do not include benefits of mitigation such as avoided impacts, or improved air quality; neither do they include possible adverse side effects.

Further Information

The information above is drawn from the Fifth Assessment Report (AR5) of the IPCC, in particular the WGIII Summary for Policy Makers and Technical Summary and the Synthesis Report Summary for Policy Makers. Short technical phrases and lists may be quoted without quotation marks. The information on advances since AR4, below, draws on the preface to the AR5 WGIII full report.

Full citation:

IPCC, 2014: **Summary for Policymakers** and **Technical Summary**, In: *Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlomer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Advances since AR4

In comparison to the Fourth Assessment Report (AR4, 2007) the WGIII report for AR5 was able to draw on a far broader range of mitigation scenarios, therefore enabling a fuller assessment of possibilities for and implications of mitigation.

Confidence

Text in italics indicates use of IPCC uncertainty language.
For likelihoods, *extremely likely* indicates >95% probability; *very likely* >90% probability; *likely* >66% probability; and *more likely than not >50% probability.*
The IPCC qualifies its statements, where appropriate, with a level of confidence ('*very low', 'low', 'medium', 'high'* and *'very high'*) based on the level of agreement in the scientific community and the amount of evidence. This confidence is specified here only where it is *medium* or lower.