Global GHG Emissions Pathways toward 2 °C temperature change limit target

- The latest scientific findings in IPCC AR5 and UNEP GAP report -

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IPCC AR4: Long-term Emissions Pathways

Left Top Figure: Target-specific CO2 emissions reviewed in the IPCC AR4

Right Bottom Table: Classification of the stabilization targets for the GHGs reviewed in the IPCC AR4

Source: National Institute for Environmental Studies
Center for Global Environmental Research
IPCC scenario database
http://www.cger.nies.go.jp/db/scenario/index.html

It requires “negative CO2 emissions” in the latter half of the 21 century

2 °C global temperature change limit

But, there were not enough number of scenarios
Discussions on Global Emissions Pathways - Transition from IPCC AR4 to IPCC AR5 -

This is the first paper focusing on potentials of BECCS (Biomass Energy with CCS) for achieving 350 CO2 ppm (i.e. corresponding to the 2 °C target level)

IPCC AR4 (2007) WG3 Chapter 3


This is the first report discussing on emissions gap between the Copenhagen Accord Pledges and 2 °C or 1.5 °C global temperature limit pathways

UNEP (2011) Bridging the Emissions Gap

IPCC reviewed various papers and discussed role of low-carbon energy strategies and negative CO2 emissions for achieving the 2°C target


UNEP AR5 (2014) WG3 Chapter 6

This is the first report summarizing global emissions scenarios, discussing potentials of achieving the 2°C target, and reviewing required reductions amounts by 2020 compared to the 1990 level for achieving the 2°C target


The scientific findings - Overviews of UNEP GAP reports -

UNFCCC parties formally recognized country pledges submitted for reducing GHG emissions for the year 2020 as part of the Copenhagen Accord, including Annex I targets and non-Annex I actions, and decided to hold the increase in global average temperature below 2°C above pre-industrial levels

UNFCCC parties took note of the Copenhagen Accord, and policy makers formally paid attention to the 2°C global temperature limit above pre-industrial levels

UNEP GAP reports

This is the first report discussing on emissions gap between the Copenhagen Accord Pledges and 2 °C or 1.5 °C global temperature limit pathways

Today’s Topics

Climate Change, 74:47-79 “CCS from Fossil fuels and Biomass”

Azar, C, et al., (2006) UNFCCC parties formally recognized country pledges submitted for reducing GHG emissions for the year 2020 as part of the Copenhagen Accord, including Annex I targets and non-Annex I actions, and decided to hold the increase in global average temperature below 2°C above pre-industrial levels

Climate Change, 74:47-79 “CCS from Fossil fuels and Biomass”

These dotted lines show the median global GHG emissions pathways with a "likely" probability (greater than 66%) of staying below a specific temperature relative to pre-industrial levels.

- 3 degree relative to pre-industrial levels
- 2.5 degree relative to pre-industrial levels
- 2 degree relative to pre-industrial levels

Caveat: This study considers 6 GHGs emissions pathways, but does not include feedback effects of reductions of air pollutants and Short-lived Climate Pollutants (SLCPs).

National pledges for 2020 are not enough to meet the global emission pathways in line with achieving 2°C target.

UNEP Emissions Gap Report 2014 - Discussions on Emissions Gap in 2030 -

Required GHG emission levels within the 2 °C limit with a "likely" probability (greater than 66%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Median (Gt CO₂e)</th>
<th>Relative to 1990 emissions</th>
<th>Range (Gt CO₂e)</th>
<th>Relative to 2010 emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>47</td>
<td>-27%</td>
<td>40 to 48</td>
<td>-8 to -30%</td>
</tr>
<tr>
<td>2030</td>
<td>42</td>
<td>-14%</td>
<td>30 to 44</td>
<td>-10 to -10%</td>
</tr>
<tr>
<td>2050</td>
<td>22</td>
<td>-40%</td>
<td>18 to 25</td>
<td>-22 to -51%</td>
</tr>
</tbody>
</table>

The Emissions Gap in 2030

The gap after 2020 is defined as the difference between global emission levels consistent with the 2 °C target versus the emissions levels expected if the pledge cases are extrapolated to 2030

Note:
Copenhagen Pledges in these scenarios were assumed to result in a range of 52 (50-53) Gt CO₂ eq total GHG by 2020. This is lower than the current pledge assessment for 2020.


The scientific findings - Overview of IPCC AR5 WG3 -
**Historical Trends of Cumulative CO2 Emissions**

- IPCC AR5 WG1 says that there is a proportional relation between temperature increase and cumulative GHG emissions. Thus, when discussing future temperature increase, it is important to consider amount of cumulative emissions.
- Historical cumulative anthropogenic CO2 emissions have more than doubled since 1970 (i.e. last 40 years).

![Graph showing historical CO2 emissions](image)

220 years 40 years

Source) IPCC AR5, Figure TS.2

**Characteristics of Scenarios in IPCC AR5**

- Since IPCC AR4, IPCC AR5 collected various papers and reviewed around 1200 scenarios.
- In order to achieve 2°C global temperature change limit target above pre-industrial levels with a "likely" probability (greater than 66%), it is necessary to reduce GHG emissions around 40-70% by 2050 compared to the level in 2010, and almost zero emission by 2100.

| CO₂ Concentrations in 2100 (CO₂ and Category label concentration range) | Relative position of the RCP | Change in Cumulative emissions (GtCO₂) | Change in CO₂ emissions compared to 2010 in (%) | Temperature change (°C) | Temperature change (°C) | Temperature change (°C) | Temperature change (°C) | Temperature change (°C) | Temperature change (°C) | Temperature change (°C) | Temperature change (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 450 (430-470) | RCP2.6 | 550-1300 | 630-1100 | −17 to −41 | −118 to −78 | −5.7 to −3.6 | −3.4 to −2.4 | −2.0 to −1.0 | −1.0 to 0.0 | −0.5 to 1.0 | 1.0 to 2.0 | 2.0 to 3.0 |
| 500 (480-520) | RCP4.5 | 550-1300 | 630-1100 | −17 to −41 | −118 to −78 | −5.7 to −3.6 | −3.4 to −2.4 | −2.0 to −1.0 | −1.0 to 0.0 | −0.5 to 1.0 | 1.0 to 2.0 | 2.0 to 3.0 |
| 550 (530–570) | RCP6.0 | 1150-1950 | 1340-2340 | −17 to −41 | −118 to −78 | −5.7 to −3.6 | −3.4 to −2.4 | −2.0 to −1.0 | −1.0 to 0.0 | −0.5 to 1.0 | 1.0 to 2.0 | 2.0 to 3.0 |
| 550 (530–570) | RCP7.0 | 1150-1950 | 1340-2340 | −17 to −41 | −118 to −78 | −5.7 to −3.6 | −3.4 to −2.4 | −2.0 to −1.0 | −1.0 to 0.0 | −0.5 to 1.0 | 1.0 to 2.0 | 2.0 to 3.0 |
| 550 (530–570) | RCP8.5 | 1150-1950 | 1340-2340 | −17 to −41 | −118 to −78 | −5.7 to −3.6 | −3.4 to −2.4 | −2.0 to −1.0 | −1.0 to 0.0 | −0.5 to 1.0 | 1.0 to 2.0 | 2.0 to 3.0 |
| >1000 | Total Target | 1310-1750 | 1500-2310 | −17 to −41 | −118 to −78 | −5.7 to −3.6 | −3.4 to −2.4 | −2.0 to −1.0 | −1.0 to 0.0 | −0.5 to 1.0 | 1.0 to 2.0 | 2.0 to 3.0 |

Source) IPCC AR5, Table SPM.1

Caveat) AR5 classified categories & discussed temperature change in 2100, but AR4 classified categories & discussed temperature change in long-term GHG equilibrium.
Without more mitigation, global mean surface temperature might increase by 3.7°C to 4.8°C over the 21st century.

2 °C global temperature change limit

Different colors show different categories which achieve the same CO2-eq concentration at the point in 2100

Dash line: the range of around 1200 scenarios

Source) IPCC AR5, Figure SPM. 4

Delayed action VS Immediate action

Delayed mitigation significantly increases the difficulty and narrow the options to reach the 2°C target.

In immediate mitigation strategies, emissions have peaked and emission levels in 2030 tend to be lower than the level of emissions in 2010.

Source) IPCC AR5, Figure SPM. 5
Cancun Agreements and 2°C target

- Cancun pledges correspond to staying below 3 °C target with “likely” probability.
- Current Cancun Pledges imply increased mitigation challenges for reaching 2°C.
- If we delay mitigation actions, it becomes more difficult to achieve the 2 °C target.

Before 2030
GHG Emissions Pathways (GtCO2 eq/yr)

After 2030 up to 2050
Rate of Annual Average CO2 Emissions Reductions Change (%/yr)

After 2030 up to 2100
Share of Low Carbon Energy (%)

Source) IPCC AR5, Figure SPM. 5

Characteristics of Scenarios in IPCC AR5

- Since IPCC AR4, IPCC AR5 collected various papers and reviewed around 1200 scenarios.

Discussions on scenarios with/without overshoot for achieving the 2 °C target

Source) IPCC AR5, Table SPM.1

Caveat) AR5 classified categories & discussed temperature change in 2100, but AR4 classified categories & discussed temperature change in long-term GHG equilibrium.
Risks of Delayed Action and Overshoot Scenarios

Discussions on with & without overshoot scenarios when achieving stringent GHG concentration scenarios

Staying below 2°C with "likely" probability

Example of overshoot in concentration

Example of overshoot in emission

Source) IPCC AR5, Chapter 6, Figure 6.14(a)

Importance of Decarbonization of Energy Supply

- Decarbonization of energy supply (i.e. technological and institutional changes upscaling of low- & zero carbon energy) is a key for limiting warming to 2°C.
- Biomass energy with CCS (BECCS) is one of the essential technologies. Mitigation efforts in one sector determine efforts in other sectors, especially in case without CCS.

Direct GHG emissions across sectors in mitigation scenarios that reach about 450 ppm CO2 eq in 2100

Source) IPCC AR5, Figure TS. 17
Importance of Reducing Energy Demand

- Energy efficiency improvements and behavioural changes also play key roles.
- But the rate of change toward the 2°C target is not in line with the current trends, much faster.

Source) IPCC AR5, Figure 6.37

Co-benefits of GHG mitigations

Mitigation can result in large co-benefits for human health and other societal goals.

Source) IPCC AR5, Figure 12.23, Figure SPM. 6
Risks from Climate Change assessed by WG2.

Levels of risk across the Five "Reasons for Concerns"

(A) Risks from climate change... (B) ...depend on cumulative CO₂ emissions...

The pink shaded range is assessed by WG1 complex models, including various uncertainties.

The ellipses show the relations between the cumulative emissions and temperature change in different emissions scenarios categories are assessed by WG3.

The constraint on changes in GHG emissions by 2050 depends on the sensitivity of the climate response.

(C) ...which in turn depend on annual GHG emissions over the next decades

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