Bridging the gap III: Overview of options

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Contents

Glossary

The entries in this glossary are adapted from definitions provided by authoritative sources, such as the Intergovernmental Panel on Climate Change.

Additionality A criterion sometimes applied to projects aimed at reducing greenhouse gas emissions. It stipulates that the emission reductions accomplished by the project would not have happened anyway had the project not taken place.

Aerosols Airborne solid or liquid particles, with a typical size of between 0.01 and 10 micrometer (a millionth of a meter) that reside in the atmosphere for at least several hours. They may influence the climate directly through scattering and absorbing radiation, and indirectly by modifying the optical properties and lifetime of clouds.

Agroforestry Farming management practice characterized by the deliberate inclusion of woody perennials on farms, which usually leads to significant economic and/or ecological benefits between woody and non-woody system components. In most documented cases of successful agroforestry, tree-based systems are more productive, more sustainable and more attuned to people's cultural or material needs than treeless alternatives. Agroforestry also provides significant mitigation benefits by sequestering carbon from the atmosphere in the tree biomass.

Annex I countries The industrialised countries (and those in transition to a market economy) that took on obligations to reduce their greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

Biomass plus carbon capture and storage (BioCCS) Use of energy produced from biomass where the combustion gases are then captured and stored underground or used, for example, in industrial processes. Gases generated through, for example, a fermentation process (as opposed to combustion) can also be captured.

Black carbon The substance formed through the incomplete combustion of fossil fuels, biofuels, and biomass, which is emitted in both anthropogenic and naturally occurring soot. It consists of pure carbon in several linked forms. Black carbon warms the Earth by absorbing heat in the atmosphere and by reducing albedo, the ability to reflect sunlight, when deposited on snow and ice.

Bottom-up model In the context of this report, a model that represents a system by looking at its detailed underlying parts. For example, a bottom-up model of emissions would compute the various sources of emissions, sector-by-sector, and then add these components together to get a total emissions estimate.

Business-as-usual In the context of this report, a scenario used for projections of future emissions that assumes that no new action will be taken to mitigate emissions.

Carbon credits Tradable permits which aim to reduce greenhouse gas emissions by giving them a monetary value.

Carbon dioxide equivalent (CO_2e) A simplified way to place emissions of various radiative forcing agents on a common footing by accounting for their effect on climate. It describes, for a given mixture and amount of greenhouse gases, the amount of carbon dioxide that would have the same global warming ability, when measured over a specified time period. For the purpose of this report, greenhouse gas emissions (unless otherwise specified) are the sum of the basket of greenhouse gases listed in Annex A of the Kyoto Protocol, expressed as carbon dioxide equivalents assuming a 100-year global warming potential.

Carbon leakage The increase in greenhouse gas emissions occurring outside countries taking domestic mitigation action.

Conditional pledge Pledges made by some countries that are contingent on the ability of national legislatures to enact the necessary laws, ambitious action from other countries, realization of finance and technical support, or other factors.

Double counting In the context of this report, double counting refers to a situation in which the same emission reductions are counted towards meeting two countries' pledges.

Emission pathway The trajectory of annual global greenhouse gas emissions over time.

Greenhouse gases covered by the Kyoto Protocol These include the six main greenhouse gases, as listed in Annex A of the Kyoto Protocol: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6).

Integrated assessment models Models that seek to combine knowledge from multiple disciplines in the form of equations and/or algorithms in order to explore complex environmental problems. As such, they describe the full chain of climate change, including relevant links and feedbacks between socio-economic and biophysical processes.

International cooperative initiatives Initiatives outside of the United Nations Framework Convention on Climate Change aimed at reducing emissions of greenhouse gases by promoting actions that are less greenhouse gas intensive, compared to prevailing alternatives.

Kyoto Protocol The international environmental treaty intended to reduce greenhouse gas emissions. It builds upon the United Nations Framework Convention on Climate Change.

Later-action scenarios Climate change mitigation scenarios in which emission levels in the near term, typically up to 2020 or 2030, are higher than those in the corresponding least-cost scenarios.

Least-cost scenarios Climate change mitigation scenarios assuming that emission reductions start immediately after the model base year, typically 2010, and are distributed optimally over time, such that aggregate costs of reaching the climate target are minimized.

Lenient rules Pledge cases with maximum Annex I land use, land-use change and forestry (LULUCF) credits and surplus emissions units, and maximum impact of double counting.

Likely chance A likelihood greater than 66 percent. Used in this report to convey the probabilities of meeting temperature limits.

Medium chance A likelihood of 50–66 percent. Used in this report to convey the probabilities of meeting temperature limits.

Montreal Protocol The Montreal Protocol on Substances that Deplete the Ozone Layer is an international treaty that was designed to reduce the production and consumption of ozone-depleting substances in order to reduce their abundance in the atmosphere, and thereby protect the Earth's ozone layer.

Non-Annex I countries A group of developing countries that have signed and ratified the United Nations Framework Convention on Climate Change. They do not have binding emission reduction targets.

No-tillage agriculture Farming practice characterized by the elimination of soil ploughing by seeding a crop directly under the mulch layer from the previous crop. It relies on permanent soil cover by organic amendments, and the diversification of crop species grown in sequences and/or association. This approach avoids emissions caused by soil disturbances related to ploughing, and from burning fossil fuels to run farm machinery for ploughing.

Pledge For the purpose of this report, pledges include Annex I targets and non-Annex I actions, as included in Appendix I and Appendix II of the Copenhagen Accord, and subsequently revised and updated in some instances.

Radiative forcing Change in the net, downward minus upward, irradiance, expressed in watts per square meter (W/m^2), at the tropopause due to a change in an external driver of climate change, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun. For the purposes of this report, radiative forcing is further defined as the change relative to the year 1750 and, unless otherwise noted, refers to a global and annual average value.

Scenario A description of how the future may unfold based on if-then propositions. Scenarios typically include an initial socio-economic situation and a description of the key driving forces and future changes in emissions, temperature or other climate change-related variables.

Strict rules Pledge cases in which the impact of land use, land-use change and forestry (LULUCF) credits and surplus emissions units are set to zero.

Top-down model A model that applies macroeconomic theory, econometric and optimisation techniques to aggregate economic variables. Using historical data on consumption, prices, incomes, and factor costs, top-down models assess final demand for goods and services, and supply from main sectors, such as energy, transportation, agriculture and industry.

Transient climate response Measure of the temperature rise that occurs at the time of a doubling of CO_2 concentration in the atmosphere.

Transient climate response to cumulative carbon emissions Measure of temperature rise per unit of cumulative carbon emissions.

Unconditional pledges Pledges made by countries without conditions attached.

20th–80th percentile range Results that fall within the 20–80 percent range of the frequency distribution of results in this assessment.

Acronyms

AAU	Assigned Amount Unit
ADP	Ad Hoc Working Group on the Durban Platform
AR4	Fourth Assessment Report of the Intergovernmental Panel on Climate Change
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
AWD	Alternate Wetting and Drying
BaU	Business-as-Usual
BC	black carbon
BioCCS	Bio-energy combined with Carbon Capture and Storage
BP	British Petroleum
BRT	Bus Rapid Transit
CCAC	Climate and Clean Air Coalition to Reduce Short-lived Climate Pollutants
CCS	Carbon Capture and Storage
CDIAC	Carbon Dioxide Information Analysis Center
CDM	Clean Development Mechanism
CEM	Clean Energy Ministerial
CER	Certified Emission Reduction
CFC	chlorofluorocarbon
CO_2e	Carbon Dioxide Equivalent
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
CP1	First Commitment Period of the Kyoto Protocol
CP2	Second Commitment Period of the Kyoto Protocol
EDGAR	Emissions Database for Global Atmospheric Research
EIA	Energy Information Administration
ERU	Emission Reduction Unit
EU-ETS	EU Emissions Trading System
GDP	Gross Domestic Product
GEA	Global Energy Assessment
GHG	greenhouse gas
Gt	gigatonne
GWP	Global Warming Potential
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
IAM	Integrated Assessment Model
ICAO	International Civil Aviation Organization
ICI	International Cooperative Initiative
IEA	International Energy Agency
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land-Use Change and Forestry
NAMA	Nationally Appropriate Mitigation Action
NGO	Non-Governmental Organization
OC	organic carbon
ODS	ozone depleting substances
PAM	policies and measures
PPP	Purchasing Power Parity
PV	photovoltaic
RD&D	research, development and demonstration
REDD+	Reduced Emissions from Deforestation and Forest Degradation
RPS	Renewable Portfolio Standards
SO_2	sulphur dioxide
SOC	soil organic carbon
TCR	transient climate response
TCRE	transient climate response to cumulative carbon emissions
UDP	urea deep placement
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Foreword

The latest assessment by Working Group I of the Intergovernmental Panel on Climate Change, released earlier this year, concluded that climate change remains one of the greatest challenges facing society. Warming of the climate system is unequivocal, human-influenced, and many unprecedented changes have been observed throughout the climate system since 1950. These changes threaten life on Earth as we know it. Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. But how much reduction is needed?

Further to the Copenhagen Accord of 2009 and the Cancún agreements in 2010, international efforts under the United Nations Framework Convention on Climate Change are focused on keeping the average rise in global temperature to below 2° C, compared to pre-industrial levels. Current commitments and pledges by developed and developing nations can take the world part of the way towards achieving this 2° C target, but this assessment shows that the there is still a significant gap between political ambition and practical reality. In short, additional emission reductions are needed.

With this fourth assessment of the gap between ambitions and needs, the United Nations Environment Programme seeks to inform governments and the wider public on how far the response to climate change has progressed over the past year, and thus whether the world is on track to meet the 2° C target. In addition to reviewing national pledges and actions, this year's assessment, for the first time, also reviews international cooperative initiatives which, while potentially overlapping, serve to complement national pledges and actions.

From a technical standpoint, meeting the 2° C target remains possible: it will take a combination of full implementation of current national pledges and actions, a scaling up of the most effective international cooperative initiatives, and additional mitigation efforts at the country level. All these efforts will require strengthened policies aimed at curbing greenhouse gas emissions. Crucially, they also require the promotion of development pathways that can concomitantly reduce emissions.

As in the previous assessment, this year's report provides updated analyses of a number of tried and tested sector-specific policy options to achieve this goal. Specifically, we show that actions taken in the agricultural sector can lower emissions and boost the overall sustainability of food production. Replicating these successful policies, and scaling them up, would provide one option for countries to go beyond their current pledges and help close the 'emissions gap'.

The challenge we face is neither a technical nor policy one – it is political: the current pace of action is simply insufficient. The technologies to reduce emission levels to a level consistent with the 2° C target are available and we know which policies we can use to deploy them. However, the political will to do so remains weak. This lack of political will has a price: we will have to undertake steeper and more costly actions to potentially bridge the emissions gap by 2020.

This report is a call for political action. I hope that, by providing high quality evidence and analysis, it will achieve its goal of supporting international climate change negotiations.

Achim Steiner
UN Under-Secretary-General,
UNEP Executive Director

Executive summary

The emissions gap in 2020 is the difference between emission levels in 2020 consistent with meeting climate targets, and levels expected in that year if country pledges and commitments are met. As it becomes less and less likely that the emissions gap will be closed by 2020, the world will have to rely on more difficult, costlier and riskier means after 2020 of keeping the global average temperature increase below 2° C. If the emissions gap is not closed, or significantly narrowed, by 2020, the door to many options limiting the temperature increase to 1.5° C at the end of this century will be closed.

Article 2 of the United Nations Framework Convention on Climate Change ('Climate Convention') declares that its "*ultimate objective*" is to "*[stabilize] greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*". The parties to the Climate Convention have translated this objective into an important, concrete target for limiting the increase in global average temperature to 2° C, compared to its pre-industrial levels. With the aim of meeting this target, many of the parties have made emission reduction pledges, while others have committed to reductions under the recent extension of the Kyoto Protocol.

Since 2010, the United Nations Environment Programme has facilitated an annual independent analysis of those pledges and commitments, to assess whether they are consistent with a least-cost approach to keep global average warming below 2° C [1]. This report confirms and strengthens the conclusions of the three previous analyses that current pledges and commitments fall short of that goal. It further says that, as emissions of greenhouse gases continue to rise rather than decline, it becomes less and less likely that emissions will be low enough by 2020 to be on a least-cost pathway towards meeting the 2° C target[2].

As a result, after 2020, the world will have to rely on more difficult, costlier and riskier means of meeting the target – the further from the least-cost level in 2020, the higher these costs and the greater the risks will be. If the gap is not closed or significantly narrowed by 2020, the door to many options to limit temperature increase to 1.5° C at the end of this century will be closed, further increasing the need to rely on accelerated energy-efficiency increases and biomass with carbon capture and storage for reaching the target.

1. What are current global emissions?

Current global greenhouse gas emission levels are considerably higher than the levels in 2020 that are in line with meeting the 1.5° C or 2° C targets, and are still increasing. In 2010, in absolute levels, developing countries accounted for about 60 percent of global greenhouse gas emissions.

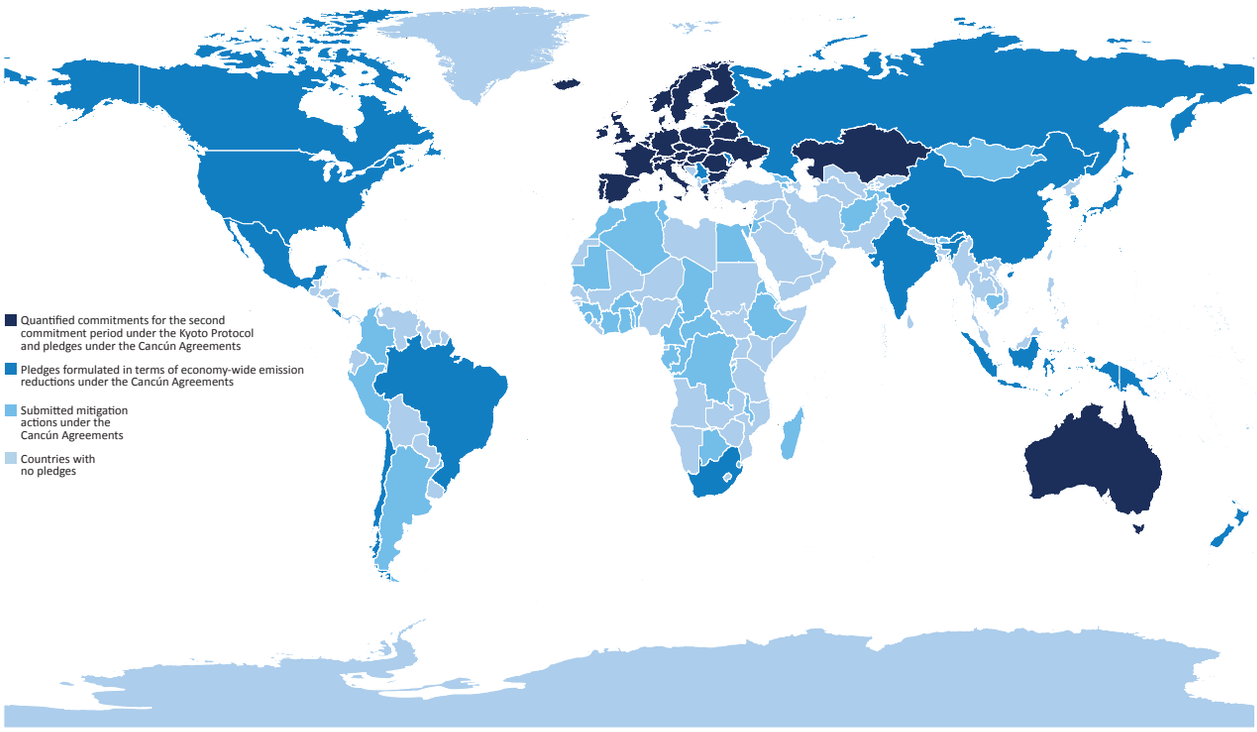
The most recent estimates of global greenhouse gas emissions are for 2010 and amount to 50.1 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) per year (range: 45.6–54.6 $GtCO_2e$ per year). This is already 14 percent higher than the median estimate of the emission level in 2020 with a likely chance of achieving the least cost pathway towards meeting the 2° C target (44 $GtCO_2e$ per year)[3]. With regards to emissions in 2010, the modelling groups report a median value of 48.8 $GtCO_2e$, which is within the uncertainty range cited above. For consistency with emission scenarios, the figure of 48.8 $GtCO_2e$ per year is used in the calculation of the pledge case scenarios.

Relative contributions to global emissions from developing and developed countries changed little from 1990 to 1999. However, the balance changed significantly between 2000 and 2010 – the developed country share decreased from 51.8 percent to 40.9 percent, whereas developing country emissions increased from 48.2 percent to 59.1 percent. Today developing and developed countries are responsible for roughly equal shares of cumulative greenhouse gas emissions for the period 1850-2010.

[1] For this report, a least-cost approach means that emissions are reduced by the cheapest means available.

[2] For this report, a least-cost pathway or a least-cost emissions pathway or least-cost emission scenarios mean the same thing – the temporal pathway of global emissions that meets a climate target and that also takes advantage of the lowest-cost options available for reducing emissions.

[3] See footnote 2.



Note:
Following the 2012 conference of the parties to the Climate Convention in Doha, a group of countries has adopted reduction commitments for the second commitment period under the Kyoto Protocol
Source: United Nations Framework Convention on Climate Change

2. What emission levels are anticipated for 2020?

Global greenhouse gas emissions in 2020 are estimated at 59 $GtCO_2e$ per year under a business-as-usual scenario. If implemented fully, pledges and commitments would reduce this by 3–7 $GtCO_2e$ per year. It is only possible to confirm that a few parties are on track to meet their pledges and commitments by 2020.

Global greenhouse gas emissions in 2020 are estimated at 59 $GtCO_2e$ per year (range: 56–60 $GtCO_2e$ per year) under a business-as-usual scenario – that is, a scenario that only considers existing mitigation efforts. This is about 1 $GtCO_2e$ higher than the estimate in the 2012 emissions gap report.

There have been no significant changes in the pledges and commitments made by parties to the Climate Convention since the 2012 assessment. However, both rules of accounting for land-use change and forestry, and rules for the use of surplus allowances from the Kyoto Protocol's first commitment period have been tightened.

Implementing the pledges would reduce emissions by 3–7 $GtCO_2e$, compared to business-as-usual emission levels.

A review of available evidence from 13 of the parties to the Climate Convention that have made pledges or commitments indicates that five – Australia, China, the European Union, India and the Russian Federation – appear to be on track to meet their pledges. Four parties – Canada, Japan, Mexico and the U.S. – may require further action and/or purchased offsets to meet their pledges, according to government and independent estimates of projected national emissions in 2020. A fifth party – the Republic of Korea – may also require further action but this could not be verified based on government estimates. However, new actions now being taken by all five of these parties many enable them to meet their pledges, although the impact of these actions have not been analyzed here. Not enough information is available concerning Brazil, Indonesia and South Africa. It is worth noting that being on track to implement pledges does not equate to being on track to meet the 1.5° C or 2° C temperature targets.

3. What is the latest estimate of the emissions gap in 2020?

Even if pledges are fully implemented, the emissions gap in 2020 will be 8–12 $GtCO_2e$ per year, assuming least-cost emission pathways. Limited available information indicates that the emissions gap in 2020 to meet a 1.5° C target in 2020 is a further 2–5 $GtCO_2e$ per year wider.

Least-cost emission pathways consistent with a likely chance of keeping global mean temperature increases below 2° C compared to pre-industrial levels have a median level of 44 $GtCO_2e$ in 2020 (range: 38–47 $GtCO_2e$)[4]. Assuming full implementation of the pledges, the emissions gap thus amounts to between 8–12 $GtCO_2e$ per year in 2020 (Table 1).

Governments have agreed to more stringent international accounting rules for land-use change and surplus allowances for the parties to the Kyoto Protocol. However, it is highly uncertain whether the conditions currently attached to the high end of country pledges will be met. Therefore, it is more probable than not that the gap in 2020 will be at the high end of the 8–12 $GtCO_2e$ range.

Limiting increases in global average temperature further to 1.5° C compared to pre-industrial levels requires emissions in 2020 to be even lower, if a least-cost path towards achieving this objective is followed. Based on a limited number of new studies, least-cost emission pathways consistent with the 1.5° C target have emission levels in 2020 of 37–44 $GtCO_2e$ per year, declining rapidly thereafter.

[4] See footnote 2.

4. What emission levels in 2025, 2030 and 2050 are consistent with the 2° C target?

Least-cost emission pathways consistent with a likely chance of meeting a 2° C target have global emissions in 2050 that are 41 and 55 percent, respectively, below emission levels in 1990 and 2010.

Given the decision at the 17th Conference of the Parties to the Climate Convention in 2011 to complete negotiations on a new binding agreement by 2015 for the period after 2020, it has become increasingly important to estimate global emission levels in 2025 and thereafter that are likely to meet the 2° C target. In the scenarios assessed in this report, global emission levels in 2025 and 2030 consistent with the 2° C target amount to approximately 40 $GtCO_2e$ (range: 35–45 $GtCO_2e$) and 35 $GtCO_2e$ (range: 32–42 $GtCO_2e$), respectively. In these scenarios, global emissions in 2050 amount to 22 $GtCO_2e$ (range: 18–25 $GtCO_2e$). These levels are all based on the assumption that the 2020 least-cost level of 44 $GtCO_2e$ per year will be achieved.

5. What are the implications of least-cost emission pathways that meet the 1.5° C and 2° C targets in 2020?

The longer that decisive mitigation efforts are postponed, the higher the dependence on negative emissions in the second half of the 21st century to keep the global average temperature increase below 2° C. The technologies required for achieving negative emissions may have significant negative environmental impacts.

Scenarios consistent with the 1.5° C and 2° C targets share several characteristics: higher-than-current emission reduction rates throughout the century; improvements in energy efficiency and the introduction of zero- and low-carbon technologies at faster rates than have been experienced historically over extended periods; greenhouse gas emissions peaking around 2020; net negative carbon dioxide emissions from the energy and industrial sectors in the second half of the century[5] and an accelerated shift toward electrification[6].

The technologies required for achieving negative emissions in the energy and industrial sectors have not yet been deployed on a large scale and their use may have significant impacts, notably on biodiversity and water supply. Because of this, some scenarios explore the emission reductions required to meet temperature targets without relying on negative emissions. These scenarios require maximum emissions in 2020 of 40 $GtCO_2e$ (range: 36–44 $GtCO_2e$), as compared to a median of 44 $GtCO_2e$ for the complete set of least-cost scenarios.

6. What are the implications of later action scenarios that still meet the 1.5° C and 2° C targets?

Based on a much larger number of studies than in 2012, this update concludes that so-called later-action scenarios have several implications compared to least-cost scenarios, including: (i) much higher rates of global emission reductions in the medium term; (ii) greater lock-in of carbon-intensive infrastructure; (iii) greater dependence on certain technologies in the medium-term; (iv) greater costs of mitigation in the medium- and long-term, and greater risks of economic disruption; and (v) greater risks of failing to meet the 2° C target. For these reasons later-action scenarios may not be feasible in practice and, as a result, temperature targets could be missed.

The estimates of the emissions gap in this and previous reports are based on least-cost scenarios, which characterize trends in global emissions up to 2100 under the assumption that climate targets will be met by the cheapest combination of policies, measures and technologies. But several new studies using a different type of scenario are now available – later-action scenarios, which assume that a least-cost trajectory is not followed immediately, but rather forwards from a specific future date. Like least-cost scenarios, later-action scenarios chart pathways that are consistent with the 2° C target. Contrary to least-cost scenarios, later-action scenarios assume higher global emissions in the near term, which are compensated by deeper reductions later, typically, after 2020 or 2030.

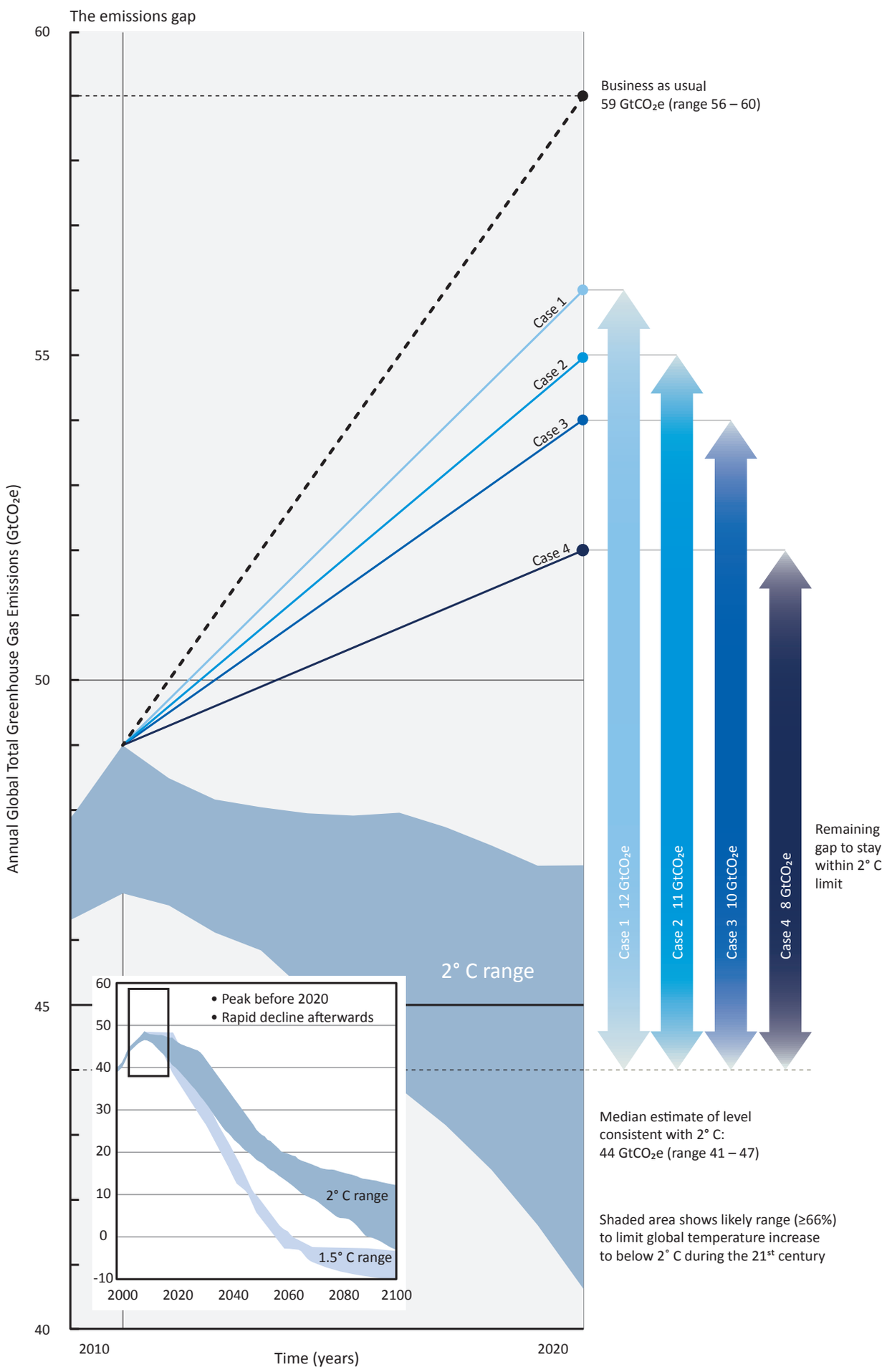
For least-cost scenarios, emission reduction rates for 2030–2050 consistent with a 2° C target are 2–4.5 percent per year. Historically, such reductions have been achieved in a small number of individual countries, but not globally. For later-action scenarios, the corresponding emission reduction rates would have to be substantially higher, for example, 6–8.5 percent if emission reductions remain modest until 2030. These emission reduction rates are without historic precedent over extended periods of time. Furthermore, and because of the delay between policy implementation and actual emission reductions, achieving such high rates of change would require mitigation policies to be adopted several years before the reductions begin.

Apart from assuming higher global emissions in the near term, later-action scenarios also have fewer options for reducing emissions when concerted action finally begins after 2020 or 2030. This is because of carbon lock-in – the continued construction of high-emission fossil-fuel infrastructure unconstrained by climate policies. Because technological infrastructure can have life-times of up to several decades, later-action scenarios effectively lock-in in these high-emission alternatives for a long period of time.

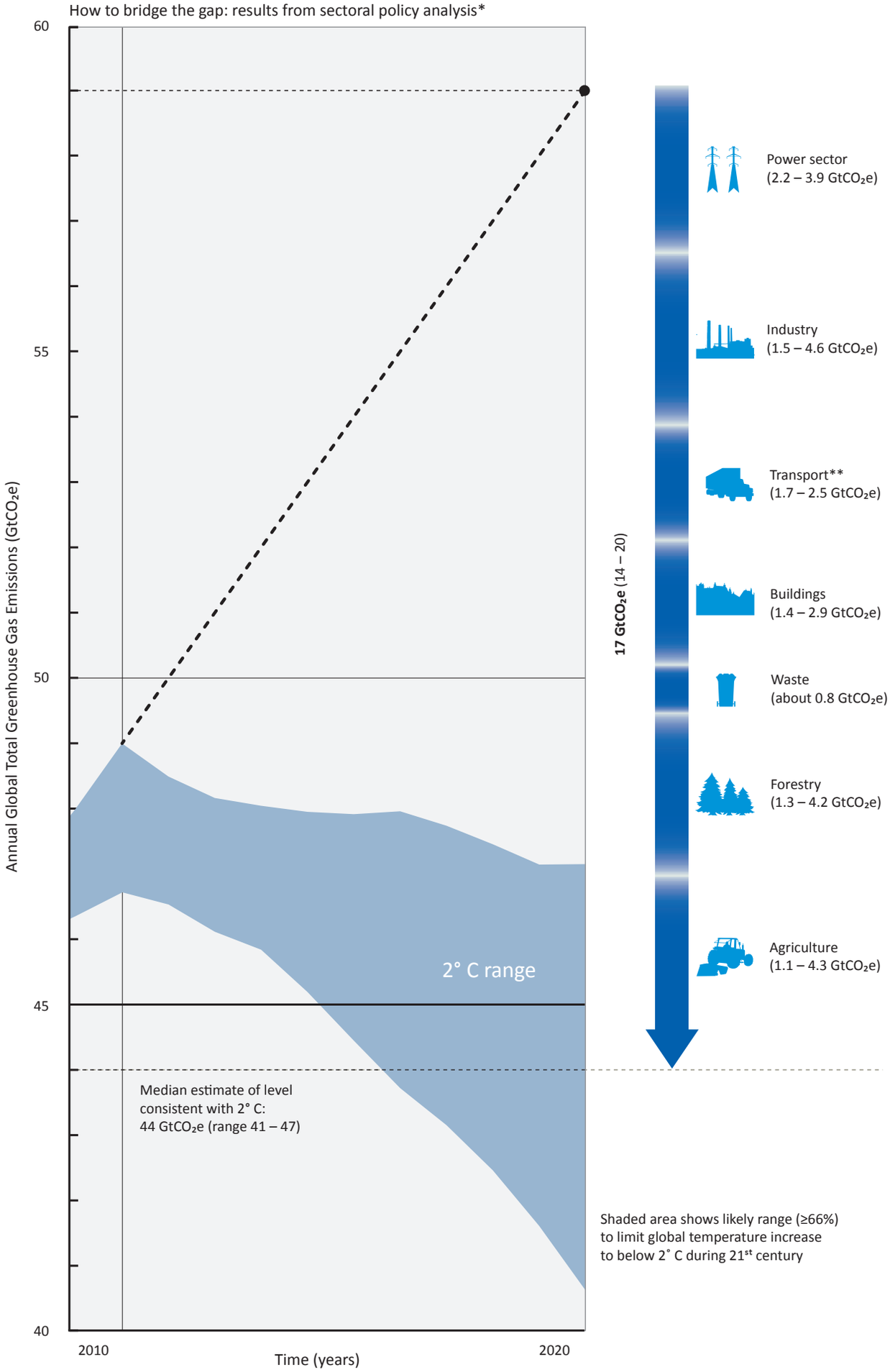
By definition, later-action scenarios are more expensive than least-cost scenarios. The actual cost penalty of later action depends on the future availability of technologies when comprehensive mitigation actions finally begin, as well as on the magnitude of emission reductions up to that point. Finally, although later-action scenarios might reach the same temperature targets as their least-cost counterparts, later-action scenarios pose greater risks of climate impacts for four reasons. First, delaying action allows more greenhouse gases to build-up in the atmosphere in the near term, thereby increasing the risk that later emission reductions will be unable to compensate for this build up. Second, the risk of overshooting climate targets for both atmospheric concentrations of greenhouse gases and global temperature increase is higher with later-action scenarios.

[5] For most scenarios.

[6] Net negative carbon dioxide emissions from the energy and industrial sectors refers to the potential to actively remove more carbon dioxide from the atmosphere than is emitted within a given period of time. Negative emissions can be achieved through, among other means, bioenergy in combination with carbon capture and storage.


The emissions gap
Annual Global Total Greenhouse Gas Emissions (GtCO₂e)
60
55
50
45
40
2010
2020
Time (years)
Business as usual
59 GtCO₂e (range 56 – 60)
Case 1
Case 2
Case 3
Case 4
Case 1 12 GtCO₂e
Case 2 11 GtCO₂e
Case 3 10 GtCO₂e
Case 4 8 GtCO₂e
Remaining gap to stay within 2° C limit
2° C range
Median estimate of level consistent with 2° C:
44 GtCO₂e (range 41 – 47)
Shaded area shows likely range (≥66%) to limit global temperature increase to below 2° C during the 21st century
• Peak before 2020
• Rapid decline afterwards
2° C range
1.5° C range
60
50
40
30
20
10
0
-10
2000
2020
2040
2060
2080
2100

How to bridge the gap: results from sectoral policy analysis*



*based on results from Bridging the Emissions Gap Report 2011
**including shipping and aviation

Third, the near-term rate of temperature increase is higher, which implies greater near-term climate impacts. Lastly, when action is delayed, options to achieve stringent levels of climate protection are increasingly lost.

7. Can the gap be bridged by 2020?

The technical potential for reducing emissions to levels in 2020 is still estimated at about 17 ± 3 $GtCO_2e$. This is enough to close the gap between business-as-usual emission levels and levels that meet the 2° C target, but time is running out.

Sector-level studies of emission reductions reveal that, at marginal costs below US $50–100 per tonne of carbon dioxide equivalent, emissions in 2020 could be reduced by 17 ± 3 $GtCO_2e$, compared to business-as-usual levels in that same year. While this potential would, in principle, be enough to reach the least-cost target of 44 $GtCO_2e$ in 2020, there is little time left.

There are many opportunities to narrow the emissions gap in 2020 as noted in following paragraphs, ranging from applying more stringent accounting practices for emission reduction pledges, to increasing the scope of pledges. To bridge the emissions gap by 2020, all options should be brought into play.

8. What are the options to bridge the emissions gap?

The application of strict accounting rules for national mitigation action could narrow the gap by 1–2 $GtCO_2e$. In addition, moving from unconditional to conditional pledges could narrow the gap by 2–3 $GtCO_2e$, and increasing the scope of current pledges could further narrow the gap by 1.8 $GtCO_2e$. These three steps can bring us halfway to bridging the gap. The remaining gap can be bridged through further national and international action, including international cooperative initiatives. Much of this action will help fulfil national interests outside of climate policy.

Minimizing the use of lenient land-use credits and of surplus emission reductions, and avoiding double counting of offsets could narrow the gap by about 1–2 $GtCO_2e$. Implementing the more ambitious conditional pledges (rather than the unconditional pledges) could narrow the gap by 2–3 $GtCO_2e$. A range of actions aimed at increasing the scope of current pledges could narrow the gap by an additional 1.8 $GtCO_2e$. (These include covering all emissions in national pledges, having all countries pledge emission reductions, and reducing emissions from international transport). Adding together the more stringent accounting practices, the more ambitious pledges, and the increased scope of current pledges, reduces the gap around 6 $GtCO_2e$ or by about a half.

The remaining gap can be bridged through further national and international action, including international cooperative initiatives (see next point). Also important is the fact that many actions to reduce emissions can help meet other national and local development objectives such as reducing air pollution or traffic congestion, or saving household energy costs.

9. How can international cooperative initiatives contribute to narrowing the gap?

There is an increasing number of international cooperative initiatives, through which groups of countries and/or other entities cooperate to promote technologies and policies that have climate benefits, even though climate change mitigation may not be the primary goal of the initiative. These efforts have the potential to help bridge the gap by several $GtCO_2e$ in 2020.

International cooperative initiatives take the form of either global dialogues (to exchange information and understand national priorities), formal multi-lateral processes (addressing issues that are relevant to the reduction of GHG emissions), or implementation initiatives (often structured around technical dialogue fora or sector-specific implementation projects). Some make a direct contribution to climate change mitigation, by effectively helping countries reduce emissions, while others contribute to this goal indirectly, for example through consensus building efforts or the sharing of good practices among members.

The most important areas for international cooperative initiatives appear to be:

- Energy efficiency (up to 2 $GtCO_2e$ by 2020): covered by a substantial number of initiatives.
- Fossil fuel subsidy reform (0.4–2 $GtCO_2e$ by 2020): the number of initiatives and clear commitments in this area is limited.
- Methane and other short-lived climate pollutants (0.6–1.1 $GtCO_2e$ by 2020); this area is covered by one overarching and several specific initiatives. (Reductions here may occur as a side effect of other climate mitigation.)
- Renewable energy (1–3 $GtCO_2e$ by 2020): several initiatives have been started in this area.

Based on limited evidence, the following provisions could arguably enhance the effectiveness of International Cooperative Initiatives: (i) a clearly defined vision and mandate with clearly articulated goals; (ii) the right mix of participants appropriate for that mandate, going beyond traditional climate negotiators; (iii) stronger participation from developing country actors; (iv) sufficient funding and an institutional structure that supports implementation and follow-up, but maintains flexibility; and (v) and incentives for participants.

10. How can national agricultural policies promote development while substantially reducing emissions?

Agriculture now contributes about 11 percent to global greenhouse gas emissions. The estimated emission reduction potential for the sector ranges from 1.1 $GtCO_2e$ to 4.3 $GtCO_2e$ in 2020. Emission reductions achieved by these initiatives may partly overlap with national pledges, but in some cases may also be additional to these.

Not many countries have specified action in the agriculture sector as part of implementing their pledges. Yet, estimates of emission reduction potentials for the sector are high, ranging from 1.1 $GtCO_2e$ to 4.3 $GtCO_2e$ – a wide range, reflecting uncertainties in the estimate. In this year's update we describe policies that have proved to be effective

Table 1 Emissions reductions with respect to business-as-usual and emissions gap in 2020, by pledge case

Case	Pledge type	Rule type	Median emission levels and range ($GtCO_2e$ per year)	Reductions with respect to business-as-usual in 2020 ($GtCO_2e$ per year)	Emissions gap in 2020 ($GtCO_2e$ per year)
Case 1	Unconditional	Lenient	56 (54–56)	3	12
Case 2	Unconditional	Strict	55 (53–55)	4	11
Case 3	Conditional	Lenient	54 (52–54)	5	10
Case 4	Conditional	Strict	52 (50–52)	7	8

Note: In this report, an unconditional pledge is one made without conditions attached. A conditional pledge might depend on the ability of a national legislature to enact necessary laws, or may depend on action from other countries, or on the provision of finance or technical support. Strict rules means that allowances from land use, land-use change and forestry accounting and surplus emission credits will not be counted as part of a country's meeting their emissions reduction pledges. Under lenient rules, these elements can be counted.

in reducing emissions and increasing carbon uptake in the agricultural sector.

In addition to contributing to climate change mitigation, these measures enhance the sector's environmental sustainability and, depending on the measure and situation, may provide other benefits such as higher yields, lower fertilizer costs or extra profits from wood supply. Three examples are:

- Usage of no-tillage practices: no-tillage refers to the elimination of ploughing by direct seeding under the mulch layer of the previous season's crop. This reduces greenhouse gas emissions from soil disturbance and from fossil-fuel use of farm machinery.
- Improved nutrient and water management in rice production: this includes innovative cropping practices such as alternate wetting and drying and urea deep placement that reduce methane and nitrous oxide emissions.
- Agroforestry: this consists of different management practices that all deliberately include woody perennials on farms and the landscape, and which increase the uptake and storage of carbon dioxide from the atmosphere in biomass and soils.

Chapter 1

Introduction

In December of 2009, 114 parties to the United Nations Framework Convention on Climate Change (the 'Climate Convention') agreed to the Copenhagen Accord[1]. Among the important provisions of the accord was the call to parties to submit voluntary emission reduction pledges for the year 2020. To date, 42 developed countries have responded to this call and submitted economy-wide greenhouse gas emission reduction pledges, 16 developing countries have submitted multi-sector expected emission reductions, and in addition 39 other developing countries have submitted pledges related to sectoral goals[2]. Another important provision was the setting of a target to keep the increase in global average temperature below 2°C relative to pre-industrial levels. In the wake of these two provisions, some very critical questions arose:

- Are the pledges for 2020 enough to keep the world on track to meet the 2° C target?
- Will there be a gap between where we need to be in 2020 versus where we expect to be?

UNEP, together with the scientific community, took on these questions in a report published just ahead of the Climate Convention meeting in Cancún in late 2010 (UNEP, 2010). This "emissions gap" report synthesized the latest scientific knowledge about the possible gap between the global emissions levels in 2020 consistent with the 2° C target versus the expected levels if countries fulfil their emission reduction pledges. Many parties to the Climate Convention found this analysis useful as a reference point for establishing the level of ambition that countries needed to pursue in controlling their greenhouse gas emissions. As a result they asked UNEP to produce annual follow-ups, with updates of the gap and advice on how to close it.

Besides updating the estimates of the emissions gap, the 2011 report also looked at feasible ways of bridging the gap from two perspectives (UNEP, 2011). The first was from the top-down viewpoint of integrated models, which showed that feasible transformations in the energy system and other sectors would lower global emissions enough to meet the 2° C target. The second was a bottom-up perspective, which examined the emissions reduction potential in each of the main emissions-producing sectors of the economy. These bottom-up estimates showed that enough total potential exists to bridge the emissions gap in 2020.

The 2012 report presented an update of the gap but also good examples of best-practice policy instruments for reducing emissions. Among these were actions such as implementing appliance standards and vehicle fuel-efficiency guidelines, which are working successfully in many parts of the world and are ready for application elsewhere to help reduce emissions.

The current report reviews the latest estimates of the emissions gap in 2020 and provides plentiful additional information relevant to the climate negotiations. Included are the latest estimates of:

- the current level of global greenhouse gas emissions based on authoritative sources;
- national emission levels, both current (2010) and projected (2020), consistent with current pledges and other commitments;
- global emission levels consistent with the 2° C target in 2020, 2030 and 2050;
- progress being made in different parts of the world to achieve substantial emission reductions.

New to this fourth report is an assessment of the extent to which countries are on track to meet their national pledges. Also new is a description of the many cooperative climate initiatives being undertaken internationally among many different actors – public, private, and from civil society.

Special attention is given to analysing new scenarios that assume later action for mitigation, compared to those used earlier to compute the emissions gap. The report also describes new findings from scientific literature about the impacts of later action to reduce global emissions.

This year the report reviews best practices in reducing emissions in an often-overlooked emissions-producing sector – agriculture. Innovative ideas are described for transforming agriculture into a more sustainable, low-emissions form.

As in previous years, this report has been prepared by a wide range of scientists from around the world. This year

[1] Since then, the number of parties agreeing to the Accord has risen to 141 (see https://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php).
[2] With the 28 member states of the European Union counted as one party.

70 scientists from 44 scientific groups in 17 countries have contributed to the assessment.

The information contained in the report provides invaluable inputs to the current debate on global climate policy and the actions needed to meet international climate targets. Meeting these targets is instrumental for limiting the adverse impacts of climate change and associated 'adaptation gaps' as illustrated in Box 1.1. UNEP hopes that this fourth update will help catalyse action in the forthcoming climate negotiations.

Box 1.1 From emissions gap to adaptation gap

This report's definition of the emissions gap is based on the internationally agreed limit to the increase in global average temperature of 2° C (or possibly 1.5°C). Chapter 3 summarizes the latest scientific findings regarding both least-cost and later-action scenarios for meeting that 1.5 or 2° C target. The chapter concludes that, with later-action scenarios, the cost and risk of not meeting the target increases significantly, compared to least-cost scenarios.

The 2° C target has become associated with what the Intergovernmental Panel on Climate Change (IPCC) termed "*dangerous anthropogenic interference with the climate system*", even though the IPCC has thus far never attached a specific temperature threshold to the concept. Nevertheless, the IPCC has characterised "*dangerous anthropogenic interference*" through five "*reasons for concern*", namely risk to unique and threatened systems, risk of extreme weather events, disparities of impacts and vulnerabilities, aggregate damage and risks of large-scale discontinuities.

These reasons for concern would thus gain particular relevance in the event that the world followed a later-action scenario emissions trajectory that in the end failed to meet the 1.5 or 2° C target. Today, when the choice between least-cost and later-action scenarios is still available to us, later-action scenarios highlight a growing adaptation problem which, by analogy with the emissions gap, could be termed an adaptation gap.

The adaptation gap is more of a challenge to assess than the emissions gap. Whereas carbon dioxide and its equivalents provide a common metric for quantifying the emissions gap, we lack a comparable metric for quantifying the adaptation gap and assessing the impacts of efforts to close it. While the emissions gap indicates the quantity of greenhouse gas emissions that need to be abated, the adaptation gap could measure vulnerabilities which need to be reduced but are not accounted for in any funded programme for reducing adaptation risks. Alternatively, it could estimate the gap between the level of funding needed for adaptation and the level of funding actually committed to the task. Developing countries needs for adaptation are believed to cost in the range of US $100 billion per year (UNFCCC, 2007; World Bank, 2010). By comparison the funds made available by the major multilateral funding mechanisms that generate and disperse adaptation finance add up to a total of around US $3.9 billion to date. From a funding perspective therefore, the adaptation gap is significant[3].

The concept of the adaptation gap is in line with the IPCC's Working Group II's use of the term *adaptation deficit*, which is used to describe the deficit between the current state of a country or management system and a state that would minimize the adverse impacts of current climate conditions.

Framing the adaptation gap in a way useful for policy making also requires a better understanding of how the costs of adaptation vary with different temperature projections. Data on the costs of adaptation under business-as-usual, and best- and worst-case emission scenarios could help policy makers better understand the relationship between adaptation to, and mitigation of climate change. Adaptation cost estimates also put the true costs of climate change, as opposed to only looking at the costs of mitigating it, into a broader and clearer perspective.

There is also a knowledge gap between what we know and what we need to know to successfully adapt to climate change. It is true that we already have enough knowledge to act on adaptation, but not enough to act well. For example, we lack information about how much existing and planned policies can reduce people's vulnerability. Evaluating the effectiveness of various interventions would arguably be a very effective way of measuring progress towards adaptation.

[3] The US $3.9 billion figure is a rough estimate based on information from the following major multilateral funding mechanisms for adaptation: an equivalent of US $399 million has been committed by the EU's Global Climate Change Alliance from 2008 to 2013 (GCCA, 2013). (It should be noted that part of these funds have supported clean energy, Reducing Emissions from Deforestation and Forest Degradation (REDD) and Disaster Risk Reduction programme); cumulative pledges to the Least Developed Countries Fund and the Special Climate Change Fund amounted to a total of US $863 million from their inception to May 2013, (GEF, 2013); US $2.3 billion has been pledged to the Strategic Climate Fund Trust fund as of December 31, 2012 (World Bank, 2013); and the Adaptation Fund had received resources amounting to US $324 billion as of 30 November, 2012 (Adaptation Fund, 2012).

Chapter 2

Emission trends, pledges and their implementation

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Contributing authors: Johannes Gütschow (Potsdam Institute for Climate Impact Research, Germany), Giacomo Grassi (European Commission's Joint Research Centre, Italy), Niklas Höhne (Ecofys, Germany), Kelly Levin (World Resources Institute, USA), Elizabeth Sawin (Climate Interactive, USA), Mark Roelfsema (PBL Netherlands Environmental Assessment Agency, Netherlands), Christopher Taylor (Department of Energy and Climate Change, United Kingdom), Zhao Xiusheng (Tshingua University, China)

2.1 Introduction

This chapter presents an update, based on the scientific literature, of the following critical topics:

- current (2010 global) emissions of greenhouse gases;
- projected emissions (to 2020) of greenhouse gases under a business-as-usual (BaU) scenario;
- projections (to 2020) of greenhouse gas emissions under four different sets of assumptions regarding implementation of national pledges to reduce emissions;
- the extent to which parties are positioned to implement their pledges, in light of their current policy portfolios and plausible assumptions regarding macroeconomic trends and offsets.

The estimated emission level in 2020 under a business-as-usual scenario is 1 gigatonne of carbon dioxide equivalent ($GtCO_2e$) higher compared to last year's emissions gap report[1]. While the emission levels in 2020 for the strict-rules cases are higher by roughly 1 $GtCO_2e$ (unconditional) and are comparable to last year's emission level (conditional), the emission levels associated with the two lenient-rules cases are lower by roughly 1 $GtCO_2e$, as compared to last year's estimates. These changes are mainly due to decisions on surpluses made by countries during the Doha climate negotiations and downward revisions to the assumptions on double counting of offsets. They illustrate that increasing stringency through the climate negotiations can help reduce emission levels in 2020 under lenient-rules cases. However, they do not reflect an increase in ambition or action, but represent a move towards stricter accounting rules. To illustrate, in last year's emissions gap report, emission levels associated with the strict-rules cases were 3 $GtCO_2e$ lower than those of the lenient-rules cases, whereas this year they are lower by around 1 $GtCO_2e$ (unconditional) and 2 $GtCO_2e$ (conditional).

While previous reports assumed full pledge implementation, this year we also explore the extent to which 13 parties, accounting for 72 percent of global greenhouse gas emissions, are already on track to implement their pledges, and where further policy implementation or offsets are likely to be required.

2.2 Current global emissions

Last year's report estimated total global greenhouse gas emissions in 2010 at 50.1 $GtCO_2e$, with a 95 percent uncertainty range of 45.6–54.6 $GtCO_2e$[2]. This bottom-up estimate from the EDGAR database (JRC/PBL, 2012) has not been updated since and is considered a comprehensive assessment of global greenhouse gas emissions in 2010[3]. Figure 2.1 shows emission levels by major economic grouping for the period 1970–2010, using this database[4]. These may differ from data derived from the National Inventory Reports, which are the latest estimate of emissions for most developed countries. The latest global estimates of energy-related carbon dioxide emissions show a continued increase for the years 2011 and 2012, although at a lower pace than the average since the beginning of the 21st century (Olivier *et al.*, 2013)[5].

[1] Unless otherwise stated, all emissions in this report are expressed in $GtCO_2e$. This is the sum of six of the greenhouse gases covered by the Kyoto Protocol (that is CO_2, CH_4, N_2O, HFCs, PFCs and SF_6), weighted by their global warming potential (GWP) (UNFCCC, 2002). Not included are ozone depleting substances (ODS), black carbon (BC), and organic carbon (OC). While nitrogen trifluoride (NF_3) has recently been added to the Kyoto Protocol, it has not been included in this analysis. Unless otherwise stated, data include emissions from land use, land-use change and forestry (LULUCF).

[2] This estimate included all six Kyoto gases and also takes into account emissions from land use, land-use change and forestry.

[3] Another comprehensive assessment of global GHG emissions is WRI's CAIT database that estimated total global GHG emissions in 2010 at 47.2 $GtCO_2e$.

[4] The reader is referred to last year's report (UNEP 2012a) for a breakdown by gas.

[5] The reader is referred to Appendix 2A for further details.

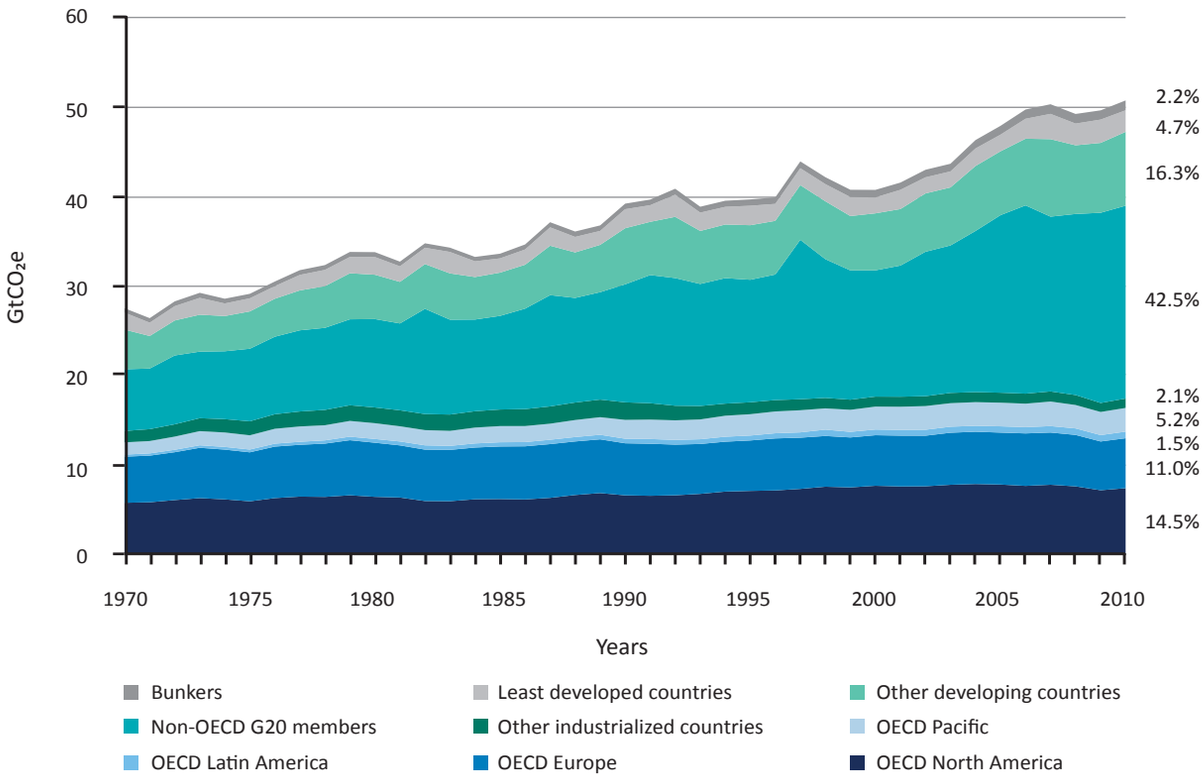

Figure 2.1: Trend in global greenhouse gas emissions 1970–2010 by major economic grouping
Note: The data plotted has been calculated using global warming potential values as used for UNFCCC/Kyoto Protocol reporting. The graph shows emissions of 50.1 $GtCO_2e$ in 2010, as derived from bottom-up emission inventories.
Source: EDGAR 4.2 FT2010 (JRC/PBL, 2012. Percentages refer to shares in global emissions in 2010.

While the last decade of the 20th century saw little change in the relative regional contributions to annual global greenhouse gas emissions, this changed drastically during the first decade of the 21st century. Between 2000 and 2010, the developed country share decreased from 51.8 percent to 40.9 percent, whereas developing country emissions increased from 48.2 percent to 59.1 percent (JRC/PBL, 2012). Referring to Figure 2.1, between 2000 and 2010 the share of global emissions of the non-OECD G20 countries (i.e. Argentina, China, Brazil, India, Indonesia, the Russian Federation, Saudi Arabia and South Africa) increased by 8.7 percent, while the share of all OECD countries and other industrialized countries declined by 9.0 percent, and the share of the remaining developing countries changed little. Today developing and developed countries are responsible for roughly equal shares of cumulative greenhouse gas emissions for the period 1850-2010 (den Elzen et al., 2013b).

Greenhouse gas emission estimates are uncertain due to differences in definitions and in the accounting of national emissions. To produce a statistically significant assessment of the uncertainty associated with those emission estimates, a large number of independent but consistent datasets is required, which at present is not the case (Appendix 2.A). It is nonetheless clear that energy-related carbon dioxide emissions have the lowest uncertainty (UNEP, 2012a), while land use and land-use change emissions of different greenhouse gases have the highest.

2.3 Projected global emissions under business-as-usual scenarios

Business-as-usual scenarios of future developments are generally based on an extrapolation of current economic, social and technological trends. They usually reflect policies that have taken effect as of a recent cut-off date, for example, 2010[8]. However, in some cases they may include policies that, while approved, will only enter into force at a future date (DEA/OECD/URC, 2013).

Business-as-usual scenarios of greenhouse gases are benchmarks against which the effectiveness of mitigation policies and measures can be tested. They are also used in this report to assess the extent to which parties' pledges can meet the 2°C or 1.5°C targets.

Business-as-usual emissions for 2020 were derived from estimates by 12 modelling groups that analyzed the reduction proposals of parties, as described in Section 2.4 [9]. Most of the modelling groups followed the same approach with regards to the types of policies included in the BaU scenario – they did not include new policies with a potential effect on greenhouse gas emissions beyond those in effect at the cut-off date[10]. Some of the modelling groups used the BaU scenarios that the parties provided.

Based on the analysis by these 12 modelling groups, global greenhouse gas emissions for 2020 are estimated at 59 $GtCO_2e$ (range 56–60 $GtCO_2e$) in 2020 under BaU assumptions, which is about 1 $GtCO_2e$ higher than the figure in the 2012 emissions gap report[11]. Two key factors explain

[8] BaU scenarios typically vary with regard to which policies they take into account for a variety of reasons, including: the cut-off year for their inclusion; whether policies have to be planned, adopted, and/or implemented if they are to be included; methodologies for quantifying the effect of included policies; and the determination of whether a policy will have a significant effect that warrants inclusion.
[9] See Table B.1 in Appendix 2.B for a listing of the modelling groups.
[10] The cut-off date for exclusion of policies varies among the modelling groups.
[11] Unless stated otherwise, all ranges in the report are expressed as 20th–80th percentiles.

this increase: using the BaU numbers from China's second national communication to UNFCCC (Government of China, 2012), and moving the base year from 2005 to 2010 in more model studies[12].

To test the robustness of the 59 $GtCO_2e$ BaU estimate, we compare our estimates with those of several international modelling groups, including six that are participating in the studies discussed in Section 2.4 (Kriegler *et al*., 2013)[13]. The BaU scenarios with which we compared our estimates (24 scenarios, developed by 12 different models) give a median of 58 $GtCO_2e$, with a range of 55–60 $GtCO_2e$. In spite of the different lower bound, this median, 58 $GtCO_2e$, is consistent with that obtained by the modelling groups contributing to this report.

2.4 Projected global emissions under pledge assumptions

Under the 2010 Cancún Agreements of the Climate Convention, 42 developed-country parties have submitted quantified economy-wide emission reduction proposals for 2020. Since November 2012, when the last emissions gap report was released, only New Zealand has significantly changed its pledge[14]. Some countries, notably Mexico, have changed underlying assumptions that effectively change their pledge[15].

At the latest Conference of the Parties (COP) to the Climate Convention, held in in Doha in late 2012, parties agreed on a second commitment period of the Kyoto Protocol. This period will run from 2013 to 2020 and provides for quantified emission reduction targets for the following Annex I parties: Australia, Belarus, the European Union and its member states, Kazakhstan, Monaco, Norway, Switzerland and Ukraine. No binding emission reduction targets were set for any other Climate Convention parties, neither Annex-I nor non-Annex I.

To date 55 developing country parties and the African group have submitted nationally appropriate mitigation actions (NAMAs) to Climate Convention (UNFCCC, 2013). Of these, 16 have been framed in terms of multi-sector expected greenhouse gas emission reductions[16]. The remaining 39 are expressed as sectoral goals or, in fewer instances, specific mitigation projects. In this assessment only the former 16 are considered[17]. Together, the 42 developed country parties with reduction targets and the 16 developing country parties accounted for about 75 percent of global emissions in 2010.

Box 2.1 Current and projected emission levels for 13 UNFCCC parties with a pledge

Figure 2.2 shows past (1990, 2005 and 2010) as expected and future (2020) emission levels for 13 Climate Convention parties that have submitted quantitative emission reduction pledges. Four different projections to 2020 are presented: the national BaU scenario, the median BaU value from several international modelling studies, and the emission levels resulting from implementation of two emission reduction pledge cases (see the next section for a description of the different pledge cases).

Annex I parties have defined their commitments in terms of emission reductions in 2020 relative to historical emission levels, typically emission levels in 1990. Conversely, non-Annex I parties have defined them in terms of emission reductions in 2020 relative to hypothetical future emission levels, typically against BaU levels in 2020, or in terms of greenhouse gas emission intensity. In this second case, the uncertainty about actual emission levels in 2020 is carried over into the estimate of the emission reductions commitment.

Most national BaU scenarios from non-Annex I parties are relatively high compared to the range in the corresponding scenario by 12 modelling studies. The reasons for this are numerous, including differences in definitions, notably as to which policies are considered in the baseline, as well in the nature of the assumptions made (DEA/OECD/URC, 2013). Crucially, some developing countries are increasingly clarifying those assumptions and the methods used to calculate the baseline[18].

[12] This resulted in higher emission levels, as economic activity – and thus emission levels – was higher in the period 2005–2010, compared to the previous base year.

[13] The estimates in this report do not include new policies affecting greenhouse gas emissions after the cut-off year.

[14] In August 2013, New Zealand announced a single 5 percent reduction target with respect to its 1990 emission levels, replacing its initial 10–20 percent target.

[15] The Mexican government recently updated the country's BaU scenario for 2020. This updated scenario leads to 960 $MtCO_2e$ emissions, which is above the previous BaU estimate, and also affects the 2020 emissions resulting from the pledge (see Box 2.1).

[16] China and India have expressed their mitigation goals in terms of emission reductions per unit of GDP; Brazil, Indonesia, Mexico, South Africa and the Republic of Korea, in terms of deviations below their respective BaU emission scenarios; Antigua and Barbuda, Marshall Islands and Republic of Moldova, in terms of absolute greenhouse gas emission reductions; and Costa Rica and the Maldives, in terms of a carbon neutrality goal. The reader is referred to Appendix 2.C for additional details on these goals.

[17] Quantifying the emission reductions resulting from these 39 actions is difficult. For this reason, this assessment assumes no reductions below BaU emission scenarios for these countries. This might be a conservative assumption.

[18] For example, in November 2012, as a part of the country's second national communication to the Climate Convention, the Chinese government released national BaU and mitigation scenarios for the first time (Government of China, 2012). The BaU scenario excludes all climate-related policies implemented since 2005, which leads to energy-related carbon dioxide emissions of 14.4 $GtCO_2$ in 2020. The mitigation scenario reflects both domestic policies and the country's international emission-intensity target and results in emissions levels of 4.5 $GtCO_2$ below BaU levels. Similarly, the Mexican government recently updated the country's BaU scenario for 2020.

Box 2.1 Current and projected emission levels for 13 UNFCCC parties with a pledge *(continued)*

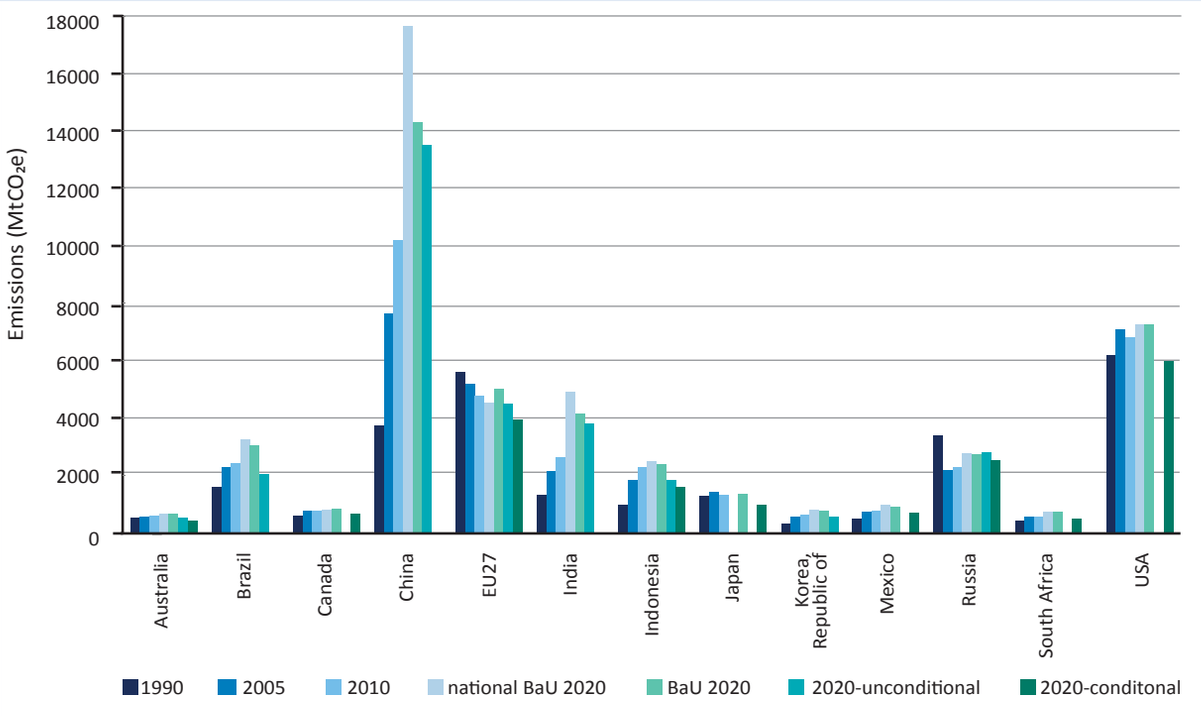

Figure 2.2. Greenhouse gas emissions, including land-use change, for 1990, 2005, 2010 and for 2020 under a national BaU (if available), median of the BaU assumed by modelling groups, unconditional pledge and conditional pledge for UNFCCC parties included in the G20 with a pledge, taking the European Union as a group.
Note: For developed countries, emissions exclude emissions from land-use change.
Note: European Union data include all current European Union member countries except Croatia, which joined the European Union on 1 July, 2013.
Source: EDGAR (JRC/PBL, 2012)[19]

Some pledges are unconditional, whereas others have been made conditional on the ability of a national legislature to enact necessary laws, the action of other countries, or the provision of financial or technical support. We refer to these pledges as, respectively, unconditional and conditional. Some countries have submitted one of each type, whereas others have submitted only a conditional or only an unconditional pledge. This creates a range of possible collective impacts from the pledges, bounded on the low end if only unconditional pledges are implemented, and on the high end if all conditional pledges are implemented. Emission levels in 2020 resulting from implementation of the pledges also depend on the rules used to account for both land use and land-use change credits and debits, and surplus emission units. These concepts are introduced in the following sections, followed by a quantification of the emission reductions resulting from different combinations of pledge cases.

2.4.1 Use of land use, land-use change and forestry credits and debits

Under the Kyoto Protocol, Annex I parties may receive credits or debits from land use, land-use change and forestry (LULUCF) activities dependent on a set of complex accounting rules that contribute to the achievement of their individual emission reduction targets. During the seventeenth Conference of the Parties to the Climate Convention, held in Durban in late 2011, new LULUCF accounting rules for countries participating in the second commitment period (CP2) of the Kyoto Protocol were agreed (UNFCCC, 2012a). The potential contribution of LULUCF accounting under these new rules appears to be relatively modest for Annex I parties that joined the first commitment period of the Kyoto Protocol (Grassi *et al*., 2012): a difference of up to about 2 percent of 1990 emissions between strict and lenient accounting, equal to about 0.3 $GtCO_2e$ per year. If the USA, which did not join the first commitment period of the Kyoto Protocol, followed these rules, the number would increase to 0.45 $GtCO_2e$ per year[20]. While these estimates

[19] National BaUs were obtained from the following sources. For developed countries, we use the best representation of a with-policies BaU scenario, i.e.: Australia (Department of Climate Change and Energy Efficiency, 2012); Canada (Environment Canada, 2012); European Union (European Environment Agency, 2012); Japan: not available; Russia (Government of the Russian Federation, 2010); USA (EIA, 2012; Bianco *et al*., 2013). For developing countries without-policies BaU scenarios (den Elzen et al., 2013a), i.e.: Brazil (Brazilian Government, 2010); China (Government of China, 2012), supplemented with the average estimate non-energy CO_2 emission projection from den Elzen et al., 2013a and estimates from Climate Action Tracker; India (Planning Commission, 2011); Indonesia (Ministry of Environment, 2010), Mexico (NCCS, 2013); South Africa (South Africa. Department of Environmental Affairs, 2011); Korea, Republic of (Republic of Korea, 2011). Note that the national BaUs for South Africa and India were reported as a range. For the figures, the mid-point has been used.

[20] For the USA, the estimated potential contribution from LULUCF credits is about 0.15 $GtCO_2e$ per year. This is calculated as follows: for forest management, assuming 2005 as reference year and given the available projections for 2020 (United States Department of State, 2010), the credit is estimated at about 0.07 $GtCO_2e$ per year; an additional credit of about 0.08 $GtCO_2e$ per year is estimated from afforestation/reforestation and deforestation (EPA, 2005).

are generally consistent with the information contained in UNFCCC (2012c), they may underestimate emissions from those countries that may adopt different accounting rules from those of the Kyoto Protocol, for example, Canada, Japan, New Zealand and Russia[21].

2.4.2 Surplus emissions units

Estimates of emission levels in 2020 can also be influenced by the potential use of surplus emission units. These surplus units could arise either when parties' actual emissions are below their emission targets for the first commitment period of the Kyoto Protocol, or when their emissions in 2020 are below their target for that year, when this does not require significant emission reductions. Note that surplus emission units refers to surpluses arising from different types of allowances – assigned amount units, emission reduction units and certified emission reductions – all introduced in the next paragraphs.

The 2012 emissions gap report estimated the maximum emission reduction in 2020 due to surplus credits at 1.8 $GtCO_2e$[22]. However, as a result of the rules for using such surplus allowances agreed to in Doha, these estimates need to be revised (UNFCCC, 2012b; Kollmuss, 2013). The parties agreed that allowances, referred to as 'assigned amount units' (AAUs), not used in the first commitment period can be carried over to the next period. However, recent decisions on surplus emission units significantly limit the use of such surplus allowances and prevent the build-up of new ones. Only parties participating in the second commitment period can sell their surplus assigned amount units. This will exclude Russia, which is the largest holder of surplus assigned amount units, but which will not participate in the second commitment period. Buyer countries can only purchase surplus assigned amount units up to a quantity of 2 percent of their own initial assigned amount for the first commitment period. In addition, Australia, Japan, Liechtenstein, Monaco, Norway and Switzerland have said that they will not purchase units from others, while the European Union has declared that they will not use any surplus emissions units (UNFCCC, 2012b)[23].

Finally, new surplus allowances are prevented by the fact that allowances that exceed the parties' average emission levels in the period 2008–2010 will be cancelled. This rule affects Belarus, Kazakhstan and Ukraine[24].

These decisions reduce the impact of surplus emissions in 2020. Based on Chen *et al.* (2013) and Gütschow (2013), the impact of Kyoto surpluses on 2020 pledges is estimated to be about 0.05 $GtCO_2e$ (range 0.05–0.15 $GtCO_2e$) for the unconditional pledge scenario and 0.55 $GtCO_2e$ (range 0.5–0.6 $GtCO_2e$) for the conditional pledge scenario, down from 1.8 $GtCO_2e$ as previously estimated[25].

The difference between scenarios stems from the European Union's declaration in Doha that its internal legislation will not allow the use of surplus assigned amount units carried over from the first commitment period, for complying with its 20 percent unconditional pledge. For its 30 percent conditional pledge, the European Union has more than enough Kyoto surplus emissions to realize the required emission reductions. The impact of surplus emissions could also be zero if the European Union decides not to use any of its Kyoto surplus emissions for complying with its 30 percent conditional target.

In addition to the assigned amount units, two of the Kyoto Protocol's flexible mechanisms, the Joint Implementation and the Clean Development Mechanism, provide credits that parties can use in the form of emission reduction units (ERUs) in the case of Joint Implementation, and certified emission reductions (CERs) in the case of the Clean Development Mechanism. These credits can be carried over to the second commitment period of the Kyoto Protocol. The 2012 Conference of the Parties to the Climate Convention did not change the rules for these credits: certified emission reductions and emission reduction units can each be carried over up to 2.5 percent of the initial assigned amount of the first commitment period. There are no restrictions on their use. Those units add to a total impact of 0.2 $GtCO_2e$ in 2020.

2.4.3 The potential impact of offsets

Offsets could affect the emissions levels associated with the pledges in two ways. First, double counting of offsets could arise where emission reductions in developing countries achieved through offsets, such as certified emission reductions, are counted towards meeting the pledges of both countries. Second, some of the offsets may actually not achieve the intended, additional emission reductions.

It is clear that emission reductions associated with 'emission reduction units' and 'certified emission reductions' or with the Kyoto Protocol's third flexible mechanism – emissions trading, should not be double counted[26]. Nevertheless, rules for avoiding double counting have not been agreed to. A rough estimate of the impact of double counting is as follows. If all parties' offsets were counted twice – a likely overestimate of double counting – global emissions would be 0.40 $GtCO_2e$ higher in the case of conditional pledges, and 0.55 $GtCO_2e$ higher in the case of unconditional pledges. In the 2012 emissions gap report (UNEP, 2012a) double

[21] For example, in the case of Russia, if the "*appropriate accounting of the potential of the forestry sector*" (UNFCCC, 2012c) is interpreted as not applying the cap on forest management credits agreed in Durban, LULUCF credits in Russia alone may reach 0.3 $GtCO_2e$ per year, instead of the 0.1 $GtCO_2e$ per year assumed in this assessment.

[22] This would apply if all surplus credits were purchased by parties with pledges that do require emission reductions, displacing mitigation action in buying parties.

[23] The European Union stated in Doha that their legislation does not allow the use of carried over surplus units (UNFCCC, 2012b). However, it is unclear if this statement is fully binding. Purchase of units was not excluded by the European Union, but is highly unlikely to happen, as the European Union holds the largest share of surplus units.

[24] In their respective pledges, the governments of Ukraine, Kazakhstan and Belarus proposed target emission levels above that 2008-2010 emissions average. Further details are available in Chen *et al*. (2013) and Kollmuss (2013).

[25] Calculations assume as a starting point the initial assigned amounts of the first commitment period of the Kyoto Protocol. The uncertainty ranges come from the future decisions of Ukraine, Belarus and Kazakhstan. If these countries stay in the second commitment period of the Kyoto Protocol and lower their commitments to their 2008-2010 emission levels, they can make use of surplus emissions.

[26] At least in theory, emission reductions could also be shared, with a certain percentage attributed to the buyer and the seller retaining the remainder.

counting was estimated at 1.5 $GtCO_2e$, which is now believed to be an overly high value[27].

In addition to double counting, there is a risk that more offset credits could be generated than emissions actually reduced. Stated differently: project activities need to be additional to the development expected without the project[28]. Although estimates are fraught with uncertainty, available evidence suggests that a significant amount of emission reductions in Clean Development Mechanism projects are not additional in this sense (Haya, 2009). Assuming this share to be 25 percent by 2020, it is estimated that offsets of up to 0.1 $GtCO_2e$ for conditional pledges and 0.15 $GtCO_2e$ for unconditional pledges could be non-additional. This would raise the total estimate of the impact of offsets to about 0.5–0.7 $GtCO_2e$.

2.4.4 Four cases of expected emissions in 2020

The findings from 12 modelling groups have been brought together to estimate expected emission levels in 2020, taking into account emission reduction proposals by parties to the Climate Convention. For more information on the contributing modelling groups, see Table B.1 in Appendix 2.B.

Of the seven modelling groups that participated in the 2012 emissions gap report, most have updated their analyses[29], and five new modelling groups contributed to this year's update[30].

In line with the 2012 report (UNEP, 2012a), the current update is structured around four emission scenarios in 2020, based on whether pledges are conditional or unconditional, and on whether accounting rules are strict or lenient (Figure 2.3). Under strict rules the allowances from LULUCF accounting, offset double counting, and surplus emission credits cannot be counted towards the emission reduction pledges. Under lenient rules this is permitted.

The results for each of the four scenarios are given below. Ranges are expressed as 20th–80th percentiles.

Case 1 – Unconditional pledges, lenient rules
Parties implement their lower-ambition pledges and are subject to lenient accounting rules: the median estimate of annual greenhouse gas emissions in 2020 is 56 $GtCO_2e$, within a range of 54–56 $GtCO_2e$.

Case 2 – Unconditional pledges, strict rules
Parties implement their lower-ambition pledges, but are subject to strict accounting rules: the median estimate of annual greenhouse gas emissions in 2020 is 55 $GtCO_2e$, within a range of 53–55 $GtCO_2e$.

Case 3 – Conditional pledges, lenient rules
Some parties offered to be more ambitious with their pledges, provided some conditions were met. If the more ambitious conditional pledges are implemented, and accounting rules are lenient, the median estimate of annual greenhouse gas emissions in 2020 is 54 $GtCO_2e$, within a range of 52–54 $GtCO_2e$.

Case 4 – Conditional pledges, strict rules
Parties implement higher-ambition pledges and are subject to strict accounting rules: the median estimate of annual greenhouse gas emissions in 2020 is 52 $GtCO_2e$, within a range of 50–52 $GtCO_2e$.

Compared to the 2012 update (UNEP, 2012a), emission levels in 2020 corresponding to the two cases for which strict rules apply are higher by around 1 $GtCO_2e$ under unconditional pledges and comparable with the corresponding estimate in the 2012 update for conditional pledges. The remaining two cases, those in which lenient rules apply, have median emissions that are around 1 $GtCO_2e$ lower compared to the 2012 update. The latter is due to the lower impact of both double counting and surplus assigned amount units due to the Doha decisions and does not reflect an increase in ambition or action, but represent a move towards stricter accounting rules. To illustrate, in last year's emissions gap report, emission levels associated with the strict-rules cases were 3 $GtCO_2e$ lower than those of the lenient-rules cases, whereas this year they are lower by around 1 $GtCO_2e$ (unconditional) and 2 $GtCO_2e$ (conditional).

Including five additional modelling groups has increased the robustness of the analysis. Despite the inclusion of these five new studies, the overall conclusions have not changed.

2.4.5 Pledged reduction effort by Annex I and non-Annex I countries

For Annex I parties, total emissions as a group of countries for the four pledge cases are estimated to be 3–16 percent below 1990 levels in 2020. For non-Annex I parties, total emissions are estimated to be 7–9 percent lower than business-as-usual emissions. This implies that the aggregate Annex I countries' emission goals fall short of reaching the 25–40 percent reduction by 2020, compared with 1990, suggested in the IPCC Fourth Assessment Report (Gupta *et al.*, 2007). Similarly, the non-Annex I countries' goals fall, collectively, short in reaching the 15–30 percent deviation from business-as-usual which is also used as a benchmark for emission reductions (den Elzen and Höhne, 2008; 2010).

[27] The 1.5 $GtCO_2e$ estimate was taken from Erickson *et al.*(2011). However, given current BaU projections, the agreed limited use of Clean Development Mechanism and other transferable units for the countries not participating in the Kyoto Protocol's CP2, and since the USA and Canada are not planning to use offsets, 0.40 $GtCO_2e$ (in the conditional pledge cases) and 0.55 $GtCO_2e$ (in the unconditional pledge cases) are now believed to be more accurate estimates. For the pledge cases it is assumed that international emission offsets could account for 33 percent of the difference between BAU and pledged emission levels by 2020 for all Annex I countries. (This is an arbitrary, conservative estimate, as many parties have yet to specify any limits to the use of transferable units.) Two exceptions are made, however. First, no offset use for the USA and Canada is assumed, because their respective governments have indicated that they will only make very limited use of offset credits (UNFCCC, 2012c). Second, regarding the European Union's unconditional pledge, the rules in the European Union's energy and climate package are assumed to have been implemented.

[28] A criterion sometimes applied to projects aiming at reducing greenhouse gas emissions. It stipulates that the emission reductions accomplished by the project would not have happened anyway if the project had not taken place.

[29] More specifically, (i) Climate Action Tracker by Ecofys, Climate Analytics and Potsdam Institute for Climate Impact Research, PIK, www.climateactiontracker.org (Climate Action Tracker, 2010); (ii) Climate Interactive (C-ROADS) (Sterman *et al.*, 2012); (iii) Fondazione Eni Enrico Mattei (FEEM) (Tavoni *et al.*, 2013); (iv) Grantham Research Institute, London School of Economics (updated based on Stern and Taylor, 2010); (v) OECD Environmental Outlook to 2050 (OECD, 2012); (vi) PBL Netherlands Environmental Assessment Agency (den Elzen *et al.*, 2013a; Hof *et al.*, 2013) and (vii) UNEP Risoe Centre (UNEP, 2012b).

[30] The five new modelling groups are: Energy Research Centre of the Netherlands (ECN), International Institute for Applied Systems Analysis (IIASA), National Institute for Environmental Studies (NIES), Pacific Northwest National Laboratory (PNNL) and Potsdam Institute for Climate Impact Research (PIK). Additional information on the participants in the project (dubbed LIMITS) is given in Appendix 2.B. Kriegler *et al.* (2013) summarises some of the project's findings.

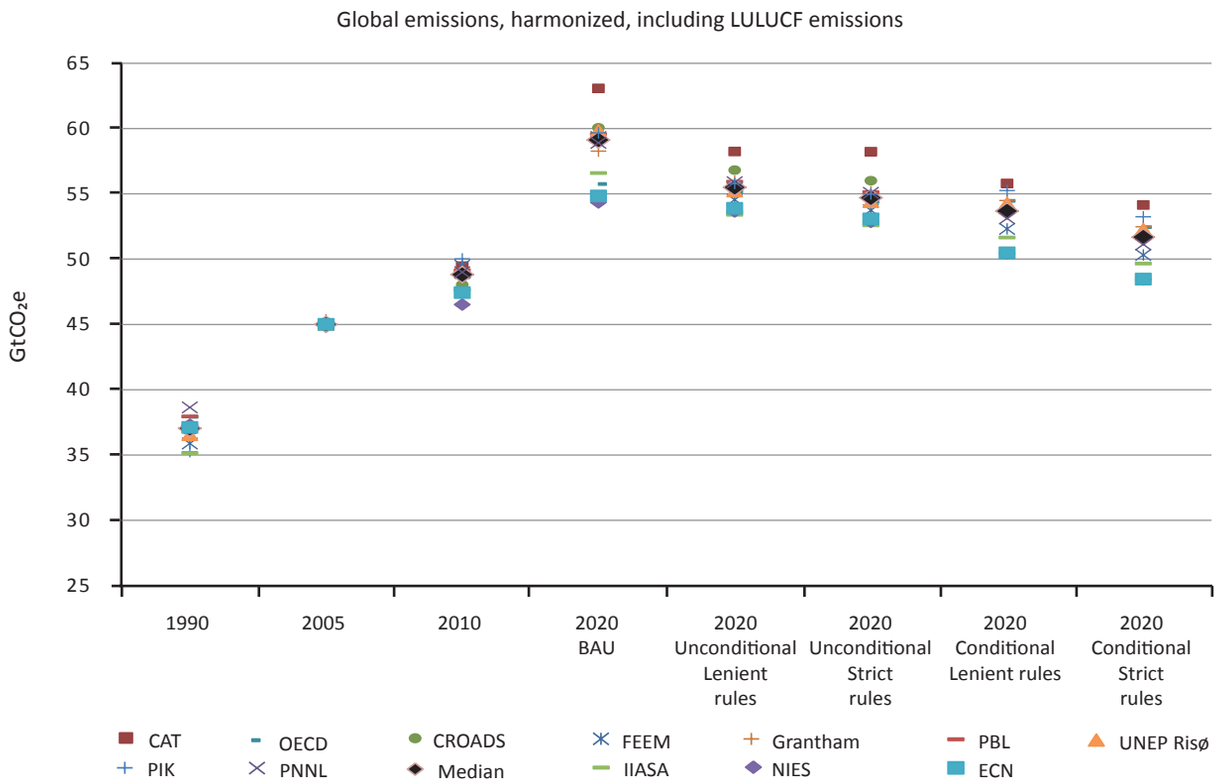

Figure 2.3: Emissions in 2020 under BaU and as a result of pledges under four cases.
Note: To ensure a consistent comparison of the pathways and pledges the data have been harmonized to the same 2005 emissions of 45 $GtCO_2e$, except for Grantham.
Source: See Appendix 2.B

2.5 National progress: do policies match pledges?

Section 2.4 examined four scenarios for national and global greenhouse gas emissions assuming that parties' pledges would be fully implemented – that is, assuming that, in 2020, parties will emit the amount indicated by their pledges. As 2020 approaches, however, the time is ripe to take stock of the extent to which parties are, in fact, on track to achieve their pledges.

This section considers the likely impact of current domestic policies, describing parties' climate-policy portfolios and examining the extent to which these policies, in combination with other factors, have put parties on track to meeting their pledges. The section focuses on the 13 parties whose economies are amongst the 20 largest in the world and who have formulated a quantitative pledge[31].

It is important to note that the 13 parties' pledges varied in terms of the extent to which they required deviation from various BaU estimates, as discussed in Appendix 2.D. The larger the deviation, the more difficult it is to achieve the pledge and the more important the role of additional policies becomes.

In order to assess whether parties' expected greenhouse gas trajectories are in line with 2020 pledges, projected 2020 emission scenarios that take into account currently adopted policies (current trajectory for 2020) were compared to the 2020 emission levels needed to achieve each pledge through domestic abatement (pledge threshold for 2020)[32].

To establish the current trajectory for 2020, we identified emission scenarios that factor in the effects of currently adopted policies[33]. We based this trajectory on official estimates presented in national communications to the Climate Convention and other government sources, and corroborated these estimates with other available literature (Table 2.1), adjusting where necessary to ensure consistency with official figures, for example, in the treatment of LULUCF. An official trajectory was not available for the Republic of Korea.

To establish the pledge threshold, we sought to identify the maximum level of 2020 emissions that each party would consider to be consistent with meeting its pledge through domestic abatement. Where a pledge is presented as a range, we adopted the higher quantity of resulting emissions as the pledge threshold – for example, if a country states it will reduce its emissions by 5–10 percent, our pledge threshold represents the 5 percent reduction. Note, if 10 percent were used, countries would have lower expected emissions in 2020.

For each of the 13 parties examined, Table 2.1 below presents both official and independent estimates of emission levels in 2020. Five parties – Australia, China, the European Union, India and Russia – appear to be on track to meet their pledges under the policies they have adopted to date, given current assumptions about macroeconomic and technology trends and offsets. Of these, three – China, India

[31] These parties account for 72 percent of global greenhouse gas emissions. They are: Australia, Brazil, Canada, China, the European Union, India, Indonesia, Japan, Mexico, the Russian Federation, South Africa, the Republic of Korea and the USA.

[32] We consider offsets only when a country has explicitly stated its intent to purchase a specific quantity of offsets.

[33] This contrasts with the BaU ranges presented in earlier sections of this report, which include estimates that do not factor in these effects.

and Russia – had pledges that, by some estimates, were less dependent on policy interventions after 2009[34]. Australia and the European Union, on the other hand, needed to strengthen their policy portfolios and, in Australia's case, purchase offsets to meet their unconditional pledges[35].

Four parties – Canada, Japan, Mexico, and the USA – may require further action and/or purchased offsets to meet their pledges, according to government and independent estimates of projected national emissions in 2020. A fifth party – the Republic of Korea – may also require further action but this could not be verified based on government estimates. However, new actions now being taken by all five of these parties may enable them to meet their pledges, although the impact of these actions have not been analyzed here. Examples of new actions include Mexico which has recently adopted comprehensive climate-change legislation, and is in the process of developing its second special programme on climate change (NCCS, 2013)[36].

Table 2.1 Pledges versus current trajectories for G20 countries with a greenhouse gas pledge[37]

Party	Pledge threshold for 2020 ($MtCO_2e$)	Pledge estimate from this study (Figure 2.2)	Current trajectory for 2020 ($MtCO_2e$)		Observation	Notes and references
			Official estimate	Independent estimate(s)		
Australia	537	427–541	637	475–645	Australia intends to meet its unconditional 5 percent pledge in part through domestic abatement and in part by purchasing 100 $MtCO_2e$ in offsets. Australia is experiencing significant policy uncertainty.	Pledge threshold and official trajectory from DCCEE (2012); independent trajectory from Roelfsema *et al*. (2013).
Brazil	2 068	1 973-2 068	N/A	1 500–2 630	Estimates of 2020 emissions vary widely above and below the pledge threshold, approximately 1 900 $MtCO_2e$ (La Rovere *et al*., 2013) and 1500 – 2630 $MtCO_2e$ (Roelfsema *et al*., 2013).	Pledge threshold based on Brazilian Government (2010); independent trajectory from La Rovere (2013) and Roelfsema *et al*. (2013).
Canada	607	614	720	730–780	According to current projections, Canada will require further policy action and/or the purchase of offsets to meet its pledge.	Pledge threshold and official trajectory from Environment Canada (2012); independent trajectory from Roelfsema *et al*. (2013).
China	11 700 (CO_2 only)	13 445-13 561 (all greenhouse gases)	11 700 (CO_2 only)	12 770–14 765 (all greenhouse gases)	Most estimates indicate that China is currently on track to meet its CO_2 intensity pledge, which was similar to some BaU estimates (though not to China's).	Pledge threshold from Roelfsema *et al.* (2013); official trajectory from The People's Republic of China (2012); independent trajectory from Roelfsema *et al*. (2013); figures assume 7 percent GDP growth and include only CO_2 emissions from energy and industry.
European Union (EU27)	4 526	3 935–4 479	4 500	4 500	According to current projections, the European Union is currently on track to meet its 20 percent unconditional pledge through domestic abatement.	Pledge threshold from UNFCCC (2012d); official trajectory from European Environment Agency (2012); independent trajectory from Roelfsema *et al*. (2013); excludes LULUCF.
India	3 537–4 016	3 751-3 834	3 537–4 016	2 655–3 795	Most estimates indicate that India is currently on track to meet its greenhouse gas intensity pledge, which is higher than some BaU estimates.	Pledge threshold and official trajectory from Planning Commission (2011) (figures assume 8 and 9 percent GDP growth, respectively); independent trajectory from Roelfsema *et al*. (2013). Figures exclude agriculture and LULUCF.

[34] Regardless of whether China and India needed new policies to meet their greenhouse gas-intensity pledges, both countries have implemented significant new climate-related policies since 2009.

[35] Australia has announced its intent to meet its pledge half through domestic abatement under its new carbon-pricing mechanism and half through internationally sourced offsets – 100 $MtCO_2e$ each (DCCEE, 2012). Australia's new coalition government, however, has announced its intent to repeal the carbon-pricing mechanism; while there is bipartisan support for Australia's pledge, it is not clear how Australia would deliver on the pledge without the carbon-pricing mechanism (Kember *et al*., 2013).

[36] It is not yet possible to quantify the abatement expected from the new special programme on climate change.

[37] Not considering purchase or sale of offsets. Figures include all gases and sectors, including LULUCF, unless otherwise noted.

Party	Pledge threshold for 2020 ($MtCO_2e$)	Pledge median estimate from this study (Figure 2.2)	Current trajectory for 2020 ($MtCO_2e$)		Observation	Notes and references
			Official estimate	Independent estimate(s)		
Indonesia	2 183	1 603–1 820	N/A	N/A	Indonesia has not published estimates of its projected 2020 emissions taking into account current policies, and independent estimates factor out the sizable share of national emissions from peatlands, due to the significant uncertainty associated with estimating these.	Pledge threshold based on Ministry of Environment (2010).
Japan	946	952	1 148–1 198	N/A	According to official estimates, Japan is on track to achieve a 5–9 percent reduction from 1990 levels, with high uncertainty; the Japanese government intends to revise its 2020 target by late 2013 (GWPH 2013).	Pledge calculated based on Ministry of Environment (2013) using Kyoto Protocol Base Year. Official trajectory based on The Energy and Environment Council (2012).
Mexico	672	672	830	800–845	According to current projections, Mexico will require further action and/or offsets to meet its pledge. New or enhanced policies included in the forthcoming Special Programme on Climate Change may reduce projected 2020 emissions.	Official pledge based on NCCS (2013); official trajectory based on Government of Mexico (2012), adjusted per NCCS (2013); independent trajectory from Roelfsema *et al*. (2013).
Republic of Korea	543	543	N/A	630–675	Information on the Republic of Korea's emission trajectory is limited; independent estimates indicate that further action and/or offsets will be needed to meet the pledge. The Republic of Korea is currently developing new policies, including an emission-trading scheme.	Pledge threshold based on the Republic of Korea (2011); current trajectory from Roelfsema *et al*. (2013); excludes LULUCF.
Russian Federation	2 921	2 515–2 763	2 750	2 085–2 455	Russia is currently on track to meet its pledge, which was above BaU estimates.	Pledge threshold based on Russian Federation (2013); official trajectory from Ministry of Natural Resources and Environment (2010); independent trajectory from Roelfsema *et al*. (2013).
South Africa	583	479	N/A	560–690	South Africa has not published estimates of its projected 2020 emissions, and independent estimates based on currently adopted policies are not available.	Pledge threshold from Department of Environmental Affairs (2011); independent trajectory from Roelfsema *et al*. (2013).
USA	5 144	5 974	6 206	6 041–6 465	According to current projections, the USA will require further action and/or offsets to meet its pledge. New or enhanced policies pursued under the Climate Action Plan announced in June 2013 may reduce projected 2020 emissions.	Pledge threshold based on EPA (2013); official trajectory from United States Department of State (2010); independent trajectory from Bianco *et al*. (2013) (with LULUCF adjusted per US Department of State (2010) and Roelfsema *et al.* (2013)).

Notes:
- Pledge threshold for 2020 refers to 2020 emission levels needed to achieve each pledge through domestic abatement.
- Current trajectory for 2020 provides scenario projections that factor in the effects of currently adopted policies. Where governmental sources are available, these are cited first (official estimates). Independent estimates are quoted next to these, for comparison.

The Republic of Korea is about to implement an emissions-trading scheme and is defining other elements of its Framework Act on Low Carbon[38]. The USA presented a Climate Action Plan in June 2013 (Executive Office of the President, 2013), and analysis has shown that it is possible for the USA to deliver on its pledge if the administration makes full use of available legal instruments (Bianco *et al*. 2013), many of which are referenced in the Climate Action Plan. A 2012 study concluded that Canada's 2020 goal was still achievable if Canada were to implement specific additional policies, though it would become more costly and difficult to achieve the longer further action was delayed (NRTEE 2012). Japan is currently in the process of reviewing both its pledge and its policy portfolio in light of the Fukushima nuclear incident and a recent government transition (GWPH, 2013).

While the three remaining countries, Brazil, Indonesia and South Africa, have all made significant progress on monitoring and reporting in recent years, for a variety of reasons insufficient information is currently available to determine whether they are on track to achieve their pledges. These countries' governments have not published estimates of their 2020 emissions that consider only currently adopted policies, and independent assessments (Roelfsema *et al*., 2013) present a wide range of possible trajectories. Indeed, some of these countries' climate policies are rapidly evolving, making it difficult to develop meaningful estimates of future emissions – South Africa, for example, is considering a carbon tax and a range of additional measures. Emission trajectories for Brazil and Indonesia are subject to considerable uncertainty related to land-use emissions (Roelfsema *et al*., 2013). As policies continue to evolve, the forthcoming Biennial Reports and Biennial Update Reports of 2014 to the Climate Convention can serve as one option for parties to take stock of, and quantify, their progress, and to communicate this internationally.

2.6 Summary

If country pledges are implemented, expected emission levels in 2020 will range from 52 to 56 $GtCO_2e$, depending on how pledges are implemented – for reference, the BaU level is 59 $GtCO_2e$. The factors affecting implementation are whether the pledges are conditional or unconditional, and whether the accounting rules applied are lenient or strict. According to best estimates presented in this chapter, global greenhouse gas emissions are expected to continue to increase. Estimated BaU emissions are 1 $GtCO_2e$ higher compared to last year's update. While emission projections in 2020 for the two strict rules cases are comparable with last year's update, the Doha decisions on surpluses, as well as our downward revisions on the impact of double counting, lower the emission levels associated with the lenient rules cases by roughly 1 $GtCO_2e$.

Global 2020 emissions resulting from the implementation of pledges can be lowered by moving from unconditional to conditional pledges, and from lenient accounting rules to strict accounting rules. For example, if conditional pledges were embraced instead of unconditional ones, emission levels in 2020 would be 2–3 $GtCO_2e$ lower. If strict rules were adopted rather than lenient ones, emissions levels in 2020 would be 1–2 $GtCO_2e$ lower. It is noteworthy that the decisions on surplus assigned amount units in Doha have lowered the emission levels under the lenient rule cases by 1 $GtCO_2e$.

For these figures to hold true, parties must also deliver on their pledges, which in some cases may require additional policies or purchased offsets. Five of the 13 major parties are well positioned to achieve their pledges using policies they have already adopted, enhancing confidence in the pledge scenarios outlined in the previous section. Of the five parties that may not yet be so positioned, all are within striking distance of achieving their pledges in 2020. Three, in particular, have taken significant steps to enhance their policy portfolios, which could lead to the ambitious policies needed to meet their pledges. It should be noted that some parties have defined their pledges at a higher level of emissions than those used to calculate the size of the gap in this report. Moreover, even those parties that have adopted ambitious policies may find it difficult to meet their pledges, owing to political circumstances, implementation shortcomings, and potentially adverse macroeconomic trends. Therefore, it will be important to monitor and, where possible, take steps to mitigate these risk factors.

Finally, serious information gaps preclude a comprehensive assessment of several countries' emission trajectories under current policies. Given the disconnect that can occur between country pledges and the policies that support them, it is imperative to address this information gap in order to fully understand the magnitude of the gap between countries' policy portfolios and the 2° C target.

[38] No official government estimate is available that concludes that the Republic of Korea is not on track to meet its pledge. However, since independent estimates point towards emission levels that are largely inconsistent with those required to meet the pledge, and given that the government of the Republic of Korea is currently developing new, aggressive policies including an emissions trading scheme, it is likely that the country is indeed not yet on track to meet its pledge through current policies. The new policies being developed may reverse this situation.

Chapter 3

The emissions gap and its implications

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3.1 Introduction

Countries have pledged to reduce or limit their greenhouse gas emissions by 2020 and at the same time have agreed to limit the increase in global mean temperature to 1.5° C or 2° C compared to pre-industrial levels. These two important commitments raise some critical questions:

- Does the combined effect of these pledges put the world on a path towards limiting warming to below 1.5° C or 2° C with a high chance of success?
- Is there an emissions gap between where the pledges lead and where pathways indicate emissions should ideally be?
- What are the implications and trade-offs of such a possible emissions gap for the achievability of the 1.5° C and 2° C targets and their associated mitigation challenges?

Earlier emissions gap reports have set out to answer these questions by combining the assessment of where emissions are heading (Chapter 2) with an assessment of emission scenarios that could limit warming to below 1.5° C or 2° C (see Appendix 3.A for background). The assessment is updated here, as it has been annually since 2010 (UNEP, 2010; 2011; 2012).

UNEP's 2012 report mentioned a new class of scenario, termed later-action scenarios, that limit warming to 1.5° C or 2° C. The special aspect of these is that they allow the achievement of climate targets even though global emissions in the near term, up to 2020, are higher than in scenarios based on immediate action. In this 2013 report we take advantage of the many new articles that have been published on later-action scenarios and examine their implications and their assumptions much more closely (Sections 3.4, 3.5 and 3.6).

3.2 Which scenarios are analyzed?

The scientific literature contains many different emission scenarios computed by integrated assessment models that limit global temperature rise to 1.5° C or 2° C above pre-industrial levels (Appendix 3.B). The differences between scenarios arise from the range of assumptions made about inputs such as costs, potential and performance of different mitigation technologies, as well as driving forces of emissions such as economic and population growth. Also important are differences in model design and the design of model experiments. The scenarios highlighted in this chapter stay, respectively, within the 1.5° C or 2° C targets with a certain probability but can differ significantly in their underlying assumptions. We also present a re-analysis of the scenario literature, where the scenarios have been divided into two groups: least-cost and later-action.

Least-cost scenarios depict the trend in global emissions up to 2100 under the assumption that climate targets will be met by the cheapest combination of policies and measures over the time period considered by a particular model. This assumes that, in the model, actions are allowed to begin immediately; that is, in the specified base year of the model's calculations, which is often 2010. This set of scenarios can be seen as a useful benchmark for evaluating implications of less stingent climate policies. As discussed below, the fact that real emissions since 2010 already deviate from these pathways has important implications.

Later-action scenarios also attempt to keep warming to below 1.5° C or 2° C, but assume that actions to reduce emissions are generally weaker and take place later than assumed in least-cost scenarios. Hence, later-action scenarios assume that less action is taken to reduce emissions in the near term as compared to least-cost scenarios (Section 3.5). Although less action is assumed, it might, for example, include complying with current pledges to reduce emissions. The set also includes scenarios that have no policy action at all in some or all regions until 2030. After

2020 or 2030, the later-action scenarios aim for more stringent policies to ensure compatibility with the temperature targets. In other words, the lack of ambition to reduce emissions in the short term is compensated by faster and/or deeper emission reductions later. Once these scenarios do begin emission reductions, they again attempt to minimize costs of mitigation, but some options are no longer available. By definition the later start will lead to higher overall costs.

Each of these scenarios has a particular trajectory of emissions. The reason a particular trajectory keeps within a specified limit of global warming – during the 21st century or in a certain year in the future – is that it stays below a certain maximum value of cumulative emissions of long-lived greenhouse gases such as carbon dioxide and nitrous oxide (Allen *et al.*, 2009; IPCC, 2013; Matthews *et al.*, 2012; Meinshausen *et al.*, 2009; Solomon *et al.*, 2010)[1]. Integrated-assessment models provide insights into how, and at what rate, the global energy system and other greenhouse gas emitting sectors can be transformed so that cumulative emissions do not exceed a particular budget over the long term. Therefore they provide very useful information about what levels of emissions are consistent with temperature targets at different points in the future.

Box 3.1 Gap implications of the Working Group I Contribution to the Fifth Assessment Report of the IPCC

The IPCC launched its fifth, and latest, assessment of climate science in September 2013 (IPCC, 2013). It emphasizes that the scientific community has a higher level of confidence than ever that human activity is significantly impacting the climate system.

A key aspect of the new IPCC Working Group I report is a quantification of the sensitivity of the climate system to increased greenhouse gas emissions and to radiative forcing. This sensitivity is expressed through several different metrics. The two most relevant for this report are the transient climate response (TCR) and the transient climate response to cumulative carbon emissions (TCRE).

The transient climate response is a measure of the temperature rise that occurs at the time of a doubling of carbon dioxide concentrations in the atmosphere. Its current likely range is 1–2.5° C, compared to 1–3° C in the previous IPCC assessment. The climate simulations used in this report are consistent with this new range (Rogelj *et al.*, 2012).

The transient climate response to cumulative carbon emissions is a measure of temperature rise per unit of cumulative carbon emissions, and has not been previously reported in an IPCC assessment. The implication of this concept is that global average temperature can only be kept to a certain value if cumulative carbon dioxide emissions do not exceed a maximum amount, or budget, over time. This is called the "carbon emissions budget". The idea of a budget is that if emissions are high now, then they have to be lower later. In general, the budget total cannot be exceeded. If it were exceeded, carbon would have to be subsequently removed from the atmosphere so that emissions returned to within budget limits. Conversely, if emissions were lower at the beginning, then they can be somewhat higher later. Thus, different emission pathways staying within the same budget will meet the same temperature target. This explains the trade-off between early and late emission reductions. UNEP's emissions gap reports explore these trade-offs by taking into account many important factors that influence emission trends.

3.3 Emissions in line with least-cost 2° C pathways

This section analyses emission levels achieved in least-cost scenarios through comprehensive, immediate action. Implications of later-action scenarios are discussed in Sections 3.5 and 3.6. To analyze these scenarios, we bring them into a common analytical framework and estimate the probability of each scenario exceeding 1.5° C or 2° C of warming. A probabilistic approach is important because of the uncertainties of climate response (see Box 3.1). Probability statements in this chapter only refer to climate-response uncertainties (see Appendix 3.A for more information), not to the plausibility of particular policy outcomes.

Least-cost emission scenarios consistent with a 'likely' chance of staying below 2° C have a median emission level of 44 $GtCO_2e$ per year in 2020, with a central range of 38–47 $GtCO_2e$ per year – dependent on their post-2020 emission trajectories (Figure 3.1 and Table 3.1)[2]. For comparison, emissions in 2005 were 45 $GtCO_2e$ per year. In this and previous emission-gap reports, we define a 'likely' chance as having a greater than 66 percent probability, consistent with the definitions of the IPCC (Mastrandrea *et al.*, 2010). For a less stringent 'medium' chance (50–66 percent), median emission levels in 2020 can be somewhat higher at 46 $GtCO_2e$ per year (range 44–48 $GtCO_2e$ per year). Global emissions in these scenarios peak around 2020 or earlier.

The main results do not differ from those presented in the 2012 report (UNEP, 2012), because most new scenarios also initiate comprehensive action from 2010 onward and near-

[1] Some greenhouse gases such as methane and tropospheric ozone have a much shorter lifetime in the atmosphere than carbon dioxide or nitrous oxide, and are therefore sometimes called short-lived climate pollutants or forcers. As compared to carbon dioxide and nitrous oxide, the *cumulative* emissions of short-lived climate pollutants have a smaller effect on maximum temperature than their *annual* emissions at the time when maximum warming occurs (Smith *et al.*, 2012).

[2] In this chapter we refer to the 20th–80th percentile range as the central range or just as the range, while the minimum-maximum range is referred to as the full spread or just as the spread.

term mitigation potentials have not greatly changed in the past year. Least-cost scenarios are indicative of the emissions path the world would have followed if it had started to implement comprehensive policies at the beginning of this decade, and serve as an important benchmark to evaluate scenarios with delayed or weaker-than-optimal near-term policy actions[3]. The fact that we are currently not on this path already has implications (Section 3.6.2).

Median emissions in 2025 are around 40 $GtCO_2e$ per year (range 35–45 $GtCO_2e$ per year) in our set of scenarios which show a 'likely' chance of staying below the 2° C target. For a 'medium' chance of staying below the target, median 2025 emissions do not exceed 44 $GtCO_2e$ per year (range 42–46 $GtCO_2e$ per year). Continuing through the century, median emissions in line with the 2° C target continue to decline, for example to 35 $GtCO_2e$ per year and 22 $GtCO_2e$ per year in 2030 and 2050, respectively. (For scenarios with a 'likely' chance of meeting the 2° C target see Table 3.1).

The ranges are due to differences in assumptions of the integrated assessment models. Despite wide ranges, the models agree that substantial emission reductions relative to business-as-usual and current emission levels are required by 2050. Higher near-term emissions will have to be offset by steeper and larger reductions later. Moreover, many of the least-cost scenarios assume that emissions become negative in the second half of the century. This raises the question of the feasibility of negative emissions. Negative emissions are achieved in these scenarios through bio-energy and carbon capture and storage (CCS), or through land-use changes, such as afforestation or reforestation. In addition, negative emissions can be achieved, for instance, by direct air capture of carbon dioxide in combination with carbon capture and storage. Technologies such as bio-energy combined with carbon capture and storage are still not proven on the large scale and, moreover, their use can have significant impacts, for instance on biodiversity and drinking-water availability (Coelho *et al.*, 2012). Some models, therefore, try to account for these impacts and explore the consequences of not being able to achieve negative emissions or the consequences of a much smaller bio-energy potential. It was found that scenarios that assumed that negative emissions cannot be achieved required substantially lower emissions in the short term in order not to exceed the carbon budget that complies with the 2° C target[4]. Around mid-century, the scenarios without net negative emissions have similar emission levels as other scenarios, while in the long term, by 2100 they are higher since the other scenarios have negative emissions.

In general, limiting the long-term mitigation potential in scenarios, by, for example, not allowing negative emissions, will require more stringent near-term emissions reductions (Table 3.1) and generally larger mitigation costs. Note that limiting key mitigation technologies in scenarios, including carbon capture and storage and bio-energy, will increase the overall mitigation costs because of the required additional short-term action, and because more expensive technologies will have to be used. Since these scenarios assume cost-effective emission reductions from 2010 onward, they are included in our set of least-cost scenarios.

Table 3.1 Overview of emissions in 2020, 2025, 2030 and 2050 of scenarios with, respectively, a 'likely' (≥ 66 percent) or a 'medium' (50–66 percent) chance of limiting global temperature increase to below 2° C during the 21st century.

	Number of scenarios	Peaking decade*	Total greenhouse gas emissions in 2020		Total greenhouse gas emissions in 2025		Total greenhouse gas emissions in 2030		Total greenhouse gas emissions in 2050	
		year	$GtCO_2e$ per year		$GtCO_2e$ per year		$GtCO_2e$ per year		$GtCO_2e$ per year	
			Median	Range and spread**	Median	Range and spread **	Median	Range and spread **	Median	Range and spread **
'Likely' chance (≥ 66 percent)	112	2010–2020	44	5–(38–47)–50	40	6–(35–45)–49	35	7–(32–42)–47	22	12–(18–25)–32
'Medium' chance (50–66 percent)	66	2010–2020	46	24–(44–49)–53	44	28–(42–46)–54	41	32–(39–44)–55	28	21–(25–32)–44
Subset of scenarios with technology restrictions* **										
'Likely' chance (≥ 66 percent)	56	2010–2020	42	5–(37–37)–50	38	6–(32–44)–49	35	7–(28–40)–47	21	13–(18–24)–31
Subset of scenarios not achieving net negative emissions from fossil fuel and industry by 2100										
'Likely' chance (≥ 66 percent)	42	2010–2020	40	5–(36–44)–50	37	6–(32–41)–47	34	7–(29–39)–47	20	13–(18–22)–27

* Because most models only provide emissions data for 5-year or 10-year intervals, the encompassing period in which the peak in global emissions occurs is given. The peak-year period here reflects the 20th–80th percentile range. With current emissions around 49–50 $GtCO_2e$ per year, a scenario with 2020 emissions below that value would in general imply that global emissions have peaked.

** The range and spread are presented as the minimum value – (20th–80th percentile) – maximum value.

*** Scenarios with technology restrictions explore the implications of a limited availability of mitigation options in the future, either because of societal choices to limit the use of certain technologies, or because technologies do not scale up as completely as currently anticipated.

[3] In this case optimal means following a least-cost pathway.

[4] Negative emissions in this case refer to negative emissions from the fossil fuel and industrial sectors. Land-use emissions are not included here in the calculation of negative emissions. For the subset of scenarios that do not reach net negative emissions in the long term, it was found that their median near-term emissions were about 4 $GtCO_2e$ per year in 2020 lower than the median of all least-cost scenarios that have a likely chance of staying below 2° C.

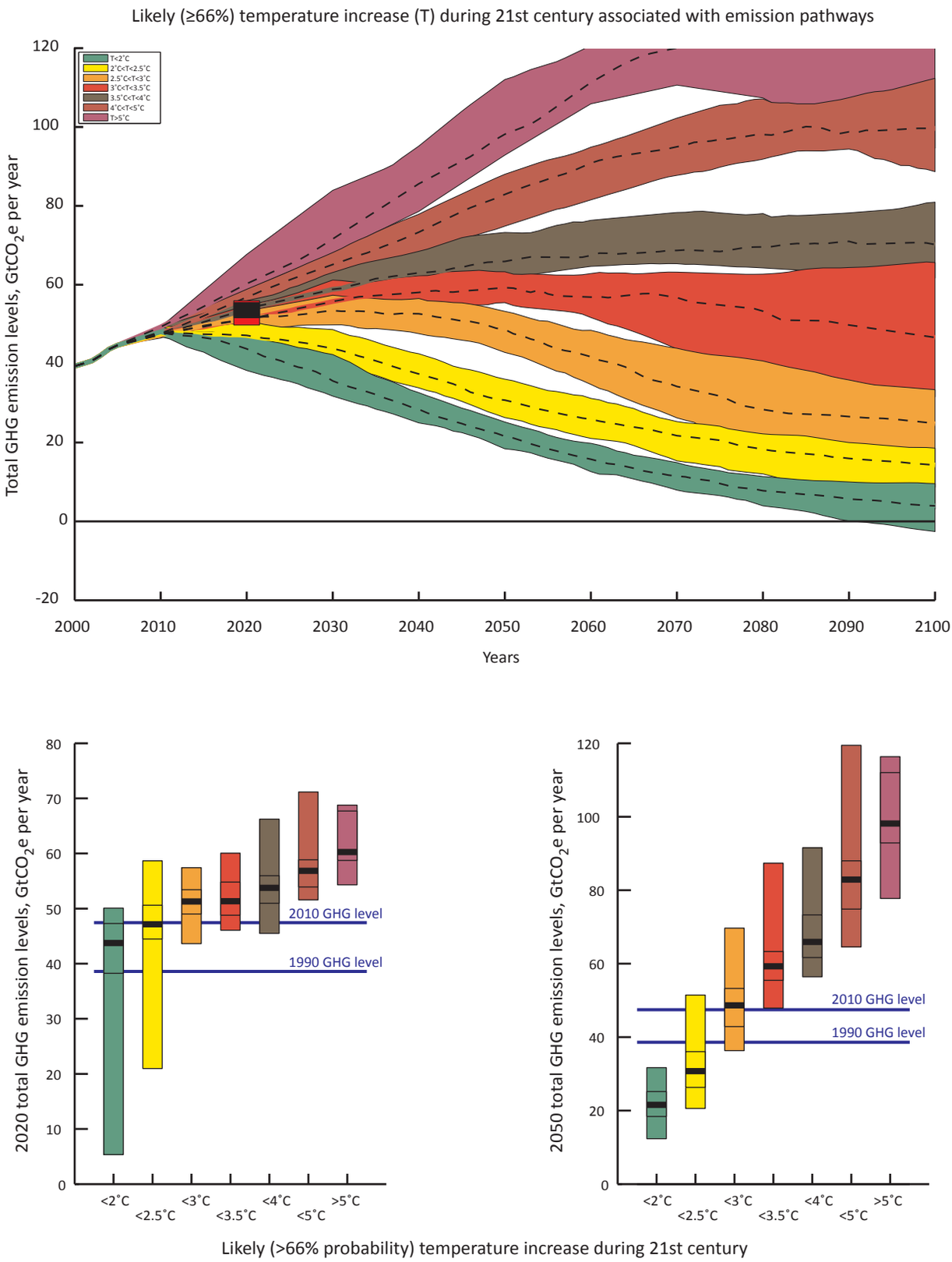

Figure 3.1 Ranges of scenarios limiting global temperature increase with a 'likely' (≥ 66 percent) chance of staying below various temperature limits (top panel). Time slices of the ranges are shown in the bottom panel for 2020 and 2050 global total emissions. The small box around 2020 indicates emission levels consistent with current pledges as assessed in Chapter 2.

Table 3.2: Overview of characteristics of 1.5° C pathways available in the scientific literature. The ranges are drawn from the studies' underlying information.

Least-cost pathways					
Temperature target	Reference	Scenario type	Total greenhouse gas emissions, $GtCO_2e$ per year		
			in 2020	in 2030	in 2050
Limiting warming below 1.5° C with at least 50 percent chance	Rogelj *et al.* (2013b)	Least cost	37–41	27–31	13–17
Limiting warming below 1.5° C with at least 50 percent chance	Luderer *et al.* (2013b)	Least cost	40–44	28–36	5–18
Studies reporting implications of later action for limiting warming below 1.5° C					
Rogelj *et al.* (2013a)	Provides ranges of 2020 emissions from scenarios in line with a 50 percent chance to limit warming to below 1.5° C by 2100 (minimum-maximum spread 36–53 $GtCO_2e$ per year in 2020) and discusses the trade-offs and implications of later action.				
Luderer *et al.* (2013b)	Discusses the economic mitigation challenges – aggregate long-term cost, transitional costs, energy prices – of later action scenarios for a range of temperature targets, including 1.5° C, deriving implications for the lower end of achievable climate targets.				
Rogelj *et al.* (2013b)	Discusses the implications – carbon prices, aggregated mitigation costs, climate risks – of later action scenarios for a range of temperature targets, including 1.5° C, from a risk perspective, taking into account mitigation technology and energy demand variations.				

3.4. Emissions in line with least-cost 1.5° C pathways

The 2010 Cancún Agreements include a provision for a possible 1.5° C limit on global mean temperature rise. The 2012 report found five scenarios in line with 1.5° C, with at least a 'medium' probability, which showed average emissions not exceeding 43 $GtCO_2e$ per year in 2020 (UNEP, 2012). Also, in 2010, UNEP found that stylized emission trajectories that start emission reductions in 2010 and stay within the 1.5° C target have average emissions of up to 44 $GtCO_2e$ per year (range 39–44 $GtCO_2e$ per year) in 2020[5].

No new 1.5° C scenarios are analyzed in this report, as all new scenarios came from model inter-comparisons which focused on the 2° C target. However, some single-model studies have looked at the implications of later action for 1.5° C. Scenarios from these studies were not included in the main scenario set, but are discussed below[6].

Three new studies available in the scientific literature (Luderer *et al.*, 2013b; Rogelj *et al.*, 2013a; Rogelj *et al.*, 2013b) and one report (Schaeffer *et al.*, 2013b) have looked explicitly at scenarios that limit warming to 1.5° C by 2100. Azar *et al.* (2013) also looked at 1.5° C scenarios, but to 2150 instead of 2100. Least-cost scenarios from Rogelj *et al.* (2013b) have emissions between 37–41 $GtCO_2e$ per year in 2020, 27–31 $GtCO_2e$ per year in 2030, and 13–17 $GtCO_2e$ per year in 2050 (Table 3.2)[7]. Mitigation in these scenarios starts after 2010 and is further tightened to limit warming below 1.5° C by 2100 with at least a 50 percent chance of achieving the target. These scenarios feature a radical commitment to energy efficiency in order to limit greenhouse gas emissions in the future. In addition, they rely heavily on negative-emission technologies such as bio-energy combined with carbon capture and storage (BioCCS). All three studies (Luderer *et al.*, 2013b; Rogelj *et al.*, 2013a; Rogelj *et al.*, 2013b) show that immediate action is very important if warming is to be limited to below 1.5° C by 2100. However, Rogelj *et al.* (2013a) also present later-action scenarios consistent with 1.5° C. These, which are discussed further in Sections 3.5 and 3.6, are able to limit warming below 1.5° C from emission levels higher than the ones cited above. On the basis of this (limited) information, and compared to the 2° C, the 1.5° C emissions gap in 2020 is between 2 and 5 $GtCO_2e$ per year wider.

3.5 Later-action scenarios in the literature

Since the 2012 update (UNEP, 2012), several new studies of later-action scenarios have become available. These scenarios assume in the near term, up to 2020 or 2030, a lower level of action to reduce emissions than implied in the least-cost scenarios. All other assumptions being the same, the later-action scenarios have higher near-term emissions than least-cost scenarios. These scenarios assume that comprehensive emission reductions would begin at a later point, but are still able to stay within long-term climate targets.

Table 3.3 provides an overview of studies that have produced later-action scenarios. It is important to note that these studies cover a wide range of assumptions regarding the time at which comprehensive mitigation begins, and the nature of the climate-policy regime assumed for the early period until the adoption of comprehensive mitigation actions. Most studies consider scenarios in which comprehensive emission reductions are postponed until 2020 or 2030 (Kriegler *et al.*, 2013b; Luderer *et al.*, 2013a; Luderer *et al.*, 2013b; Riahi *et al.*, 2013; Rogelj *et al.*, 2013a; Rogelj *et al.*, 2013b). While some scenarios assume climate policies to be absent altogether in the near term, others incorporate the impact of current climate policies or their extensions. Some of these scenarios assume that current country emission pledges for 2020 are implemented. Compared to emissions in least-cost scenarios, emissions in the later-action scenarios are reduced more rapidly after the adoption of comprehensive mitigation actions in order to have at least a 'medium' chance of meeting the 2° C target.

[5] Stylized emission scenarios are ones that are not computed with a detailed integrated assessment model, but by assuming an evolution of emission reduction rates throughout the century.

[6] The reason for only including model inter-comparisons in the main scenario set is to achieve a somewhat balanced representation of the various modelling frameworks that are available in the scientific literature. Including particular single-scenario studies, which combined have produced more than 1 000 scenarios, would bias the results presented here towards the results of one or two models. Therefore, these studies are discussed separately.

[7] Luderer *et al.* (2013b) found a range of 40–44 $GtCO_2e$ per year in 2020, 28–36 $GtCO_2e$ per year in 2030 and 5-18 $GtCO_2e$ per year in 2050.

Box 3.2 Key Properties of 1.5° C and 2° C Scenarios

Scenarios consistent with 1.5° C and 2° C targets have several similar characteristics. First, their emission-reduction rates throughout the 21st century are high – and both improvements in energy efficiency and the introduction of zero- and low-carbon emission technologies are often at rates faster than experienced historically over an extended period of time (van der Zwaan *et al.*, 2013). Second, the scenarios typically reach their peak emission levels before or around 2020 in order to avoid an extensive overshoot of emission budgets, concentrations and, possibly, temperatures in the 21st century (Kriegler *et al.*, 2013c). Third, the scenarios often have net negative emissions in the second half of the century. Finally, these scenarios almost universally feature an accelerated shift towards electrification (Krey *et al.*, 2013).

The 2012 report (UNEP, 2012) highlighted the potential role of both negative emissions and energy-efficiency measures. Negative emissions refers to the potential of actively removing more carbon dioxide from the atmosphere than is emitted at a given period. Here we highlight new literature on the topics of both negative emissions and energy efficiency in scenarios that meet the 1.5° C and 2° C targets.

Negative emissions

About one third of the scenarios analyzed in this chapter with either a 'likely' or a 'medium' chance of meeting the 2° C target – and most of the small number of 1.5° C scenarios – have negative total emissions of all Kyoto gases, not only carbon dioxide, before 2100. Moreover, about 40 percent of the scenarios that have a likely chance of complying with the 2° C target have negative energy and industry-related carbon dioxide emissions by 2100. In these scenarios, bio-energy with carbon capture and storage is usually applied in the second-half of the century, assuming this option is economically attractive within a least-cost path over time. Such a path implies that the discounted costs of an additional unit of reduction is stable over time, and thus allows for much more expensive technologies to expand in the second half of the century. Also considered economically attractive is the ability to avoid very rapid, and thus costly, emission reductions in the short term (Azar *et al.*, 2010; Edmonds *et al.*, 2013; van Vuuren *et al.*, 2013). It should be noted that the application of bio-energy with carbon capture and storage is even more necessary in later-action scenarios, as well as in 1.5° C scenarios, because they need steeper and deeper cuts after 2020/2030 (Section 3.5).

Negative emissions can be achieved in several ways, including afforestation/reforestation, carbon dioxide storage in combination with direct air capture, and bio-energy in combination with carbon capture and storage (Tavoni and Socolow, 2013). The last option is often applied in model-based studies because of its attractive costs and overall potential. Still, the validity of assuming large-scale bio-energy with carbon capture and storage deployment crucially hinges on two key factors (UNEP, 2012; van Vuuren *et al.*, 2013):

- the technical and social feasibility of large-scale carbon capture and storage, for example, the development of a carbon capture and storage infrastructure; and
- the technical and social feasibility of sustainable large-scale bio-energy production, for example, the development of second-generation bio-energy conversion technologies, such as technologies for producing fuels from woody biomass.

Even if both technologies are technically feasible and socially acceptable, the deployment of bio-energy with carbon capture and storage may have severe sustainability implications, for instance in terms of food-price developments and pressure on water resources. Many factors that may limit the availability of bio-energy are not fully represented in integrated-assessment models (Creutzig *et al*., 2012), and current integrated-assessment model estimates of the total mitigation potential vary greatly, sometimes by a factor of three (Tavoni and Socolow, 2013). Importantly, integrated assessment models also show that stringent climate targets can be achieved without bio-energy with carbon capture and storage (Riahi *et al*., 2012). As noted previously, if scenarios do not rely on this in the future, significantly lower emissions are required in the near term. Conversely, high emissions in the near term lock in the need for negative emissions later (Section 3.6).

Energy efficiency

Energy-efficiency improvements also play a key role in the early phases of mitigation, since they provide relatively rapid returns on investment and require technologies less advanced than low-carbon options (IEA, 2012; Kainuma *et al.,* 2012; van Vuuren *et al.*, 2007). However, as costs of low-carbon technologies gradually decline, and the most cost-effective energy-efficiency improvements are exhausted, further efficiency improvements gradually play a smaller role (Krey *et al.*, 2013). By contrast, although 1.5° C scenarios require the same type of technology options as 2° C scenarios, these might only be sufficient when they are combined with strong and sustained efficiency improvements (Luderer *et al.*, 2013b; Rogelj *et al.,* 2013a; Rogelj *et al.*, 2013b). In general, across all temperature targets and technology options, energy efficiency improvements appear crucial in significantly reducing overall costs. Strong and sustained efficiency improvements can also be a hedge against the risk of other mitigation technology failures, which would preclude achieving stringent temperature targets (Luderer *et al.*, 2013b; Riahi *et al.*, 2013; Rogelj *et al.*, 2013a).

Table 3.3: Overview of later-action scenarios in the literature

Study	Delay until	Near-term climate policies
Model comparison studies		
AMPERE WP2 (Bertram *et al.*, 2013; Eom *et al.*, 2013; Riahi *et al.*, 2013) (9 participating models)	2030	Two higher-than-optimal interim emission targets for 2030.
AMPERE WP3 (Kriegler *et al.*, 2013a) (11 participating models)	2030	Staged accession to international climate agreement.
LIMITS (Kriegler *et al.*, 2013b) (8 participating models)	2020, 2030	Weak and stringent interpretation of Copenhagen (UNFCCC COP15) pledges.
RoSE (Luderer *et al.*, 2013a) (3 participating models)	2020, 2030	Unconditional and lenient Copenhagen (UNFCCC COP15) pledges, and moderate reductions beyond 2020.
EMF-22 (Clarke *et al.*, 2009) (10 participating models)	2050	Staged accession to international climate agreement.
RECIPE (Jakob *et al.*, 2012; Luderer *et al.*, 2012) (3 participating models)	2020	No climate policies or fragmented climate policies with different coalitions as first movers.
Single-model studies		
van Vliet *et al.* (2012)	2020	Copenhagen (UNFCCC COP15) pledges.
OECD (2012)	2020	Copenhagen (UNFCCC COP15) pledges.
Rogelj *et al.* (2013a)	2020	Various higher-than-optimal interim emissions targets for 2020.
Rogelj *et al.* (2013b)	2020, 2030	No climate policies, except for efficiency measures.
Luderer *et al.* (2013b)	2020, 2030	Unconditional and lenient pledges, and moderate reductions beyond 2020.

3.6 The emissions gap: trade-offs and implications of today's policy choices

3.6.1 The emissions gap

We now update the estimate of the emissions gap from previous reports. To do so we draw on the assessment of emission reduction pledges in Chapter 2, and the computed range of emissions from the analysis of least-cost scenarios in Section 3.3. As in previous reports, we define the emissions gap in 2020 as the difference between global emissions from least-cost scenarios that are consistent with the 2° C target and the expected global emissions implied by the pledges. Table 3.4 shows that, depending on the interpretation and implementation of the pledges, this gap ranges from 8–12 $GtCO_2e$ per year in 2020 for having a 'likely' chance of staying below 2° C, and from 6–10 $GtCO_2e$ per year for having a 'medium' chance. As indicated earlier, a large number of least-cost scenarios assume implementation of climate policy from 2010 onwards.

Certain later-action scenarios imply that in some cases current pledges could be compatible with the 2° C target, if a radical shift to stronger emission reductions is assured later – risks and trade-offs are discussed in Section 3.6.3. However, if these emission reductions do not materialize, then the 2020 emissions under the four pledge cases in Chapter 2 (52–56 $GtCO_2e$ per year), will be on a trajectory with a 'likely' chance of limiting warming to 3–4° C, not 2° C (Figure 3.1)[8].

3.6.2 Implications of the gap for achieving least-cost 2020 emission levels

Our assessment shows that there is a gap in 2020 between the emission levels implied by the pledges and the emissions under a least-cost scenario consistent with limiting warming to below 2° C. It is important to note, however, that the least-cost scenarios assume that comprehensive emission reductions begin immediately after the base year, typically 2010[9]. We are now in 2013, and actual emission levels are above most least-cost scenarios, indicating that we have missed an opportunity to lower emissions in the cheapest way possible from the starting year 2010. As time progresses, more and more of the near-term emission reduction opportunities assumed in the least-cost scenarios might be lost, making it increasingly difficult to reach the initial least-cost 2020 emission levels. Some studies indicate it is still possible to close the gap by 2020 (Blok *et al.*, 2012). However, as time passes, this comes with increasingly higher costs than indicated by the least-cost scenarios. The more real-world emissions deviate in the coming years from least-cost pathways, the greater the extra reduction efforts required for closing the gap in 2020[10].

3.6.3 Implications and trade-offs of not closing the gap

If the gap between global emissions from least-cost scenarios and global emissions implied by the pledges is not closed by 2020, then a later-action scenario has, effectively, been assumed for limiting global temperature increase to 1.5° C or 2° C. As noted previously, later-action scenarios are designed to investigate a delay of globally comprehensive reductions of emissions with comparatively lower near-term reductions. A number of recent studies

[8] Both least-cost and later-action scenarios require strong absolute emission reductions throughout the entire century. However, the stringency of emission reductions in least-cost scenarios – for example, in terms of the increase of discounted marginal abatement costs – is spread equally over time, starting from the base year.

[9] Consistent with the first mentioning of a 2° C temperature limit under the Climate Convention (UNFCCC, 2010).

[10] Denotes efforts both in terms of costs and actual reductions.

(Kriegler *et al.*, 2013b; Luderer *et al.*, 2013a; Luderer *et al.*, 2013b; Riahi *et al.*, 2013; Rogelj *et al.*, 2013a; Rogelj *et al.*, 2013b; van Vliet *et al.*, 2012) show that such a choice implies important trade-offs.

On the one hand, later-action scenarios show short-term flexibility – they reduce the mitigation burden and associated costs in the near term, and move emission reduction requirements further into the future. This would give more time to build a global framework of ambitious policies, and for national policy makers to implement commensurate policies and measures. On the other hand, this short-term flexibility comes at the expense of stronger long-term requirements, reduced choices and higher risks of climate policy failure over the long term. Moreover, to meet the 1.5° C target, there is much less flexibility to delay emission reductions in the coming years and mitigation requirements remain very stringent (Luderer *et al.*, 2013b; Rogelj *et al.*, 2013a). As discussed in Box 3.2, any climate change mitigation scenario aiming at limiting warming to no more than 2° C or 1.5° C comes with major societal, economic and technological challenges. Recent studies with explicit focus on interim targets (Kriegler *et al.*, 2013b; Luderer *et al.*, 2013a; Luderer *et al.*, 2013b; Riahi *et al.*, 2013; Rogelj *et al.*, 2013a) indicate that delays or less stringent near-term policies will exacerbate many of these challenges. The key impacts of later-action scenarios, and, by extension, of not closing the emissions gap, are:

Stronger medium-term emission reduction requirements. Higher near-term emissions imply more rapid emission reductions later on to stay within the carbon budget consistent with, for example, the 2° C target.

Lock-in to carbon-intensive and energy-intensive infrastructure. Unless credible, comprehensive and ambitious climate policies are put into place, the world will continue to expand its carbon- and energy-intensive infrastructure, and will not sufficiently incentivize the development and scale-up of climate-friendly technologies. Later-action scenarios delay the installment of such policies.

Reduced societal choices. The more modest the near-term emission reductions, the higher society's dependence on specific technologies, thus foreclosing options and societal choices for the future. In particular, more scenarios depend on negative emissions to achieve the 2° C target.

Higher overall costs and economic challenges. Lower near-term costs in later-action scenarios imply a lower burden on current economic growth but larger overall mitigation costs. They also imply much higher economic challenges during the transition towards a comprehensive climate-policy regime, including substantial impacts on global economic growth and energy prices in the long term.

Higher climate risks. The risk that the world fails in its effort to limit global warming to 2° C or 1.5° C increases strongly with further delays of global action.

Stronger medium-term emission reduction requirements

As discussed in Sections 3.2 and 3.3, limiting global warming to 1.5° C or 2° C implies a tight limit on cumulative greenhouse gas emissions. As a consequence, scenarios with higher emissions in the near term require stronger medium-term mitigation to reach the same global average temperature over the long term. Inevitably, once comprehensive climate policies are finally introduced, emission reduction rates need to be greater than those in scenarios with strong near-term reductions. The AMPERE study found that modest emission reductions until 2030 imply that about 70 percent of the 2010–2100 cumulative carbon-dioxide emissions budget for a medium chance of limiting warming below 2° C target will have been consumed by 2030 (Bertram *et al.*, 2013; Riahi *et al.*, 2013).

Least-cost scenarios that achieve the 2° C target take stringent action immediately to reduce emissions. Their rate of emission reductions over the medium term, 2030-2050, is around 2–4.5 percent per year[11]. Historically, such reductions have been achieved by individual countries (Peters *et al.*, 2013), but not globally.

By contrast, later-action scenarios delay stringent measures to reduce emissions, and consequently the annual rate of medium-term reductions needs to be much higher, around 6–8.5 percent in the case that emission reductions are modest until 2030 (Riahi *et al.*, 2013), to meet the same target. Rogelj *et al*. (2013a) found similar results. Hence limiting the amount of mitigation over the next few years would require twice as fast a reduction in global emissions after 2030. It is important to note that these scenarios do not account for political and societal inertia, which could make such fast and radical emission reductions even more difficult to achieve if the change in policy comes unexpectedly (Riahi *et al.*, 2013). A strong and reliable early policy signal is required in order to reduce emissions now, or have a chance of achieving higher ambition levels in the following decades.

Table 3.4 Assessment of the emissions gap between global emissions implied by the pledges and global emissions from least-cost scenarios consistent with limiting warming below 2° C. The gap range is based on the 20th–80th percentile ranges of both the pledge and the scenario assessments. Values in parentheses are from last year's report (UNEP, 2012).

		BAU	Case 1	Case 2	Case 3	Case 4
What is the expected gap for a 'likely' chance of staying below 2° C?	Median	**15** (14)	**12** (13)	**11** (10)	**10** (11)	**8** (8)
	Range	**9–19**	**7–15**	**6–14**	**5-13**	**3-11**
		(10–19)	(9–16)	(7–14)	(7–15)	(4–11)
What is the expected gap for a 'medium' chance of staying below 2° C?	Median	**13** (12)	**10** (11)	**9** (8)	**8** (9)	**6** (6)
	Range	**8–16**	**6–12**	**5–11**	**4–10**	**2–8**
		(9–16)	(8–13)	(6–11)	(6–12)	(3–8)

[11] Exponential reduction rates were used here.

Lock-in to carbon-intensive and energy-intensive infrastructure

Apart from having higher global emissions in the near term, later-action scenarios also have fewer options for reducing emissions later. This is because of carbon lock-in, that is, the continued construction of high-emission fossil-fuel infrastructure unconstrained by climate policies (Bertram *et al.*, 2013; Luderer *et al.*, 2013a; Rogelj *et al.*, 2013a). As an example, some later-action scenarios in the AMPERE study have a 50 percent larger capacity of coal-fired power plants compared to current levels by 2030 (Bertram *et al.*, 2013). The lack of near-term climate policies in these scenarios is also found to hinder the scaling up of low-emission, green-energy technologies (Eom *et al.*, 2013).

The same lock-in effect applies to lost opportunities for energy efficiency. The Global Energy Assessment (Riahi *et al.*, 2012) shows the critical importance of energy-efficiency measures for limiting warming to below 2° C during the 21st century, and similar findings are valid for returning warming to below 1.5° C (Luderer *et al.*, 2013b; Rogelj *et al.*, 2013a; Rogelj *et al.*, 2013b). Later-action scenarios tend to further lock-in power plants, buildings and other infrastructure with low levels of energy efficiency. This makes the transition to a high-energy-efficiency future more difficult, and creates a greater demand for alternative emission reduction measures.

These lock-in effects can be reduced through an early policy signal as discussed above. For example, if power companies know for sure that stringent reductions will be required over the coming years, they might favour more in low-emissions infrastructure investments.

Reduced societal choices

As stated earlier, later-action scenarios need to compensate for their higher near-term emissions with faster and deeper reductions later. Many later-action scenarios assume that a full portfolio of mitigation options is available, including technologies that are not yet proven on the large scale such as bio-energy combined with carbon capture and storage. When key future mitigation technologies do not become available, costs increase (Kriegler *et al.*, 2013c). This increase was found to be bigger in later-action scenarios than in least-cost scenarios (Luderer *et al.*, 2013b; Riahi *et al.*, 2013; Rogelj *et al.*, 2013a; Rogelj *et al.*, 2013b; van Vliet *et al.*, 2012). If the range of future technological options is constrained, then the later-action scenarios were found to have higher mitigation costs and have a more difficult time complying with temperature targets than the least-cost scenarios. Furthermore, the more emission reductions are delayed, the greater the dependence on future technologies (Luderer *et al.*, 2013b; Riahi *et al.*, 2013; Rogelj *et al.*, 2013a)[12]. In other words, beginning emission reductions early, as is done in the least-cost scenarios, means that policymakers have a greater chance of meeting these temperature targets.

It is not only the availability of specific technologies, that is, an important factor in later-action scenarios, but also the pace at which they can be scaled up. For example, emissions under later-action scenarios have to be reduced very quickly and this requires very rapid decarbonization of the energy system, which in turn puts great pressure on society to rapidly deploy low-carbon technologies[13].

Higher overall costs and economic challenges

Later-action scenarios show that a delay in beginning global comprehensive mitigation action increases the overall costs to reach a climate target (Clarke *et al.*, 2009; Jakob *et al.*, 2012; Kriegler *et al.*, 2013b; Luderer *et al.*, 2013a; Luderer *et al.*, 2013b; OECD, 2012; Riahi *et al.*, 2013; Rogelj *et al.*, 2013b; Rogelj *et al.*, 2013a). The larger the delay, the higher costs. Furthermore later-action scenarios clearly shift the burden of mitigation costs to later generations (Luderer *et al.*, 2013b; OECD, 2012; Rogelj *et al.*, 2013a)[14].

The cost penalty of later action depends on when comprehensive mitigation actions finally begin, the magnitude of emission reductions up to that point, and the future availability of technologies[15].

Later-action scenarios may also have higher economic costs during the transition from modest early actions to comprehensive mitigation actions (Kriegler *et al.*, 2013b; Luderer *et al.*, 2013a; Luderer *et al.*, 2013b). For scenarios meeting the 2° C target, transitional economic costs increase strongly with further delay. For example, beginning comprehensive reductions after 2030, rather than after 2015, causes a three times greater effect of mitigation policies on economic growth in the decade after reductions begin (Luderer *et al.*, 2013b), as in this case very rapid reductions are required beyond 2030 that can only be achieved through adopting high-cost mitigation measures.

Higher climate risks

Although later-action scenarios can reach the same temperature targets as their least-cost counterparts, later-action scenarios pose greater risks of climate impacts for four reasons.

First, delaying action causes more greenhouse gases to build up in the atmosphere, thereby increasing the risk that the carbon emissions budget is exceeded for particular temperature targets. The risk comes from the fact that the steep reductions required later may not materialize.

[12] As an example of technological dependency, it was found that only two out of nine models in the AMPERE study could reach a long-term 450 ppm carbon-dioxide concentration target, and thereby comply with the 2° C target, without scaling up carbon capture and storage (Riahi *et al.*, 2013). A similar dependency is found for other mitigation technologies (Riahi *et al.*, 2013; Rogelj *et al.*, 2013b; Rogelj *et al.*, 2013a).

[13] Eom *et al.* (2013) find that the expansion of both nuclear power and solar photovoltaic (PV) installations in the 2030–2050 period increases by a factor of three when stringent emission reductions are delayed until 2030, as compared to when they are introduced immediately.

[14] For example, Rogelj *et al.* (2013a) found that mitigation costs between 2020 and 2050 could be up to 20 percent higher in scenarios that meet the 2° C target if global emissions in 2020 are 56 $GtCO_2e$ per year instead of 44 $GtCO_2e$ per year. Global carbon reduction prices after 2020 are increased by about a factor of two or more. This translates into an increase of discounted costs between 2020 and 2050 of more than US $7 trillion. Meanwhile, the cost of reducing emissions in the near-term, 2010–2020, was estimated to be about one third of this amount. When estimating cumulative mitigation costs over longer time frames, the medium to long-term economic effects appear to be relatively small because of discounting.

[15] Note, however, that the costs of mitigation in least-cost scenarios can also vary widely depending on the set of mitigation technologies assumed to be available in the future.

[16] For the case of staged accession to a global climate agreement aiming at stabilizing atmospheric greenhouse gas concentrations at 450 ppm carbon-dioxide equivalent, Kriegler *et al.* (2013a) found that the risk of overshooting the 2° C limit might increase from around 30 to around 50 percent even if reluctant nations join later, since late-joiners might not be willing to compensate for their initially higher emissions.

This may happen because key technologies such as carbon capture and storage cannot be scaled up as expected. Equally likely is that future policy makers may be unwilling to take on the higher costs of mitigation[16]. Failure to steeply reduce emissions would cause a higher level of cumulative emissions than initially projected, and this would lead to higher eventual warming and a lower likelihood, or in some cases the impossibility, of staying below temperature targets (Meinshausen *et al.*, 2009). As one example, Luderer *et al*. (2013b) found that delaying comprehensive mitigation actions beyond 2030 increases the achievable lower level of global temperature during the 21st century by about 0.4° C as compared to a scenario with comprehensive reductions starting in 2020, in effect pushing the 2° C target out of reach.

Second, the risk of overshooting climate targets, both concentration and temperature, is higher (den Elzen *et al.*, 2010; Rogelj *et al.,* 2013a; Schaeffer *et al*, 2013a; van Vliet *et al.*, 2012). Later-action scenarios have higher near term emissions than least-cost scenarios and this tends to increase the temporary overshoot of climate targets (Clarke *et al.*, 2009; den Elzen *et al.*, 2010; Kriegler *et al.*, 2013a; Luderer *et al.*, 2013a; Rogelj *et al.*, 2013a; Schaeffer *et al.*, 2013a; van Vliet *et al.*, 2012). Overshooting these targets, or extending the overshoot period, implies a greater risk of large-scale and possibly irreversible changes in the climate system (Lenton *et al.*, 2008). The extent of the risk is very uncertain.

Third, the rate of temperature increase in the near to medium term is higher (den Elzen *et al.*, 2010; Schaeffer *et al.*, 2013a; van Vliet *et al.*, 2012) and this can imply an earlier onset of particular climate impacts and require more rapid adaptation. For example, based on results from 11 integrated-assessment models, Schaeffer *et al.* (2013a) found that later-action scenarios meeting the 2° C target have on average a 50 percent higher rate of decadal temperature increase in the 2040s than least-cost scenarios.

Fourth, when action is delayed, options to achieve stringent levels of climate protection are increasingly lost. All other factors being the same, each year of delay results in the steady loss of options to meet temperature targets with high probability (Luderer *et al.*, 2013b; Rogelj *et al.*, 2013b). Assuming that emission reductions begin in 2010, Rogelj *et al.* (2013b) found that some scenarios have more than a 50 percent chance of limiting warming below 1.5° C. However, if comprehensive mitigation action is delayed until 2020, the probability sinks to 40–50 percent. If delayed until 2030, the probability sinks to 10–20 percent. Also, spending large sums on mitigation, by assuming a carbon price of about US $1 000 per tonne of carbon dioxide, cannot make up for these lost options.

3.6.4 Policy implications of the 2020 emissions gap and later-action scenarios

In Section 3.6.1 and 3.6.2, we have indicated that a large emissions gap continues to exist between least-cost scenarios and the current emission pledges for 2020. The least-cost scenarios assessed in this report assume that climate policies are introduced from 2010 onwards. However, emission reductions in reality have not kept up with the least-cost paths. As a result, it is becoming increasingly difficult to achieve the emission levels in 2020 specified by least cost scenarios. This situation has inspired the research community to look into scenarios that explore the impact of later action. While such scenarios can lessen the necessity for short-term emission reductions they come with many additional costs and challenges. To avoid these costs, it is important to increase near term policy efforts aiming at reducing emissions by 2020, even if they do not reach the level of the least-cost scenarios. Without such efforts, the carbon-emission budgets consistent with keeping temperatures below 1.5° C or 2° C are exhausted rapidly, and mitigation challenges in the future are increased.

Chapter 4

Bridging the gap I: Policies for reducing emissions from agriculture

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4.1 Introduction

Bridging the emissions gap requires a substantial increase in ambition and action, as the previous chapters of this report have illustrated. In 2012, the UNEP Emissions Gap Report (UNEP, 2012) reviewed a number of policies in three sectors – building, transport and forestry – that are proving successful in substantially reducing emissions. In this report we review best-practice policies in agriculture, an often-overlooked emissions-producing sector. The sum of the policies from these different sectors, if replicated and scaled up, shows great potential for narrowing the emissions gap. Moreover, in many cases, these policies can help fulfil important national development objectives beyond climate goals as they can, depending on the policy, boost agricultural productivity, save costs of heating homes, promote eco-tourism, reduce traffic congestion, abate air pollution and associated adverse health effects, or a combination of these.

Here we focus on agriculture because it is among the sectors most affected by climate change, while, at the same time, contributing a significant fraction of the world's greenhouse gas emissions (IPCC, 2007a). Tubiello *et al*. (2013) recently estimated that in 2010 direct emissions from agriculture contributed to 10–12 percent of global greenhouse gas emissions, releasing 5.4–5.8 $GtCO_2e$ into the atmosphere. UNEP (2012) gave a best estimate of 11 percent.

According to Bellarby *et al*. (2008) 38 percent of the emissions can be attributed to nitrous oxide from soils, 32 percent to methane from enteric fermentation in ruminant livestock, 12 percent to biomass burning, 11 percent to rice production and 7 percent to manure management. Direct agricultural emissions, as opposed to indirect ones discussed below, account for 60 percent of global nitrous oxide emissions and 50 percent of global methane emissions (Smith *et al*., 2008).

Globally, 80 percent of deforestation and forest degradation is believed to be related to agriculture (Kissinger *et al*., 2012). A more realistic evaluation of emissions related to agriculture should therefore include the emissions released by the conversion of forests and grasslands into agricultural land and the degradation of peat lands. These emissions can be described as indirect emissions from agriculture and, according to Vermeulen *et al*. (2012), amounted to 2.2–6.6 $GtCO_2e$ in 2008. If agricultural pre- and post-production emissions are also added, the global food system accounts for about 19–29 percent of global greenhouse gas emissions (Vermeulen *et al*., 2012)[1].

Between 1990 and 2005, direct agricultural emissions rose by around 0.6 $GtCO_2e$ per year (IPCC, 2007b), reflecting trends in major drivers such as population growth and rising affluence. These trends are expected to continue although their trajectories largely depend on our choices in natural resource management, food systems and consumer behaviour. Scenarios of continued population growth and consumption suggest that, by 2055, global agricultural methane and nitrous oxide emissions might increase by 57 percent and 71 percent, respectively (Popp *et al*., 2010).

Although current trends predict strong growth of agricultural greenhouse gas emissions, there is significant potential to reduce them in the coming decades, particularly if mitigation options are mainstreamed into agricultural policies and incentives. At marginal costs of less than US $50–100 per tonne of carbon-dioxide equivalent, the direct emission reduction potential of agriculture lies in the range of 1.1–4.3 $GtCO_2e$ per year in 2020 (Chapter 6). About 89 percent of this potential could be realized through improved management practices such as conservation tillage, combined organic/inorganic fertilizer application, adding biochar to the soil, improved water management and reducing flooding and fertilizer use in rice paddies (Smith *et al*., 2008). Emissions could be further reduced by abating emissions in the broader food sector, for example, by reducing food waste and meat consumption.

[1] Emissions originate from the global food system during pre-production (fertilizer manufacture, energy use in animal-feed and pesticide production); during production (direct and indirect emissions from producing crops and livestock); and during post-production (primary and secondary food processing, food storage, packaging and transport, food refrigeration, retail of food products, catering and domestic food management, and the disposal of food waste).

The most promising and cheapest mitigation options in agriculture are those that lead to an increase in productivity and income, while the demand for inputs, land or labour rise at a lower rate. It is, however, necessary to minimize environmental externalities to avoid undermining the long-term provisioning capacity of our agro-ecosystems (Garnett *et al*., 2013; Neufeldt *et al*., 2013). It should also be noted that climate mitigation in agriculture involves more than reducing emissions. It can also mean increasing the uptake of carbon dioxide from the atmosphere by biomass or soil organic matter. Furthermore it can also involve avoiding or displacing emissions, either by substituting fossil fuels with biofuels, or forestalling the conversion of natural vegetation into agricultural lands (Smith *et al*., 2008).

Bringing about change in agricultural management practices, however, for climate or other reasons is not easy. More often than not there are important market- or tenure-related barriers that need to be overcome. Experience also suggests that overcoming these barriers individually is often unsuccessful. It is better that they are addressed in an integrated way, with interventions simultaneously supporting farmers, the governance and market conditions in which they operate, and the science and resources upon which technological change depends. Experience has also shown that the policies successful in overcoming barriers are often the ones that are attuned to local conditions.

In the remainder of this chapter we present examples of concrete agricultural policies that have managed to overcome barriers and have been successful in mitigating climate change while raising income and enhancing food security.

4.2 Conversion of tillage to no-tillage practices

Drivers and benefits of policy change

Conventional plough-based farming developed largely as a means for farmers to control weeds. However, it leaves soils vulnerable to water and wind erosion, increases agricultural runoff, degrades soil productivity and releases greenhouse gases by disturbing soils and burning fossil fuels for farm machinery. No-till practices – sowing seeds directly under the mulch layer from the previous crop – reverse this process by minimizing mechanical soil disturbance, providing permanent soil cover by organic materials and diversifying crop species grown in sequence and/or association (FAO, 2013a).

The financial benefits of no-till practices can be considerable, but depend on the location. Farmers save between 30–40 percent of time, labour and fossil fuel inputs using no-till practices, compared to conventional tillage (FAO, 2001; Lorenzatti, 2006). In Argentina it was found that one litre of fuel was needed to produce 50 kg of grain under conventional tillage, but it could produce 123 kg under no-till practices (Lorenzatti, 2006).

Climate adaptation benefits can also be significant. While Kazakhstan's 2012 drought and high temperatures halved wheat yields overall, wheat grown under no-till practices were more resilient, producing yields three times higher than conventionally cultivated crops (FAO, 2012).

Although no-till practices have only a small effect on reducing methane or nitrous-oxide emissions (Smith *et al*., 2008), a number of studies show the significant potential of no-till cultivation to sequester carbon. The expansion of Brazil's no-tillage system under its National Plan for Low Carbon Agriculture (ABC Plan), for example, may build up an additional 500 kg per hectare and year of soil organic carbon, offsetting a total of 16–20 $MtCO_2e$ by 2020, equivalent to 1.6–2.0 $MtCO_2e$ per year. Kenya anticipates an increase in carbon uptake of 1.1 $MtCO_2e$ by 2030, equivalent to 0.04 $MtCO_2e$ per year, from no-till farming activities under its Climate Change Action Plan (Stiebert *et al*., 2012). In China, no-till farming may sequester a total of 2.27 $MtCO_2e$ of soil carbon by 2015, equivalent to 0.5 $MtCO_2e$ per year (Cheng *et al*., 2013a). These are all estimates of the potential to mitigate greenhouse gas emissions; estimates of what has already been achieved are given in the next section.

Policies that work

Governments have traditionally encouraged no-till practices as a measure to curtail soil erosion, and have only recently begun to promote it as a way to mitigate greenhouse gas emissions. However, farmers face difficult challenges during the transition to no-till practices related to high investment costs for machinery, increased dependence on such herbicides as glyphosate, changes in production inputs, and differences in crop and cover-crop management[2]. Thus, support is required for farmers during the transition.

In 2011 Brazil established its ABC Plan, the first national policy promoting no-till cultivation, which includes state-level activities, based upon local and sub-national government plans[3]. It sets implementation goals, anticipating that adoption of no-till practices increase from 31 million hectares to 39 million hectares under the plan. Farmers have access to ABC Plan credit and finance as well as training and extension services if management practices are compliant with the approach.

The adoption of no-till practices in Brazil was brought about by many factors: new knowledge on no-till systems stemming from research by the Brazilian Agricultural Research Corporation; support from farmer associations such as the Brazilian Federation of Direct Planting and Irrigation; backing from agricultural machinery companies who recognize the potential benefits from promoting the technology and expanding their markets; and recognition by farmers that no-till practices bring increased land productivity and reduced production costs (Casão Junior *et al*., 2012).

Between 1982 and 1997 overall cropland erosion dropped by more than a third in the USA, where policy interventions to promote no-till practices on highly erodible land contributed up to 62 percent of the overall reductions (Claassen, 2012)[4]. Classifying soils as highly erodible made it easier to target

[2] To combat weeds, farmers may resort to an over-use of glyphosate or may rely on genetically modified crops, notably corn or soy. Alternatives are available, but support for farmers is required if those alternatives are to be introduced.

[3] Brazil's ABC Plan also includes: species diversification through rotation of crops, succession or combination of crops in a variety of production systems; permanent soil cover, either as mulch or perennial species; organic matter of sufficient quality and according to the soil's biological demand; and further conservation agriculture practices, depending on the location.

[4] From 3.1 billion tonnes of soil in 1982 to 1.9 billion tonnes in 1997.

specific areas for conversion to no-till cultivation, enabled by financial support from the United States Department of Agriculture. To get this support, farmers on highly erodible lands, approximately 25 percent of all USA cropland, had to devise and have approved a soil conservation plan. As a result, in 2009, 35 percent of USA cropland, mostly producing soy, was under no- or reduced-tillage, although often not permanently, which reduces its effectiveness to sequester carbon.

No-till agriculture increased in Australia from 9 percent of cropland in 1990 to 74 percent in 2010 (Llewellyn and D'Emden, 2010), particularly in grain producing areas. Awareness of soil erosion problems, region-specific information and learning opportunities for farmers, and declines in the price of glyphosphate, all contributed to the adoption of no-till practices (D'Emden, *et al*., 2006; Llewellyn and D'Emden, 2010). Australia's Landcare Programme, a community-based approach to land management, which is now made up of 6 000 farmer groups across the country, has played a key role in information dissemination and technical support (Department of Agriculture, 2013). The programme provides a refundable tax offset, financed by carbon-tax revenues, of 15 percent of the purchase price of an eligible no-till seeder to participating farmers. More recently, Australia has recognised the greenhouse gas reduction potential of no-till practices by including them in its Carbon Farming Futures programme – part of Australia's Clean Energy Future Plan, and central to the cropland management component of Australia's national greenhouse gas-reduction target.

Chinese interventions to increase the use of no-till practices have aimed to reduce soil erosion, treat crop residue, and eliminate their post-harvest burning.[5] Up to now, reducing greenhouse gas emissions has not been a factor. As in much of Asia, smaller farm sizes restricted adoption of no-till practices. In addition, crop residues were commonly used for alternative purposes, such as feed for livestock (Lindwall and Sontag, 2010). China hopes to expand no-till practices to 13.3 million hectares by 2015 (Ministry of Agriculture, 2009), especially by providing subsidies to farmers (Zhao, *et al*., 2012).

No-till practices have spread across diverse soil types and agricultural production systems around the world over the last 30 years. The MERCOSUR countries of Argentina, Brazil, Paraguay and Uruguay have the highest rates of no-till cultivation, covering 70 percent of total cultivated area, two-thirds of which are under permanent no-till schemes, resulting in significantly increased soil carbon storage (Derpsch *et al*., 2010). Table 4.1 shows the cumulative mitigation benefits of up to 240 $MtCO_2e$ of avoided emissions in selected countries based on annual greenhouse gas mitigation rates in different climatic zones as provided in Smith *et al.* (2008) and best-available information on the coverage of no-till cultivated areas[6].

Table 4.1 Greenhouse gas mitigation through no-till cultivation, selected countries.

Country	Climate zone	Base year	Area under no-tillage in 2007/8	Best estimate cumulative avoided greenhouse gas emissions by replacing till- with no-till cultivation (between indicated base year and 2007/8)
Unit			*(million hectares)*	*($MtCO_2e$)*
Notes	*(a)*	*(b)*	*(c)*	*(d)*
Australia *(e)*	warm-dry	1976	17	95.2
Argentina	warm-moist	1993	19.7	109.4
Bolivia	warm-moist	1996	0.7	3.1
Brazil	warm-moist	1992	25.5	145.7
Canada	cool-moist	1985	13.5	82.3
China[(f)]	cool-dry	2000	2	1.6
Kazakhstan	cool-dry	2006	1.2	0.2
New Zealand	cool-moist	1993	0.16	0.7
Uruguay	warm-moist	1999	0.66	2.0
USA	cool-moist	1974	26.5	241.3

Notes:
(a) Considering the lack of information on where no-till cultivation is being practiced, we assume one climate zone throughout the country, considering, where possible, the regional distribution of no-till agriculture.
(b) The base year is the estimated year in which the area of no-till cultivation began significantly expanding from a small baseline value in the country. The base year was estimated by linearly extending adoption rates from Derpsch *et al.* (2010), unless otherwise stated.
(c) From Derpsch *et al.* (2010), unless otherwise stated.
(d) Mitigation here refers mostly to avoided carbon dioxide emissions, with a small amount of avoided nitrous oxide emissions. Mitigation estimates on a per hectare basis are from Smith *et al.* (2008). These were multiplied by the area covered by no-till cultivation to obtain a value for total avoided emissions in Mt per year in the country for a particular year. To obtain the cumulative emissions in column 5, the annual emissions were summed for each year from 2007/8 back to the base year (in column 3). To compute the area covered by no-till cultivation in each year, it was assumed that the area covered decreased linearly from 2007/8 back to the base year (in column 3). In countries with long histories of no-till agriculture this probably led to an underestimate of the mitigation that was achieved. However, if the use of no-till cultivation began very slowly, then it is also possible that cumulative avoided emissions were overestimated.
(e) The 2007/8 estimate is derived from Derpsch *et al.* (2010) whereas the base year was established from Llewellyn and D'Emden (2010).
(f) The area stated for China is derived from Liu and Qingdong (2007) and Ministry of Agriculture (2009).

[5] Refers to materials left in the field after harvest, such as straw, which can act as mulch if retained until the next crop.
[6] These best estimates have a wide uncertainty range caused by the variation in conditions under which measurements were made, among other factors.

4.3 Improved nutrient and water management in rice systems

Drivers and benefits of policy change

Rice cultivation contributes more than 25 percent of global anthropogenic methane emissions but there are good options for reducing these emissions. Here we focus on three innovative and promising cropping practices that not only reduce methane emissions but also greatly improve the management of water and nutrients in rice cultivation – alternate wetting and drying (AWD), the system of rice intensification, and urea deep placement (UDP).

Alternate wetting and drying is a water management practice for irrigated rice fields through which farmers can achieve 5–30 percent water savings, lower labour costs, no significant yield penalty and profit increases of up to 8 percent (IRRI, 2013). Where it has been used on farms in Bangladesh, yields have risen by more than 10 percent, raising income by US $67–97 per hectare (IRRI, 2013). In Rwanda and Senegal, rice yield increased from 2–3 tonnes per hectare to 6–8 tonnes per hectare due to the similar system of rice intensification (Baldé, 2013; Cissé, 2013).

Another option for reducing emissions, urea deep placement, consists of inserting urea granules into the rice root zone after transplanting. It is reported to reduce fertilizer use by 35 percent while increasing crop yields by about 20 percent (IFDC, 2012). In Nigeria, for example, farmers were able to harvest 2.69 tonnes more rice per hectare using this technology than when broadcasting urea (IFDC, 2012)[7].

Although the emission reduction potentials of these nutrient and water conserving techniques are in principle very high, actual reduction figures are sparse. Adoption of alternate wetting and drying has been shown to reduce the emissions of methane by 40 percent per year on China's rice paddies, compared to continuously flooded rice production (Li *et al*., 2005). With urea deep placement, large fertilizer users such as China and India could achieve nitrogen fertilizer savings of up to 6.43 Mt and 2.89 Mt per year, respectively (Sutton *et al.*, 2013). At the same time, nitrous oxide emissions would be reduced because of lower leaching and denitrification. In China, for instance, a mitigation potential of 0.08 to 0.36 tCO_2e per tonne of grain yield is possible by reducing nitrogen chemical fertilizer rates along with intermittent flooding in paddy rice cropping systems (Cheng *et al.,* 2013b).

Policies that work

There are many examples of success in adopting alternate wetting and drying, the system of rice intensification and urea deep placement across the world. Governments have helped in many cases by providing the necessary incentives and support.

In Bangladesh, government support and policies, as well as targeted public-private partnerships and research, have led to high adoption rates of both alternate wetting and drying and urea deep placement. As an example of government support, alternate wetting and drying was introduced into the draft of the first National Irrigation Policy of Bangladesh. A key incentive turned out to be the government's support for appropriate irrigation pipes or the adaptation of existing pipes (Kürschner *et al*., 2010). The International Rice Research Institute and the Bangladesh Rice Research Institute played key roles in mainstreaming the technique by raising awareness of its benefits and providing technical guidance. The use of TV, radio and newspapers also played an important role in the awareness raising process (Kürschner *et al*., 2010) – to date more than 100 000 farmers have adopted alternate wetting and drying practices (IRRI, 2012).

As a promoter of the fertilizer deep placement technology, the International Fertilizer Development Center took a leadership role in introducing urea deep placement to Bangladesh in the mid-1980s. Among other actions, the Centre organized demonstrations of urea deep placement techniques. By 2012 more than 2.5 million Bangladeshi farmers were using the technology, and it was expected to be adopted by an additional 1 million farmers across the country (IFDC, 2013).

Alternate wetting and drying and the system of rice intensification (a technique similar to alternate wetting and drying) have also been introduced very successfully to other parts of Asia. According to Uphoff (2012) more than 1 million Vietnamese farmers had adopted the system of rice intensification by 2011; in the Philippines, more than 100 000 farmers had begun using alternate wetting and drying by 2012, and it is expected that 600 000 farmers will have adopted this technology by 2015 (Rejesus *et al*., 2013; IRRI, 2013).

In Africa, the government of Madagascar supported the diffusion of the system of rice intensification by providing access to microcredit services, particularly in areas with weak coverage by microfinance institutions. The government facilitated the acquisition of farm equipment by liaising with microcredit institutions and by offering incentives to the private sector in production areas (Ministry of Agriculture, 2008). These credits also promoted knowledge and information sharing and thereby helped scale up the technology.

As women play a prominent role in rice production in Madagascar, the government also relied extensively on women's networks to promote the system of rice intensification. Priority was given to providing women with training in how the system is practiced. Some rural communities relaxed current restrictions on women's access to land and agricultural equipment, suggesting that women, through government support, have significantly contributed to the increase in usage of the system[8]. The technique is also being used on a small scale, but with increasing interest, in several other African countries, including Benin, Cameroon and Senegal (Agridape, 2013)[9].

As a general lesson, emissions of greenhouse gases from rice cultivation can be substantially reduced through efficient management of fertilizer and water. Here we have

[7] Broadcasting refers to a uniform distribution of fertilizer on the soil surface. It differs from deep placement in the sense that it requires more fertilizer and also increases leaching and run-off of nitrogen, especially during the rainy season.

[8] In many African locations women do not have land ownership rights.

[9] The governments of Rwanda and Senegal have helped introduce the system of rice intensification by providing credits to rice cooperatives and through knowledge and information sharing (Cissé, 2013).

Figure 4.1 **Mature *Faidherbia albida* between maize in Tanzania. One of the characteristics of the species is its reverse phenology: the tree sheds its leaves in the rainy season and goes dormant, reducing competition for light and water while providing valuable nitrogen-rich litter that is also good fodder. (Copyright: ICRAF).**

talked about three innovative and promising approaches – alternate wetting and drying, urea deep placement and the system of rice intensification. Several steps could be taken to quickly scale up of these useful practices. First, they could be included in national agricultural policies. Second, direct financial support could be provided to farmers. Third, it would be very helpful to coordinate the support coming from the private sector and from organizations involved in research and agricultural extension training. Finally, direct support to women involved in rice cultivation would be very effective in scaling up these practices.

4.4 Agroforestry

Drivers and benefits of policy change

Agroforestry refers to a land management approach involving the simultaneous cultivation of farm crops and trees. In addition to sequestering carbon in the tree biomass, agroforestry generally improves microclimate and water balance, reduces erosion and raises soil fertility, among other ecosystem services. It leads, therefore, to higher crop and livestock productivity and, hence, income (Garrity *et al.*, 2006; Schoeneberger *et al.*, 2012). For instance, Haglund *et al*. (2011) reported 18–24 percent higher household incomes following the introduction in Niger of a variant of agroforestry called 'farmer managed natural regeneration'. Garrity *et al*. (2010) summarized experiences with maize grown in association with a tree called *Faidherbia albida* in several African countries, reporting yield increases of 6–200 percent, depending on the age of the trees (Figure 4.1). In temperate mechanized agroforestry systems, Dupraz and Talbot (2012) have shown land equivalent ratios reaching 1.2–1.6, suggesting that planting trees and crops together is more efficient than when the two are planted separately[10].

Through diversification of income from fuel, fodder, fruit, timber, and the reduction of labour for firewood collection and the generally strong resilience of trees to climate variability, agroforestry has also shown to provide greater food security under climate shocks than conventional farming (Thorlakson and Neufeldt, 2012).

The mitigation potential of agroforestry systems is theoretically very high, but strongly dependent on the agro-ecosystem, the species being planted, and on the specific type of agroforestry practice. One estimate is that it could potentially mitigate 2.2 $GtCO_2e$ per year (Verchot *et al.*, 2007). This large figure stems from the fact that agroforestry has the possibility of being applied to 630 million hectares worldwide (Verchot *et al.*, 2007).

The amount of carbon sequestered in agroforestry systems typically ranges from 1.06 tCO_2 per hectare per year to 55.77 tCO_2 per hectare per year for biomass carbon (Nair *et al.*, 2009) and from 0.17 tCO_2e per hectare per year to 1.89 tCO_2e per hectare per year for soil carbon (Smith *et al.*, 2008). Recently Aertsens *et al*. (2013) estimated that agroforestry could provide 90 percent of the potential of agriculture in Europe to take up additional carbon dioxide from the atmosphere[11].

Policies that work

Despite agroforestry's high potential for increasing welfare and providing environmental services, there may be significant opportunity costs associated with establishing such systems and long time-lags before they generate returns (FAO, 2013b). Particularly in smallholder farming, the barriers include lack of access to farm inputs, capital, markets and training; uncertain land tenure situations; weak institutions and governance structures; and poor seed and seedling provisioning systems (Thorlakson and Neufeldt, 2012). Policies are needed to overcome these barriers.

[10] A land equivalent ratio of 1 suggests that planting crops and trees together requires just as much land as planting them separately. A ratio greater than 1 indicates that it requires less land to produce the same amount of crops and trees.

[11] The total technical potential in the EU-27 is estimated to be 1 566 $MtCO_2e$ per year, corresponding to 37 percent of all carbon dioxide equivalent emissions in the EU in 2007. The introduction of agroforestry is the measure with the highest potential – 90 percent of the total potential of the measures studied (Aertsens *et al.*, 2013).

Niger is one example of a country where these barriers have been overcome. Here, a combination of declining traditional governance structures in the 1920s and 1930s and severe droughts and famines in the 1970s and 1980s resulted in the overuse of common lands, which led in turn to a shrinking of natural tree cover by about 90 percent (Sendzemir *et al*., 2011). Reforestation began in earnest in the 1980s when the practice of 'farmer managed natural regeneration', introduced by several non-governmental organizations, was adopted on a large scale because of a change in government policies regarding the use and felling of parkland tree species (Reij *et al*., 2009). While farmers had previously ripped out germinating trees because they had no claim to ownership over the trees' products and services, they now let them grow selectively. Within two decades this combination of non-governmental and governmental support led to a re-greening of about 5 million hectares of nearly barren bush savanna (Reij *et al*., 2009).

Another example is Kenya, where the government has adopted policies to promote farm forestry[12]. Key actions include the relaxation of restrictions on harvesting and marketing of tree products, tax incentives for growing trees on farms, and the creation of contract farming schemes to enhance trading of tree products between landholders and companies[13]. Wangari Mathai's Green Belt Movement has also been instrumental in raising awareness about the importance of trees and for mobilizing thousands of women to plant millions of trees. In western and central Kenya this mix of regulation and incentives has resulted in a 215 000 hectares expansion of agroforestry over the last 30 years (Norton-Griffiths, 2013). Other national policies have promoted tree planting on Kenyan farms (Ajayi and Place, 2012) by supporting the training of extension service staff, establishing tree nurseries countrywide and prohibiting the harvesting of trees from public forests[14].

In northern India, beginning in the late 1970s, poplar trees have been rapidly added to irrigated wheat and barley farms and now cover about 280 000 hectares – or 10 percent of irrigated agricultural lands in this region. Poplars provide timber and other benefits to farmers and barely compete with crops for light and water. Meanwhile, the Forest Conservation Amendment Act of 1988 prohibited cutting timber from state forests, and this increased the price of wood and created an economic incentive to plant trees on farms (Ajayi and Place, 2012). Agroforestry was further encouraged through credits for tree planting from the National Bank for Agriculture and Rural Development and through support provided by the timber industry in the form of higher quality planting material, such as seeds, fruit or aggregate fruit; training in agroforestry; and guaranteed timber prices.

In Europe and North America, agroforestry is mainly promoted for the ecosystem services it provides (Dupraz and Liagre, 2008; Current *et al*., 2009; Jacobson, 2012; Schoeneberger *et al*., 2012). Yet, despite its long-term economic benefits, agroforestry has not achieved its potential in Europe because of high investment costs and the perceived complexity of introducing annual and perennial plantings into high-input, mechanized agriculture (Papanastasis and Mantzanas, 2012). To encourage the expansion of agroforestry, the European Agroforestry Federation has recently called for reforms of the European Common Agricultural Policy, including greater financial support to farmers and more flexible eligibility rules (EURAF, 2013).

4.5 Lessons learned

To mitigate greenhouse gas emissions effectively while achieving development goals in the agriculture sector, the following factors should be considered:

- **Agricultural mitigation options require a coordinated mix of policy support, private and public sector investment, strengthened research, and capacity building of key stakeholders.** Specific actions are needed to demonstrate the benefits of new technologies to farmers, to coordinate needed investments and to disseminate information about benefits and how to overcome barriers. These actions can be supported by public-private partnerships and by research centres, governments, agricultural extension services, the private sector and non-governmental organizations.
- **Multiple benefits require multiple goals.** At the early policy-development stage it makes sense to articulate a number of environmental, social and other goals rather than one objective alone. This makes it easier to identify synergies between different goals rather than having to resolve trade-offs between them. Multiple goals can lead to multiple benefits of climate change mitigation, improved agricultural productivity and enhanced food security.
- **Financial incentives are needed.** A major barrier to the adoption of emission reduction measures has been the lack of financial incentives for farmers to adopt new technologies and practices. Financial incentives, including tax offsets, subsidies, and credits, are needed to help farmers in both developing and developed countries defray high up-front investment costs. Incentives are also needed because no-till and agroforestry practices can have a several year time-lag before their climate and other benefits are realized. Subsidies and microcredit may be particularly important for poor rice farmers who usually lack access to capital and credit.
- **In order to be successful in mitigating emissions, new technologies must be context-specific to the region or country where they are introduced.** For example, for no-till practices to be successful they must take into account local farm size, crop and soil types, carbon/nitrogen ratio over the crop rotation. Context specific research at landscape scale, as well as learning from past mistakes, is important for making each mitigation option work. In addition, land tenure issues have to be resolved before the needed investments and changes in new agricultural practices can be made.

[12] Through the Economic Recovery Strategy (Ministry of Planning and National Development, 2003), the Forest Act (Ministry of Water and Irrigation, 2005) and the Draft Forest Policy (Ministry of Enviroment and Natural Resources, 2007).

[13] Contract farming is agricultural production carried out according to an agreement between a buyer and farmers, which establishes conditions for the production and marketing of a farm product or products (FAO, Rome, 2008).

[14] The Forest Policy (Goverment of Kenya, 1968) and the Rural Afforestation and Extension Services Division, set up in 1971.

Chapter 5

Bridging the gap II: International cooperative initiatives

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5.1 Introduction

There are many initiatives underway outside of the Climate Convention aimed at reducing emissions of greenhouse gases by promoting actions that are less greenhouse gas intensive. We refer to these initiatives collectively as international cooperative initiatives[1]. These initiatives complement and support pledges and other actions under UNFCCC in a number of different ways: some focus on assisting countries to meet a variety of goals and have climate change mitigation as an ancillary benefit, while for others the central objective is reducing emissions of greenhouse gases for climate purposes.

This chapter pays particular attention to those initiatives that can support meeting and exceeding current pledges and help narrow the emissions gap. Specifically, this would include international cooperative initiatives that provide emission reductions that are likely to be additional to those stemming from national emission reduction pledges and actions.

The chapter first provides an overview of the different initiatives, including a categorization by type. Appendix 5.A complements this information by giving a sample of the many international cooperative initiatives currently active. It then identifies where large potential exists to close the gap and finishes with a set of possible criteria for designing initiatives that could be most effective in closing the emissions gap.

5.2 Current international cooperative initiatives

A categorization of existing initiatives reveals that the topics covered, actors involved and participation levels vary greatly across them. The reader is referred to Appendix 5.A for an overview of initiatives (note that the overview is illustrative and not comprehensive).

Initiatives underway can be put into three categories:

1. **Global dialogues**. These initiatives provide a forum for national governments to exchange information and understand national priorities. Some are primarily at the head-of-government level, such as the G8 and the G20; others at the ministerial level, such as the Major Economies Forum. Some include industry, academia, and/or civil society. These groups may issue statements of intent or voluntary commitments and otherwise contribute to consensus building.
2. **Formal multilateral processes.** A number of international organizations and formal international negotiation processes are addressing issues that are relevant to the reduction of greenhouse gas emissions. These include international treaties such as the Montreal Protocol on Substances that Deplete the Ozone Layer or sector specific organizations such as the International Civil Aviation Organization or the International Maritime Organization. These international cooperative initiatives can produce binding international agreements to reduce emissions.
3. **Implementation initiatives**. There are many initiatives that focus on enabling countries to meet their pledges through sharing good practices and technical knowledge. Some concentrate on **technical dialogues**, including for instance the Mitigation and MRV Partnership, or the Clean Energy Ministerial. The more technical the discussion, the more non-governmental actors are often involved. Other initiatives go beyond dialogue to support **sector-specific initiatives** through the collective implementation and, in many cases, funding of programmes or projects. This may include the facilitation of clean energy projects, for example, through the Renewable Energy and Energy Efficiency Partnership, the development of sector-specific action plans such as those developed under the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, or the implementation of programmes

[1] In this chapter we assume that international cooperative initiatives are initiatives with participants from at least three countries. These could be governmental entities from the national, sub-national or local level and/or non-state actors, including businesses and NGOs.

to reduce emissions from deforestation and forest degradation such as the REDD+ Partnership. Some of these sector-specific implementation groups are independent of national governments.

To assess the extent to which international cooperative initiatives can help bridge the emissions gap, it is necessary to differentiate between the type of contribution each initiative makes – direct or indirect. Global dialogues and many of the implementation initiatives focus on building consensus and sharing best practices, making an important – but indirect – contribution to narrowing the gap. Other initiatives lead to direct greenhouse gas reductions. To the extent that they cover sectors and countries currently outside of the pledges, or support countries to reduce emissions beyond these pledges, they make a direct contribution to narrowing the gap. The remainder of this chapter focuses on initiatives that may lead to direct reductions, particularly in those areas that represent high mitigation potential.

5.3 Promising areas for international cooperative initiatives to close the gap

Three studies (Blok *et al.,* 2012; IEA, 2013; UNFCCC, 2013) have identified promising mitigation measures and areas to narrow the gap (Table 5.1). Criteria used to identify these promising areas across the studies include:

- a minimum level of already-started activity;
- an organization that can take the lead in scaling up activities;
- a positive or neutral impact on the economy;
- a minimum level of mitigation potential, of size or critical mass of participants.

The above three studies highlighted four priority mitigation measures in particular:

- energy efficiency;
- fossil fuel subsidy reform;
- methane and other short-lived climate pollutants; and
- renewable energy.

Table 5.1 Promising areas for international cooperative initiatives and three estimates of associated reduction potential

Mitigation measures and areas		Reduction Potential			Initiatives
		Wedging the gap (Blok *et al.,* 2012) $GtCO_2e$ per year in 2020	**UNFCCC technical paper (UNFCCC, 2013)** $GtCO_2e$ per year in 2020	**IEA energy/ climate map (IEA, 2013)** $GtCO_2e$ per year in 2020	**Approximate number**
Energy efficiency	Buildings' heating and cooling	0.6	2	0.5	25
	Ban of incandescent lamps	0.5		0.5	
	Electric appliances	0.6			
	Industrial motor systems			0.4	
	Car- and truck-emission reduction	0.7		0.2	
Renewable energy	Boost solar photovoltaic energy	1.4	1–2.5		17
	Boost wind energy	1.2			
	Access energy through low- emission options	0.4			
Limiting inefficient coal use in electricity generation				0.7	None
Methane and other short-lived climate pollutants	Reducing methane emissions from fossil-fuel production	*	1.1	0.6	7
	Other methane and other short-lived climate pollutants				
	Efficient cook stoves	*			
Fluorinated greenhouse gases		0.3	0.5		3
Fossil-fuel subsidy reform		0.9	1.5–2	0.4	1
International transport		0.2	0.3–0.5		4
Agriculture		0.8	1.3–4.2		1
Reduce deforestation		1.8	1.1–4.3		15
Waste			0.8		1
Reduce emissions from companies	Top-1 000 company emission reduction	0.7			4
	Supply chain emission reduction	0.2			1
	Green financial institutions	0.4			1
	Voluntary offset companies	2.0			None
Voluntary offsets by consumers		1.6			None
Major cities initiative		0.7			3
Sub-national governments		0.6			2
Total		9.7**	Not added because of ranges	3.3 ***	

*not estimated, **accounting for overlaps, *** total does not add up because of roundings
Notes: The reduction potential is not strictly comparable. The UNFCCC technical paper (UNFCCC, 2013) presents mitigation potentials for entire sectors. Blok *et al.* (2012) estimate the potential of an initiative assuming that it can realize only a fraction of the theoretical potential. IEA (2013) reports model estimates. The numbers of initiatives are approximations based on the annex, which includes only a selection of initiatives.

Fluorinated greenhouse gases and international transport are also frequently listed as priority areas. In addition, the International Energy Agency (IEA) highlights the large short-term potential of limiting inefficient coal use in electricity generation, an area that is currently not covered by any international cooperative initiatives. On the other hand, other areas are covered by more than one initiative, for example, reducing emissions from deforestation.

To date there have been very few quantitative assessments of the impact of cooperative initiatives. Some studies analyze the past and possible future impact of individual initiatives, notably studies on the Sustainable Energy for All Initiative (Rogelj *et al.* 2013), the WWF Climate Savers Programme (Ecofys, 2012), the Covenant of Mayors (Cerutti *et al.*, 2013), and the phase out of hydrofluorocarbons (Hare *et al.*, 2013; Molina *et al.*, 2009; UNEP, 2011; Velders *et al.,* 2009; Velders *et al.*, 2012; Xu *et al.,* 2013; Zaelke *et al.,* 2012). No study was found on the aggregate past impacts of cooperative initiatives.

Only a few initiatives are clearly outside the scope of national pledges, namely those on international aviation and shipping, and those on short-lived climate pollutants, or initiatives on non-carbon dioxide gases for those countries whose pledges only apply to carbon dioxide emissions. All other initiatives potentially overlap with national pledges and, because of this, it is not yet possible to assess the volume of reductions expected from these initiatives alone.

The overview of initiatives in Appendix 5.A illustrates the diversity found in both approach and membership, as well as the overlap found in some priority mitigation measures. An element of coordination or integration among overlapping initiatives would likely strengthen their collective effectiveness.

Finally, participation in the initiatives, especially for developing countries, is constrained by various factors. One is the limited amount of time and capacity available for participation. Another is limited expertise in the subject areas of the initiatives. These factors raise concerns about the credibility and legitimacy of some initiatives. This would argue for fewer, but more effective and ambitious initiatives. Some have proposed that a coalition of initiatives could be helpful (Blok *et al.,* 2012).

5.4 How to make international cooperative initiatives effective in closing the gap?

Few studies have been conducted on the effectiveness of initiatives (Bausch and Mehling, 2011; Weischer *et al.,* 2012; Young, 2011). Nevertheless, based on the small amount of experience gained up to now, we speculate that five aspects are particularly important: focus and goals; participation; funding and institutions; incentives and benefits; and transparency and accountability.

Focus and goals

It has been argued that some international cooperative initiatives might be "*specialized venues [that] could each address a small piece of the puzzle that the UNFCCC could not tackle as a whole*" (Moncel and van Asselt, 2012). As an example, the Consumer Goods Forum, a global industry network of over 400 retailers, agreed to begin phasing out hydrofluorocarbon refrigerants by 2015, and work to achieve zero net deforestation by 2020. Following this model, international cooperative initiatives could be effective by having a sharp focus on a limited number of ambitious goals.

Participation

Some authors argue that limiting the number of participants is an important factor for effectiveness. Smaller groups are able to act faster (Biermann *et al.,* 2009) and can be expected to be 'narrow-but-deep', reaching substantial policy goals that would not have been reached in a 'broad-but-shallow' regime that has more participants but less ambition due to the compulsions of placating all signatories (Aldy *et al.,* 2003). On the other hand, the contribution to closing the gap will be larger if all major current and future emitters participate, which might argue for a slightly larger group (Bausch and Mehling, 2011).

In the field of renewable energy, we find all models. The recently launched German initiative for a renewables club brings together a small group of ministers from 10 countries considered to be leaders. Meanwhile, the Clean Energy Ministerial encompasses a larger group of 23 countries accounting for 80 percent of global greenhouse gas emissions, and the International Renewable Energy Agency has almost universal participation, with 114 member states, plus 46 in accession. No assessment has been made on the effectiveness of these different models, but it is likely that the right group size depends on an initiative's mandate.

Participation of stakeholders, beyond the government representatives that traditionally conduct climate negotiations, is another factor that might enhance effectiveness. International cooperative initiatives might help bring in constituencies that have so far not been active in climate change issues, but could make essential contributions to solving the problem (Moncel and van Asselt, 2012). This can include government agencies that deal with related issues such as energy or security, as well as business and civil society. Two examples of multi-stakeholder partnerships bringing together governments, industry representatives, non-governmental organizations and researchers are the Renewable Energy Partnership for the 21st century (REN21) and the Climate and Clean Air Coalition to reduce Short-lived Climate Pollutants.

Another important aspect of participation is whether high-level participation, for example from ministers or heads of government, might lead to a stronger political buy-in and thus make an international cooperative initiative more effective in closing the gap. To facilitate implementation of their programmes, it might be useful for such initiatives to include not only high-level dialogues, but also mechanisms for working-level cooperation. For example, the Clean Energy Ministerial and the Climate and Clean Air Coalition both incorporate meetings of ministers with meetings of working groups consisting of experts who work on implementation.

Funding and institutions

The design of international cooperative initiatives has to strike a difficult balance between providing the necessary institutional framework for meaningful cooperation yet avoiding too bureaucratic an operation. An appropriate set-up might include a secretariat, clear procedures and

sufficient resources (Bausch and Mehling, 2011). Conversely, avoiding bureaucracy means fewer formalities, allowing for more flexibility and pragmatic action. For example, the G8 and G20 presidencies rotate from year to year and have no permanent secretariat, which makes systematic implementation and follow-up difficult, whereas the International Energy Agency's Implementing Agreements have a secretariat, a dedicated budget and the capacity to implement their own projects.

Incentives and benefits

If international cooperative initiatives are to catalyse significant additional emission reductions, they need to offer compelling reasons for potential participants to join. These incentives would predominantly be economic benefits that need to be significant, equitably distributed among participants and, at least to a certain extent, exclusive to the participants (Weischer *et al.,* 2012). One example of benefits is the technical and policy support provided by the Collaborative Labelling and Appliance Standards Program to governments working on energy efficiency standards and labels. Other examples are the two separate, complementary funding mechanisms provided by the Forest Carbon Partnership Facility.

Transparency and accountability

In order to determine whether an international cooperative initiative is making a contribution to closing the emissions gap, its activities and their emissions impact need to be transparent. Enhancing transparency and accountability might also make initiatives more effective, as it represents an incentive to follow through on commitments and provide participants with confidence that others are acting as well (Bausch and Mehling, 2011). This might, for instance, include regular reporting or peer-review procedures. A good example is the Covenant of Mayors initiative, which developed detailed monitoring requirements for its actions, regular reporting by participants, and the independent verification of results.

5.5 Links with the United Nations Framework Convention on Climate Change

At present, there are no formal links between UNFCCC and the various international cooperative initiatives. Nevertheless, within the Convention's *Ad Hoc* Working Group on the Durban Platform there is an on-going discussion about what role initiatives could play in helping to close the 2020 emissions gap. Whether and how to account within the convention for the emission reductions achieved by international cooperative initiatives is a key part of the discussion. Parties could, in principle, do this through existing reporting practices and rules, or through a purpose-made methodology to account specifically for reductions attributable to international cooperative initiatives. Irrespective of the form it takes, such a reporting mechanism could provide an informal platform for recognizing efforts and, in this way, encourage performance.

5.6 Conclusions

International cooperative initiatives have the potential not only to support existing pledges, but to go beyond them to narrow the gap. To achieve this, however, they need to focus on the large opportunity areas and be designed and implemented in an effective way.

A large number of international cooperative initiatives currently exists, and they are very diverse in scope and approach. Some make an indirect contribution to closing the emission gap by promoting dialogue and sharing experience and best practice. Others have the potential to make direct contributions, as their mandate focuses on catalysing additional mitigation – by involving additional actors or covering additional sectors or by providing incentives for action beyond current pledges.

A review of the limited literature available suggests four broad priority areas:

1. **Energy efficiency** with significant potential, up to 2 $GtCO_2e$ by 2020. It is already covered by a substantial number of initiatives. Focus and coherency is needed.
2. **Fossil-fuel subsidy reform** with varying estimates of the reduction potential: 0.4–2 $GtCO_2e$ by 2020. The number of initiatives and clear commitments in this area is limited.
3. **Methane and other short-lived climate pollutants** as a mix of several sources. Reducing methane emissions from fossil-fuel production has received particular attention in the literature. This area is covered by several specific initiatives and one that is overarching.
4. **Renewable energy** with particularly large potential: 1–3 $GtCO_2e$ by 2020. Several initiatives have been started in this area. Focus and coherency is needed.

While further research is needed to arrive at more comparable figures on emission reduction potential, additional sectors in which the potential may be high include fluorinated greenhouse gases, international transport, limiting inefficient coal use in electricity generation, agriculture and forestry. It would be useful to have guidelines for clear and quantifiable commitments, and transparent monitoring and reporting to allow for a more precise quantification of the contribution of international cooperative initiatives to closing the gap.

Any instigator of a new initiative should assess the landscape before beginning something new. In issue areas with a high number of existing initiatives, a consolidation of efforts could be considered.

International cooperative initiatives need to be effective in delivering actual emission reductions. The following provisions can enhance the effectiveness of international cooperative initiatives:

- a clearly defined vision and mandate;
- the right mix of participants appropriate for that mandate, going beyond traditional climate negotiators;
- stronger participation from developing country actors;
- sufficient funding and an institutional structure that supports implementation and follow-up, but maintains flexibility;
- incentives for participants;
- transparency and accountability mechanisms.

These are preliminary findings. Additional research is clearly needed to systematically identify empirical lessons from the existing initiatives and gain a clearer understanding on what makes initiatives effective.

Chapter 6

Bridging the gap III: Overview of options

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6.1 Introduction

The analysis in Chapters 2 and 3 of this report concluded that the emissions gap in 2020 is likely to be 8–12 $GtCO_2e$ and showed an increase in projected business-as-usual emissions in 2020 compared to the 2012 report. Starting from the estimated total emission reduction potential, and based on the findings of the previous chapters, this chapter provides an overview of options to reduce the emissions gap.

The chapter starts by asking whether the gap can be bridged. To answer this question, the best available estimates of the total emission reduction potential and possible changes in these estimates are discussed. Following this, a summary of options to narrow, and potentially bridge, the emissions gap in 2020 is presented.

6.2 Emission reduction potentials in 2020 and 2030: can the gap be bridged?

The options to narrow the emissions gap discussed in the previous chapters of this report – emission reduction pledges, Chapter 2; national climate and development policies, Chapters 2 and 4; and international cooperative initiatives, Chapter 5 – all have connections with one another and all will help bridge the emissions gap in 2020.

UNEP's Bridging the Emissions Gap Report (2011a) estimated the total emission reduction potential in 2020 to be in the range of 17 ± 3 $GtCO_2e$ [1,2]. Table 6.1 provides an overview of emission reduction potentials by sector from the earlier report together with estimates for 2030 from the IPCC (2007).

The mid-range of 17 $GtCO_2e$ is slightly greater than the estimated difference between business-as-usual emissions in 2020 and the 2020 emissions level consistent with a likely chance of staying within the 2° C target of 15 $GtCO_2e$. This indicates that there is still a chance to close the gap by 2020, but it also means that even relatively small changes in the total emission reduction potential could have important implications on the ability of society to bridge the gap. Total emission reduction potentials change over time, reflecting among other things technological development and the speed and comprehensiveness with which policies and options are adopted and implemented.

Table 6.1 Estimates of sectoral greenhouse gas emission reduction potentials, 2020 and 2030

Sector	Emission reduction potential in 2020 ($GtCO_2e$ per year)	Emission reduction potential in 2030 ($GtCO_2e$ per year)
Power sector	2.2–3.9	2.4–4.7
Manufacturing industry	1.5–4.6	2.5–5.5
Transportation	1.7–2.5	1.6–2.5
Buildings	1.4–2.9	5.4–6.7
Forestry	1.3–4.2	1.3–4.2
Agriculture	1.1–4.3	2.3–6.4
Waste	Around 0.8	0.4–1.0
Total (central estimate)	**17 ± 3**	**23 ± 3**
Total (full range)	**10–23**	**16–31**

Source: Emission reduction potential in 2020 is taken from UNEP, (2011a; 2012). The 2030 potential is taken from IPCC (2007).

UNEP's Emissions Gap Report 2012 emphasized that, although the emission reduction potential in 2020 remains high, time is running out with respect to realizing this potential (Chapter 3). First, there can be a considerable time lag between the adoption of emission reducing policies and options, their implementation and the reaping of the associated emission reductions. Second, many investments in, for example, transportation systems, energy production, buildings and factories are long-lived. Failure to invest today in best available technologies and options not only represents a lost opportunity to reduce emissions, it also curtails our ability to reduce them in the near future as high energy use and emission patterns are locked-in for several decades. Postponing action implies that part of the potential in 2020 may be lost and that steeper and more costly action will be required to achieve the remaining potential (Chapter 3).

[1] Adopting a sectoral bottom-up approach, with marginal costs in the range of 50–100 US $/$tCO_2e$.

[2] Assuming that the uncertainties are independent between sectors, which may hold under many cases, an error propagation rule to calculate the range of the sum of the sectors is applied – that is, the square root of the sum of squares of the range for each sector. This gives a reduced range of ± 3 $GtCO_2e$ compared to the full range of ± 7 $GtCO_2e$.

Furthermore, it is unclear to what extent national pledges and international cooperative initiatives cover the sectoral emission reduction potentials. As countries rarely specify a split of their pledge by sector, it is difficult to make a complete assessment of the degree of overlap. Ideally, such overlaps should be taken into account when assessing options for narrowing the emissions gap through additional action.

Comprehensive and regular updates of emission reduction potentials are a prerequisite for in-depth assessments of the feasibility of bridging the emissions gap. Unfortunately, the number of new studies published since the 2012 update (UNEP, 2012) is limited and prevents a thorough re-evaluation of the emission reduction potentials in Table 6.1. The new studies do, nonetheless, provide an assessment of the possible take-up of emission reduction options for particular scenarios and specific assumptions regarding policy regimes and carbon prices. They give an indication of current trends for the sectoral emission reduction potentials reported in Table 6.1. Recent developments in the power and transportation sectors point towards possible increases in the emission reduction potentials for 2020 – modest – and 2030 – potentially substantial. More specifically, for the power sector, rapid growth of renewable energy (Breyer, 2011; REN21, 2013) might be able to more than compensate for the limited development reported for nuclear energy and carbon capture and storage reported by the International Energy Agency (IEA, 2013). Some authors highlight that, if the current rate of growth of wind and solar photovoltaic power continues after 2020, decarbonization rates for electricity could be higher than expected in even the most ambitious scenarios, increasing the 2030 emission reduction potential by several $GtCO_2e$ (Blok and Van Breevoort, 2011). In the transportation sector, a rapid decline of carbon-dioxide emissions per vehicle kilometre for passenger cars is observed (IEA, 2013). Less is known about other parts of the transportation sector. A study for 2030 shows that implementation of appropriate policies for vehicle efficiency, modal shift and activity reduction could lead to a reduction in greenhouse gas emissions of 5.8 $GtCO_2e$ in 2030, compared to a business-as-usual scenario (Façanha *et al*., 2012). This is more than double the potential in 2030 given in Table 6.1, although developments in other parts of the transport sector would need to be factored in.

Progress in the manufacturing industry and building sectors is limited and raises concerns about the feasibility of achieving its mid-range potential by 2020. For the manufacturing industry current uptake of energy-efficient technology is moderate according to the International Energy Agency (IEA, 2013). However, large developing countries such as China and India now have substantial industrial energy efficiency programmes in place, although the actual impact of these is difficult to quantify at this stage. Given the limited level of implementation globally, the remaining potential in 2020 is likely to be closer to the lower end of the range rather than the higher. Since a large part of the potential is retrofit and add-on technology, the estimate of the 2030 potential is probably still valid. The building sector shows limited progress, according to Ürge-Vorsatz *et al*. (2012) and the International Energy Agency (IEA, 2013), who claim that a large untapped potential exists. This raises concern about the feasibility of reaching the 2020 potentials and also makes it difficult to make a statement about the change in potential for 2030.

Similarly for agriculture and forestry, the limited level of actual implementation of policies may limit the feasibility to achieve the higher ends of the range of emission reduction potentials for 2020.

To conclude, the findings of recent studies are generally consistent with the range of 2020 emission reduction potentials summarised in Table 6.1. However, they do give reason for concern about the feasibility of achieving the potentials by 2020. They also illustrate the need for comprehensive updates of the potentials for each sector for 2020 and 2030, and for tracking progress towards them.

Most of all, this section, along with the previous chapters of this report, illustrates that emission reduction potentials will only be realised if strong, long-term and sector-specific policies and policy portfolios are in place at the international and national level (Box 6.1).

6.3 Options to narrow and potentially bridge the emissions gap in 2020

A number of options to narrow the 2020 emissions gap can be identified based on the information of the previous chapters of this report. These range from applying more stringent accounting practices for pledges to increasing the scope of pledges to going beyond them. Figure 6.1 summarizes these options and illustrates how, if implemented together, they have the potential to bridge the emissions gap in 2020. Each of these options and their potential contribution to narrowing the emissions gap are summarised below.

As described in Chapter 2, the gap can be narrowed by 1-2 $GtCO_2e$ by applying more stringent accounting practices for emission reduction pledges, i.e. by moving from lenient to strict rules. This includes:

- Minimizing the use of lenient land-use credits .
- Minimizing the use of surplus emission units
- Avoid double counting of offsets

The gap can be further narrowed by 2-3 $GtCO_2e$ if all countries were to move from their unconditional to their more ambitious conditional pledges. This would require the fulfilment of the conditions on those pledges and the swift implementation of policies to deliver the additional reductions. These conditions include expected action of other countries as well as the provision of adequate financing, technology transfer and capacity building. Alternatively it would imply that conditions for some countries be relaxed or removed.

These two approaches, applying more stringent accounting practices plus implementing the more ambitious pledges, leads to a reduction of the emissions gap of 4 $GtCO_2e$.

The gap can be further narrowed by other actions aimed at increasing the scope of current pledges:

- Coverage of all emissions in national pledges (up to 0.5 $GtCO_2e$): some country pledges cover only a part of a country's total emissions. For example some countries have pledges to reduce carbon dioxide emissions and have not specified actions for the other greenhouse gases. This would apply to roughly 3 $GtCO_2e$ of current emissions. Assuming these are reduced by 15 percent

[3] Some countries are set to move in this direction (see Section 2.5)

Box 6.1 Best-practice policies for reducing greenhouse gas emissions and achieving development goals from the 2012 and 2013 UNEP emissions gap reports

The 2012 and 2013 UNEP emission gap reports identify policies for four sectors that have proven successful in reducing greenhouse gas emissions in many different countries, while contributing to national development goals (Chapter 4; UNEP, 2012). Such sector-specific policies have the potential to make a significant contribution to bridging the gap, if scaled up in both ambition and geographical reach.

Agriculture

- Promotion of no-tillage practices: no-till refers to direct seeding under the mulch layer of the previous season's crop, reducing greenhouse gas emissions from soil disturbances and fossil-fuel use by farm machinery.
- Improved nutrient and water management in rice production: includes innovative cropping practices such as alternate wetting and drying and urea deep placement that reduce methane and nitrous oxide emissions.
- Agroforestry: consists of different agricultural management practices that all deliberately include woody perennials on farms and the landscape, and which promote a greater uptake of carbon dioxide from the atmosphere by biomass and soils.

Buildings

These policies lower energy use and therefore reduce carbon-dioxide and other emissions:

- Building codes: regulatory instruments that set standards for specific technologies or energy performance levels and that can be applied to both new buildings and retrofits of existing buildings.
- Appliance standards: regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products that are below a minimum level of efficiency.
- Appliance labels: energy-efficiency labels that are fixed to manufactured products to describe the products' energy performance. Endorsement labels are seals of approval that are awarded if energy-saving criteria are met. Comparative labels allow consumers to compare performance among similar products.

Forests

These policies slow down deforestation and thereby reduce carbon dioxide and other emissions:

- Protected areas: designating some forested areas as protected areas.
- Command-and-control measures: enacting and enforcing environmental regulations and putting adequate monitoring systems in place to ensure compliance.
- Economic instruments: using economic tools such as taxes, subsidies, and payments for ecosystem services for encouraging forest conservation.

Transport

These policies reduce energy use and therefore reduce carbon dioxide and other emissions:

- Transit-oriented development: the practice of mixing residential, commercial and recreational land uses to promote high-density neighbourhoods around public transit stations.
- Bus Rapid Transit (BRT): key elements of bus rapid transit include frequent, high-capacity service; higher operating speeds than conventional buses; separated lanes; distinct stations with level boarding; and fare prepayment and unique branding.
- Vehicle performance standards: establish minimum requirements based on fuel consumption or greenhouse gas emissions per unit of distance travelled by certain vehicle classes.

These policies do not represent a comprehensive list. Moreover, some best-practice policies will be more appropriate and successful in reducing emissions in some countries than in others. Their success also depends on how stringently they are implemented.

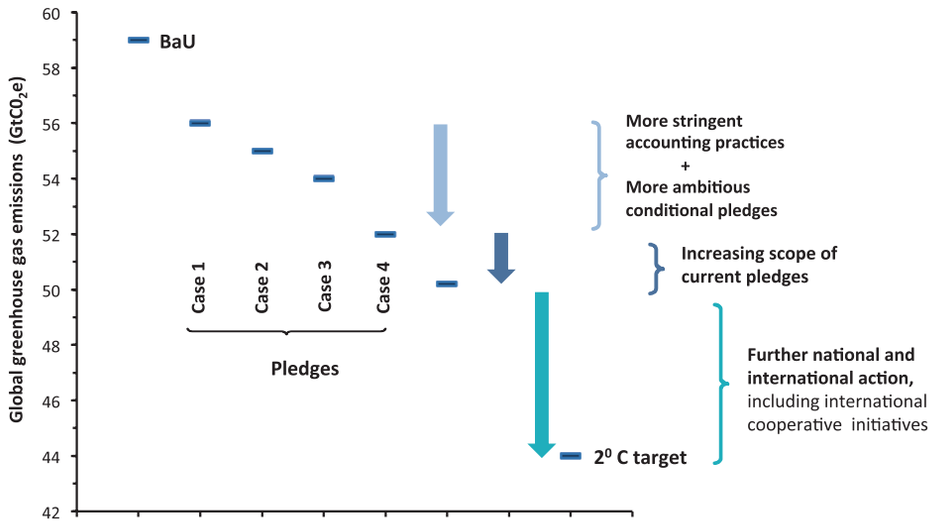

Figure 6.1 Overview of options to narrow the emissions gap in 2020

by 2020, the order of magnitude of pledges made by other countries, the resulting reduction would be 0.5 $GtCO_2e$.

– New pledges by countries that have not yet pledged (up to 1 $GtCO_2e$): some countries have not yet put forward pledges. Aggregated emission levels from those countries amounted to roughly 7 $GtCO_2e$ in 2010. If they were to reduce emissions by 15 percent by 2020, which is the order of magnitude of pledges made by other countries, the resulting reduction in emissions would be 1 $GtCO_2e$.
– Additional reductions from sectors not covered by national pledges (0.3 $GtCO_2e$): Some sectors, notably international transport, are not covered by national pledges. The mitigation potential in these sectors is 0.3 $GtCO_2e$ (UNEP, 2011a).

These three actions to increase the scope of current pledges would further reduce the gap by up to 1.8 $GtCO_2e$.

Adding together the more stringent accounting practices, the more ambitious pledges, and the increased scope of current pledges, reduces the gap by around 6 $GtCO_2e$, or about a half.

The remaining gap can be bridged through further national and international action, including international cooperative initiatives. These initiatives may partly overlap with national pledges, but can also be additional to these pledges. If they are additional and implemented rapidly, they have the potential to substantially reduce the gap by 2020 (Blok *et al*., 2012).

Reductions of short-lived climate pollutants would have to occur in addition to reductions of emissions of long-lived greenhouse gases, and would not be a replacement. Some ozone precursors and black carbon are not covered by national pledges, but are already assumed to be reduced in the calculations of the gap. Missing out on these reductions would increase the gap by a rough equivalent of 1–2 $GtCO_2e$ (Hare *et al*., 2012; UNEP, 2011b).

6.4 Conclusions

This chapter illustrates that it is difficult to estimate the impact of various options for reducing emissions and narrowing the gap. For this reason it would be beneficial to set up an objective accounting system for tracking progress towards closing the gap. Also, comprehensive updates of emission reduction potentials in different sectors would provide invaluable information for decision making as we move closer to 2020.

Importantly, this chapter shows that applying more stringent accounting practices, implementing more ambitious pledges, and increasing the scope of current pledges, will bring the world halfway to bridging the gap. The remaining gap can be bridged through further national and international action, including international cooperative initiatives. As shown in the beginning of this chapter this is technically possible.

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