GHG emissions growth between 2000 and 2010 has been larger than in the previous three decades.

Based on Figure 1.3
GHG emissions rise with growth in GDP and population.

Based on Figure 1.7
The long-standing trend of decarbonization has reversed.
Regional patterns of GHG emissions are shifting along with changes in the world economy.

The following IPCC country delegations expressed their reservations to the WGIII report regarding income-based country groupings: Bahamas, Bolivia, Egypt, India, Iraq, Jordan, Malaysia, Maldives, Qatar, Saudi Arabia, Sudan, Syria, and Venezuela.

See also:
Regional patterns of GHG emissions are shifting along with changes in the world economy.

The following IPCC country delegations expressed their reservations to the WGIII report regarding income-based country groupings: Bahamas, Bolivia, Egypt, India, Iraq, Jordan, Malaysia, Maldives, Qatar, Saudi Arabia, Sudan, Syria, and Venezuela.

See also:
About half of the cumulative anthropogenic CO$_2$ emissions between 1750 and 2010 have occurred in the last 40 years.
Without additional mitigation, global mean surface temperature is projected to increase by 3.7 to 4.8°C over the 21st century.
Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond.
Risks from climate change depend on cumulative CO$_2$ emissions...
...which in turn depend on annual GHG emissions over the next decades.

Mitigation involves some level of co-benefits and of risks due to adverse side-effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change.

Carbon Dioxide Removal Technologies

Based on SYR Figure SPM.10
Stabilization of atmospheric GHG concentrations requires moving away from business as usual.
Lower ambition mitigation goals require similar reductions of GHG emissions.
Many scenarios make it at least \textit{about as likely as not} that warming will remain below 2°C relative to pre-industrial levels.

Based on Figures 6.32 and 7.16
Still, between 2030 and 2050, emissions would have to be reduced at an unprecedented rate...

Based on Figures 6.32 and 7.16
...implying a rapid scale-up of low-carbon energy.
Delivering emissions reductions increases the difficulty and narrows the options for mitigation.

Based on Figures 6.32 and 7.16
Delaying emissions reductions increases the difficulty and narrows the options for mitigation.

Based on Figures 6.32 and 7.16
Delaying emissions reductions increases the difficulty and narrows the options for mitigation.

Current Cancún Pledges imply increased mitigation challenges for limiting warming to 2°C relative to pre-industrial levels.
Decarbonization of energy supply is a key requirement for limiting warming to 2°C.

Based on Figure 7.11
Energy demand reductions can provide flexibility, hedge against risks, avoid lock-in and provide co-benefits.

Based on Figure 7.11
Baseline scenarios suggest rising GHG emissions in all sectors, except for CO$_2$ emissions from the land-use sector.

Based on Figure TS.15
Mitigation requires changes throughout the economy. Systemic approaches are expected to be most effective.
Mitigation efforts in one sector determine efforts in others.

Based on Figure TS.17
Global costs rise with the ambition of the mitigation goal.

Based on Table SPM.2

<table>
<thead>
<tr>
<th>Concentration [ppm CO₂ eq]</th>
<th>Percentage Point Reduction in Annualized Consumption Growth Rate over 21st Century</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>0.06 (0.04-0.14)</td>
</tr>
<tr>
<td>500</td>
<td>0.06 (0.03-0.13)</td>
</tr>
<tr>
<td>550</td>
<td>0.04 (0.01-0.09)</td>
</tr>
<tr>
<td>2030</td>
<td>0.03 (0.01-0.05)</td>
</tr>
<tr>
<td>2050</td>
<td>0.03 (0.01-0.05)</td>
</tr>
<tr>
<td>2100</td>
<td>0.03 (0.01-0.05)</td>
</tr>
</tbody>
</table>
Technological limitations can increase mitigation costs.

Based on Figure 6.24
What are the consequences for international energy and climate policy?

A few personal thoughts:
The climate problem at a glance

Resources and reserves to remain underground

<table>
<thead>
<tr>
<th></th>
<th>Until 2100</th>
<th>With CCS [%]</th>
<th>No CCS [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td></td>
<td>70</td>
<td>89</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>35</td>
<td>63</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td>32</td>
<td>64</td>
</tr>
</tbody>
</table>

Source: Bauer et al. (2014); Jakob, Hilaire (2015)
There is far more carbon in the ground than emitted in any baseline scenario.

Source: Edenhofer, Hilaire, Bauer
85 percent of the IPCC scenarios in line with the 2° target venture into the unknown territory of negative emissions.

85 percent of the IPCC scenarios in line with the 2° target venture into the unknown territory of negative emissions.

<table>
<thead>
<tr>
<th>Negative emissions options</th>
<th>2020-2100 Low to high potential (GtCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BECCS</td>
<td>178 – 453</td>
</tr>
<tr>
<td>Biochar</td>
<td>143</td>
</tr>
<tr>
<td>Agricultural soil carbon sequestration</td>
<td>104 – 130</td>
</tr>
<tr>
<td>CO₂ air capture</td>
<td>108 – 260*</td>
</tr>
<tr>
<td>Ocean alkalinity enhancement</td>
<td>84 – 260*</td>
</tr>
<tr>
<td>Afforestation &amp; forestry</td>
<td>80 – 100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>~700 – ~1,300*</td>
</tr>
</tbody>
</table>

Further Negative emissions options:
- Afforestation (limited representation in AR5 scenarios)
- Not represented in AR5 scenarios:
  - CO₂ air capture
  - Carbon sequestration in soils (biochar...)
  - Ocean fertilization and alkalinity enhancement
  - Enhanced weathering

Quelle: aus Tabelle 5; Stranded Carbon Assets and NETs (2015), Arbeitspapier SSEE, Univ. of Oxford (*at least)
The scarcity rent of $\text{CO}_2$ emissions

- Fossil fuel rents decrease with the ambition of climate policy.

- If the optimal $\text{CO}_2$ price is implemented globally, this loss is over-compensated by the carbon rent.

- The revenues of the carbon tax or auctioning of emission permits can be used to finance tax reductions, infrastructure investments or debt reduction.

Bauer et al. (2013)
The Globalization Paradox: a trilemma

- Hyper-Globalization
- Global Federalism
- Democracy
- Compromise of Bretton-Woods
- National Sovereignty

Gilded cage
Tax evasion limits national room for maneuver

Mobility of capital

- International markets
- Flight of capital undermines infrastructure investments
- Undersupplying national public goods

- No legitimization
- Voting

Democracy
CO$_2$-taxes free economic potential

Mobility of capital and trade of resources

- International markets
- CO$_2$-Tax
- Optimale supply for national public goods

Expression of national preferences possible

Democracy

Voting
A modelling study illustrates the economic potential of CO$_2$-taxes.

Franks et al. (2015)
Massive infrastructure investments are needed globally.

- Telecommunication
- Access to electricity
- Water availability
Infrastructure investments

- Achieve universal energy access by 2030: US$ 36-41 bln per year (Riahi et al. 2012)
- “Great convergence” of global health standards by 2035: about US$ 40 bln per year (Jameson et al. 2013)

Data from 2009, Source: WDI online
CO$_2$-tax and infrastructure

Quelle: Jakob et al., 2015
Climate change mitigation can result in co-benefits for human health and other societal goals.

Based on Figures 6.33 and 12.23