

Closing the 2020
emissions gap:
Issues, options and
strategies

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Date: 03 August 2012

Acknowledgments: This document has been funded by the Children's Investment Fund Foundation (CIFF) to catalyze thinking among governments, businesses and civil society about issues, options and strategies that might contribute to closing the emissions gap. The authors wish to thank CIFF, in particular, Kate Hampton, Sophie Pullan and Farhana Yamin, for their support for this work. The authors also acknowledge the useful comments and reviews on previous drafts from Mark Roberts, Marion Vieweg, Farhana Yamin, Durwood Zaelke and one anonymous reviewer. The current draft remains open for further comments and reviews, which should be sent to Nicholas Harrison (n.harrison@ecofys.com). The views expressed and information contained in this draft are those of the authors and are not necessarily those of, or endorsed by CIFF, which can accept no responsibility for such views or information or for any reliance placed on them.

Authorship note: All authors contributed to chapters 1 and 4. Climate Analytics authors were responsible for the content of chapter 2 while Ecofys authors were responsible for chapter 3.

Summary

Without further and accelerated action it appears very likely that global greenhouse-gas (GHG) emissions levels in 2020 will be far above those that are consistent with agreed international warming goals. This gap between where emissions are headed and where they need to be exists due to the inadequacy of current mitigation pledges, which, if fully implemented, will lead to warming of 3-3.6°C by 2100. The gap is now widely acknowledged by the international community and at the United Nations Framework Convention on Climate Change (UNFCCC) COP17 in Durban a work plan on enhancing mitigation ambition was launched to explore options for strengthening efforts by all Parties.

In this context, this briefing paper explores a range of issues, options and strategies for urgently bridging the 2020 emissions gap. We begin by reviewing some of the recent science in relation to limiting warming to the agreed warming goals, and the relative role of different GHGs and other climate forcing agents. The scientific analysis in this paper is new in that it integrates insights from the recent reports published by the United Nations Environment Programme (UNEP) relating to air pollution, methane and hydrofluorocarbon (HFC) emissions reductions in the context of efforts to limit warming to below 2°C, and ultimately to 1.5°C.

Another innovative feature of this briefing paper is a practical analysis of a range of initiatives that, taken together, could have the potential to reduce emissions from present projected levels to those that are consistent with a 2°C warming limit and assist national governments in implementing and strengthening their emissions reduction pledges. We provide an overview of such initiatives – often led by players other than national governments and in many cases driven by concerns broader than climate change. Together, these initiatives could have the potential to bridge the emissions gap.

Finally we highlight further work needed to elaborate on the scientific issues, mitigation options and barriers to their achievement in order to realize the possibilities outlined in the paper.

HFC, CH₄ and N₂O reductions are necessary but not sufficient to meet the warming goals.

To meet the warming goals of 1.5 or 2°C, deep reductions are needed in emissions of all the main GHGs, including carbon dioxide (CO₂), methane (CH₄) and HFCs. Reductions in air pollutants that affect the climate, including black carbon, sulphur oxides and tropospheric ozone precursors are also needed.

Action to limit HFCs can reduce projected warming by 0.05-0.5°C, depending upon the assumed future growth of emissions of these gases. Nitrous oxide (N₂O) reductions play a relatively small role, reducing warming by about 0.1°C. Reductions in CH₄ emissions are very important, and lower projected warming by about 0.3°C by 2100. Apart from the direct effect of lower methane levels, decreased methane emissions also reduce tropospheric ozone concentration.

With reductions in emissions of these non-CO₂ gases only, global warming would produce a temperature increase of approximately 2.6°C by 2100, still far above the warming limits.

Deep CO₂ reductions are required to meet warming goals.

The largest contribution to lowering projected warming is achieved by deep reductions in CO₂ emissions. This would further reduce the projected warming by about 0.9-1.0°C. In other words, without strong CO₂ reductions the 1.5 and 2°C warming goals cannot be achieved.

Reducing air pollutants is also an important part of a comprehensive mitigation strategy.

Reducing black carbon emissions, particularly from fossil-fuel sources, will decrease the net radiative forcing of the Earth and lead to slower or lower short-term warming. Reductions in these and other pollutants have major benefits for air quality (including sulphur (SO_x)) and significant regional climatic consequences. Most of the pollutant reductions that can be achieved from air-quality measures will also be achieved in the energy-system transformation required to achieve low CO₂ emissions levels. This is due to decreased activity in the high-pollutant fossil-fuel energy supply. There are large air-pollutant reduction benefits from the energy-system transformation required to reach a low-carbon development pathway.

It is likely only in a scenario where CO₂ measures are not reduced below current pledges *and* where air-quality measures exclude SO_x, that accelerated action on black carbon and other air-quality measures can lead to a slower rate of warming for a few decades in a continuously warming world.

Non-CO₂ measures cannot be used as a means to “buy time” to enable reductions in CO₂ emissions to be achieved later. A ten-year delay in starting CO₂ emissions reductions more than doubles the probability of exceeding 2°C of warming in the 21st century from 20% to 50%. After such a delay, energy-related CO₂ reduction rates until 2050 would need to be on average 2.4% (of 2010 levels) per year, rather than the 1.5% per year in the absence of a delay.

A comprehensive and effective mitigation strategy requires deep CO₂ reduction and non-CO₂ measures to work side-by-side to provide the most technically and economically feasible package. This is important to bear in mind as in some cases there is confusion about the role of non-CO₂ gases in maintaining a 2°C or lower pathway. The most promising perspective from a climate policy context would be to combine deep reductions of CO₂ and other long-lived GHGs with accelerated action on air pollutants. Without strong CO₂ reductions the warming goals considered here cannot be achieved.

The gap can be narrowed substantially by scaling up and combining initiatives in a green growth approach to international action on climate change.

With the “Wedging the Gap” approach, Ecofys has identified twenty-one initiatives that together have substantial potential to narrow the emissions gap, supporting and going beyond what national governments have pledged.

Working with initiatives of actors that are intrinsically motivated to act is a fundamentally different approach from attempting to secure agreement among countries that are to some extent resistant to action.

We estimate that the combined effect of the scaled-up initiatives could be in the order of 10 GtCO₂e reductions below business-as-usual (BAU) levels in 2020 plus the effect of enhanced reductions in methane and air-pollutant emissions (excluding sulphur). Roughly half the effect goes beyond what national governments have pledged.

The selection of only a few of these initiatives would not result in sufficient reductions. Every effort has to be made to scale up as many of these initiatives as possible to realize a significant effect. Because the gap is large, it overlaps with pledges by national governments, and some initiatives may fail along the way.

For each area of possible reduction, initiatives are already underway by parties other than national governments and are often driven by interests beyond climate change. Many represent a green growth approach to global action on climate change and some have already gained significant political momentum. However, most of these initiatives currently lack clear quantified commitments or targets.

Many initiatives can be implemented independently of direct national government intervention while for some, success may depend to an extent on intervention to remove barriers, reduce risk or provide other support. For example, national governments would have to regulate the access of renewable electricity generation to the electricity grid (where this is a barrier), but would not necessarily have to provide financial incentives. In this case some administrative but no direct financial burden is put on national governments, which may be particularly relevant for developing country governments.

Some initiatives are further advanced than others. Consequently a varying degree of effort and resources will be needed to enhance action enough to fully exploit the available mitigation potential in each case. An assessment of feasibility often depends on viewpoint and this report provides further information as a basis for such an assessment.

We propose building a coalition or coalitions formed from scaled-up initiatives as a green growth approach to global action on climate change. Working together on a coalition of such initiatives could serve as a catalyst, greatly enhancing the willingness of non-state actors to engage in activity that reduces global greenhouse-gas emissions and supports the implementation and strengthening of the pledges for which national governments remain responsible.

The successes of the coalition of initiatives have to be fed back into the UNFCCC process and must have an impact on national government pledges. Otherwise national governments may feel that they are released from the necessity to implement and strengthen their pledges as they can rely on the success of action elsewhere. This feedback can be achieved by inviting the coalition of initiatives to communicate with the UNFCCC process on a regular basis and a clear mandate to countries to revise their pledges in light of the new information.

Next steps

We propose the following next steps:

- **Systematic assessment of uncertainties in relation to air pollutants and climate policy:** A substantial scientific issue in relation to air pollutants and climate change policy is that of uncertainty in aerosol properties and in different sources of precursors such as fossil-fuel and biofuel black carbon, biomass black carbon and SO_x.
- **Deeper evaluation and quantification of measures:** There is a need to quantify and evaluate the feasibility of measures identified and to place them within an integrated framework in order to assess their efficacy in meeting climate and sustainable development goals.
- **Identification of a convener or conveners of a coalition of initiatives:** We have shown how initiatives can contribute significantly to closing the gap and that these initiatives would benefit from being part of a global coalition. Such initiatives could be brought together by one convener (e.g. UNEP or an individual), or could be a loose coalition of initiatives with a secretariat.
- **Seeking commitments from the sectors and associations involved:** As a next step, existing associations have to be effectively engaged, to bring them together into a coalition.
- **Presenting an overall agreement in December 2012:** If the process is successful, a coalition of initiatives could be presented in December 2012 at the margins of the UNFCCC COP.

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1 Introduction

1.1 Background

All 194 Parties to the UNFCCC agreed in Copenhagen and reaffirmed in Cancun that they would work together to maintain the global average temperature increase below 2°C above pre-industrial levels and to consider a lower goal of 1.5°C in a review process to be conducted from 2013 to 2015. Since Copenhagen, 90 governments have put forward pledges to control their emissions of GHGs (see Rogelj et al. 2009; Rogelj et al. 2010a; Rogelj et al. 2010b; UNFCCC 2011c; UNFCCC 2011a; UNFCCC 2011b).

Several independent scientific analyses indicate that current pledges by governments to date to reduce emissions by 2020 are not consistent with a scientifically evaluated global emissions pathway to either maintain warming below 2°C, or reduce it to 1.5°C by the end of the 21st century. Instead, the pledges put forward to date are consistent with a warming of over 3°C above pre-industrial levels by 2100 (Rogelj et al. 2010a).

Exacerbating this situation is the growing evidence that present emission trends are not consistent with meeting of the pledges (UNEP 2010; Höhne et al. 2011; UNEP 2011a). Without further and accelerated action it appears very likely that emissions levels in 2020 will be far higher than those consistent with the agreed warming goals implied by the pledges.

Only six months ago governments came together in Durban and agreed on a historic package of next steps. They agreed on the Durban Platform for Enhanced Action (DPEA) and set up a new ad hoc group (DPA) to begin negotiations on a new international legal agreement to be adopted by 2015 that will cover all 194 Parties to the UNFCCC. This agreement will take effect from 2020. Emission commitments made under the new agreement would therefore only be in effect from 2020 onwards, in other words at the earliest for the period 2020 to 2025.

Given the present trend in emissions and scientific analyses of required reductions, action needs to be taken urgently to increase the level of mitigation action so that emissions peak before 2020. This is necessary to ensure that emissions levels by 2020 are consistent with mid- to long-term technologically and economically feasible pathways to hold warming below 2°C, and ultimately leave open the option of limiting warming to 1.5° in the longer term. Unless urgent action is taken prior to 2015 to change present emission trends it is very unlikely that the new legal agreement to be agreed upon in 2015 will be able to include emission commitments and actions for the post-2020 period that are consistent with the agreed long-term warming goals.

For these reasons, the Durban package agreed that the negotiations under ADP would “launch a work plan on enhancing mitigation ambition to identify and to explore options for a range of actions that can close the ambition gap with a view to ensuring the highest possible mitigation efforts by all Parties.”

1.2 Objective of this paper

This briefing paper is designed to help countries, businesses and civil society address key choices relevant to increasing ambition pre-2020. It does so by clarifying a number of issues relating to the science of emissions pathways to limit global mean warming below 2°C. It explains:

- Where emissions are currently heading
- The size of the resulting pre-2020 emissions gap
- The role of different gases in slowing the rate of warming and absolute temperature increase
- Whether it is still feasible to meet the 2°C and 1.5° limits

The scientific analysis in section 2 of this paper is new in that it integrates within a single model insights from the new reports published by the UNEP, relating to HFC emissions (UNEP 2011b), action on methane and action to reduce air pollution (UNEP 2011d; UNEP 2011c), in the context of efforts to reduce GHG emissions to levels consistent with holding warming to below 2°C, and ultimately to 1.5°C (UNEP 2010; UNEP 2011a). It takes into account the large literature on the co-benefits of air pollution policy and climate change mitigation, in particular the synergies between GHG emissions reductions and reduced air pollution levels and costs (Rafaj et al. 2010; Amann et al. 2011; Heyes et al. 2011; McCollum et al. 2011; Rafaj et al. 2011; McCollum et al. 2012). Reducing air pollution in the context of also achieving large GHG emissions reductions produces substantial co-benefits, reducing human health damages and agricultural costs.

An innovative feature of this briefing paper is the practical analysis of various possible initiatives that have the potential to reduce emissions from present projected levels to those that are consistent with 1.5 and 2°C warming limit (chapter 3). In this respect the paper builds on the “Wedging the Gap” approach by Ecofys (Blok et al. 2012). The analysis of the initiatives in this briefing is only an initial review. We recognize that more detailed analytical work is needed to further identify key issues and options raised by these initiatives, including in particular, how these relate to reductions already covered by pledges made under UNFCCC processes. A second area of additional analysis is how the various initiatives could be implemented in a timely way and specifically what kind of coalition building is necessary among and between governments, businesses and civil society to advance them within UNFCCC processes and outside these. As a first step in catalyzing the discussion we set out some key organizations and players that might take the lead responsibility.

2 Feasibility of limiting warming below 2°C and reducing it to below 1.5°C

In this section we review some of the recent science in relation to limiting warming to the agreed warming goals, and the relative role of different GHGs and other climate forcing agents. For clarity our analysis is based on two broad scenarios. The first “Current Pledges” (CP) scenario assumes that the Copenhagen and Cancun pledges made by 90 governments¹ are fully implemented.

Unfortunately, the resultant emissions still produce a warming of over 3°C² above pre-industrial levels by 2100 (see [Figure 1](#)). In the absence of these assumed policies implementing pledges in full, warming might be higher and exceed 3.5°C by 2100. The second scenario follows the emissions from the lowest emissions scenario of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5), RCP3PD³ (van Vuuren et al. 2011). The RCP3PD scenario assumes that the world has at least a 66% chance of succeeding in getting onto a low-emissions pathway consistent with limiting warming to 2°C or lower.

These two published and scientifically reviewed scenarios serve as a reference point for the assessment in this briefing. However, a number of additional issues are considered, including different scenarios for HFC emissions, different methane reduction policies and a comparison of action on air pollutants that affect climate change.

This paper takes into account a large literature on the co-benefits of air pollution policy and climate change mitigation, in particular the synergies between GHG emissions reductions and reduced air pollution levels and costs (Rafaj et al. 2010; Amann et al. 2011; Heyes et al. 2011; Rafaj et al. 2011). Reducing air pollution in the context of achieving large GHG emissions reductions produces substantial co-benefits, reducing human health and ecosystem damage and agricultural costs.

2.1 Science of the pathways towards 2°C and 1.5°C

The science of climate change remains complex but the four IPCC assessment reports undertaken between 1990 and 2007, and numerous special reports during that period and since, have established a solid basis of evidence indicating that urgent mitigation action is needed to avoid irreparable and significant negative impacts for ecosystems and human societies. Global climate change already shows observable effects worldwide. These include, for example, impacts on water availability and food security. In northern African countries, water resources have been affected such that the frequency of extreme events such as floods or extended droughts has increased (Agoumi 2003). A direct consequence is crop loss, causing starvation of human populations or livestock, if alternative food sources are not available. In contrast, in Mediterranean Africa, a decrease in precipitation of up to 40% is expected with a 2°C increase in temperature. A recent study showed that by mid-century, aggregate production changes in Sub-Saharan Africa will amount to -22, -17, -17, -18 and -8% for maize, sorghum, millet, groundnut and cassava (Lobell et al. 2008). Moreover, increased temperatures (such as those seen in the year 2010) are usually accompanied by extreme climate events and associated impacts, including flooding, drought, forest fires and coral bleaching.

¹ Including the 27 member states of the EU. See (UNFCCC 2011a; UNFCCC 2011b)

² All warming levels mentioned in this report refer to median estimates, i.e. the level achieved in 50% of the cases in a probabilistic carbon-cycle/climate model run with 600 individual realizations. The uncertainty in warming projections by 2100 is considerable, with a ± 1 standard deviation level at about 0.5°C below and above the median. See e.g. Meinshausen et al (2009).

³ The Representative Concentration Pathway (RCP) RCP3PD is the lowest scenario assessed by all three IPCC working groups for the IPCC AR5.

There are many uncertainties in our scientific understanding of the climate system. These include the sensitivity of the climate to increasing GHG emissions and concentrations, uncertainty about the effect of different forcing agents – particularly aerosols – on the climate system, the response of the carbon cycle to warming and the rate of ocean heat uptake. As a consequence, in recent years scientists have attempted to create methodologies and approaches that provide a probabilistic estimate of warming given future emissions pathways (Meinshausen et al. 2009). These estimates typically put together all of the known uncertainties in the climate system and of the properties and effects of different GHGs and forcing agents within a model that then provides a range of warming rather than a single number for a given emissions pathway. With these approaches it is possible to estimate whether or not a given warming limit will be exceeded, and with what probability, given a future emissions pathway.

Limiting warming to levels such as 1.5°C or 2°C also requires knowledge about whether or not emissions pathways that maintain warming within these limits are technically and economically feasible. One of the main approaches taken here is to rely upon published integrated assessment model scenarios and to evaluate which of these meets certain warming levels. These kinds of models encode our present knowledge about plausible developments in technology and economic activity in the future, and therefore represent pathways that can be considered technically and economically feasible.

Figure 1 illustrates some of the results of recent science relating to expected warming under present proposals and the consequences of low-emissions pathways for global mean warming against the 2°C and 1.5°C warming limits.

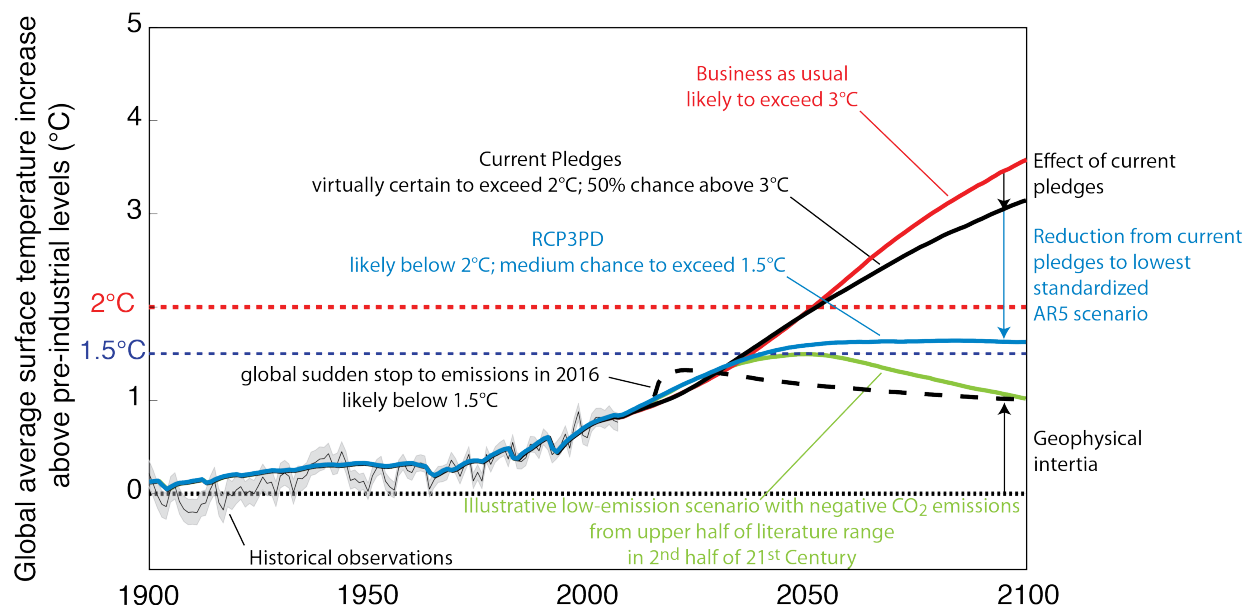


Figure 1: Warming projections from Hare et al (2011) and Schaeffer et al (2012). The CP scenario leads to warming exceeding 3°C by 2100 (orange), slightly below the level of warming that would result from the business-as-usual emission assumptions (red). The lowest IPCC AR5 scenario (RCP3PD - blue) produces a median estimate of warming below 2°C, but with about a 60% chance of exceeding 1.5°C. A stylized low-emissions scenario (green) with negative carbon-dioxide emissions at a scale consistent with the upper half of the literature range for these technologies in the 2nd half of the 21st century brings warming back below 1.5°C by 2100. A hypothetical scenario where global emissions cease in 2016 (black dotted), also limits warming below 1.5°C, showing the effects of geophysical inertia due to the operation of the carbon cycle and slow uptake of heat by the global oceans. The role of aerosol in masking some of the warming that could otherwise have been expected from increased GHG emissions and concentrations in this scenario from the initial rise of temperature before warming declines – reduced emissions of all aerosol precursors have an immediate net effect of

“unmasking” part of GHG warming, while the concentration and therefore warming effect of GHGs takes a longer time to dissipate.

Very deep reductions of carbon dioxide, the main GHG, are needed to limit warming to 2°C and/or 1.5°C by 2100 (Rogelj et al. 2011a). Carbon dioxide emissions (see [Figure 2](#), below) must approach zero or net-negative levels by 2100 in the scenarios that limit warming below 2°C with a likely or higher probability (at least 66%). Likewise, to bring warming back to 1.5°C or below by 2100 necessarily involves significant net-negative carbon dioxide emissions by 2100. Negative emissions (i.e. net removal of CO₂ from the atmosphere) are achieved in the integrated assessment models at present principally through the application of modern biomass energy combined with carbon capture and storage technologies (BECCS) and to a much smaller extent by enhanced terrestrial carbon sinks, for example due to reforestation and afforestation efforts. Such scenarios imply a negligible chance of exceeding 3°C warming, compared to a 50% chance for the CP scenario.

Recent work has evaluated the available set of integrated assessment model results for a wide range of scenarios, including those that limit warming below 2°C (Rogelj et al. 2011b) (UNEP 2010; UNEP 2011a). These pathways include air pollutants and aerosols that affect the climate system, and the probabilities of exceeding warming levels take these fully into account, insofar as the relevant processes are included in the reduced complexity climate model used for these calculations. [Figure 3](#), below shows a systematic relationship between emissions levels in 2020 and associated maximum warming levels over the 21st century. The emissions levels corresponding to warming levels below 2°C, on the left-hand side of this figure, are those that are consistent with limiting warming to the agreed global goals. If emissions in 2020 are above this range, then there is no as yet published integrated assessment model that manages to produce a technologically and economically feasible post-2020 pathway that compensates sufficiently for excessive pre-2020 emissions in order to ultimately limit warming below 2°C (See Appendix, Figure A1, for an graphic illustration of the full emissions pathways). This does not mean that it is impossible to limit warming below 2°C, but it does mean that the emissions reduction rates required after 2020 are larger than those typically emerging as feasible in integrated assessment models. Note that “allowed” levels in 2020 for 1.5 and 2°C are below today’s emissions, which implies that the economically feasible scenarios in the literature lead to global emissions stabilizing and declining within this decade. The options to achieve this are discussed in sections 2.3 and 2.4.

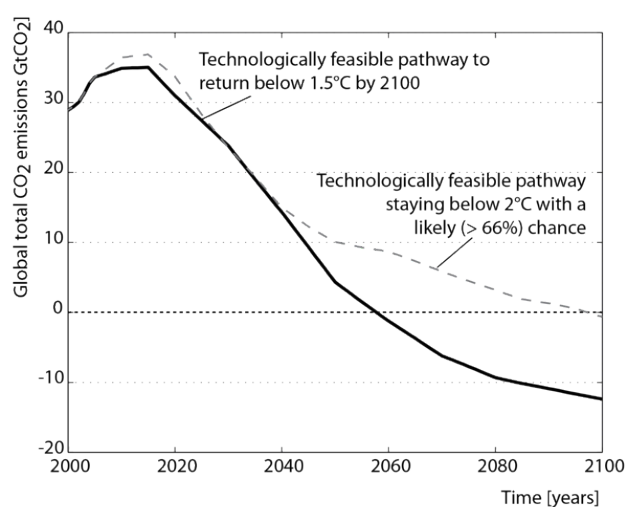


Figure 2: Technologically feasible pathways for maintaining warming below 2°C require zero or net-negative CO₂ emissions by 2100, whereas pathways that return warming below 1.5°C require the deployment of negative CO₂ technologies, achieving net-negative emissions by the 2060s.

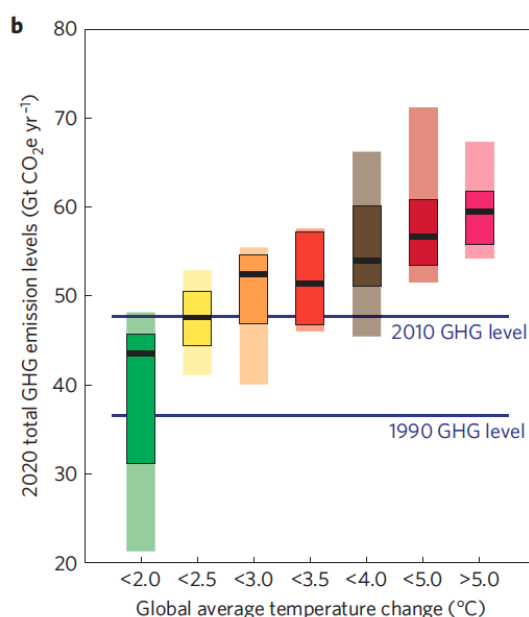


Figure 3: Emissions in 2020 corresponding to IAM results for different levels of warming (Rogelj et al. 2011b).

2.2 Where are emissions headed?

Since the 2009 Copenhagen Accord and the 2010 Cancun Agreements, 85 Parties have put forward pledges to reduce their GHG emissions. Of these, 38 are developed countries and 47 are developing countries. These pledges cover 83% of global GHG emissions. The effect of these pledges can be quantified and compared to a both typical and illustrative mitigation pathway from the integrated assessment modeling (IAM) literature that keeps global temperature increase to below 2°C relative to pre-industrial values⁴.

Fehler! Verweisquelle konnte nicht gefunden werden. shows the global emissions levels in 2010, 2020 and 2100 of a pathway that takes into account the current pledges made by Parties (from Climate Analytics et al. 2011, see also Figure 4), and of RCP3-PD, a mitigation scenario that stays below 2°C with at least a 66% chance and which is used in IPCC inter-comparison studies (van Vuuren et al. 2011). From this information it becomes clear that in a typical 2°C-consistent scenario, emissions from long-lived GHGs (for example, carbon dioxide) must be reduced significantly more than would be the case in the CP scenario.

In 2020, total carbon dioxide emissions are 5.8 GtCO₂/yr lower in the 2°C-consistent pathway than in the CP scenario. This difference amounts to more than 20% of global emissions levels in 1990. Looking at all *well-mixed GHGs* (Total WMGHG), the CP scenario results in emissions that are 10

⁴ Not all of the pledges are in a form that allows a straightforward quantification. The emissions of countries whose pledges are analyzed in this report account for 81.5% of global emissions (excl. LULUCF) in 2010, i.e. a somewhat smaller fraction than the total emissions of countries that have made 2020 pledges (83% of global). Interpretation of even those pledges that are analyzed here is contested and uncertainty remains, as explained at length in the UNEP Gap Reports.

GtCO₂e/yr higher in 2020 than a typical low emissions pathway like RCP3PD. This simplified comparison already indicates that current pledges are very far from bringing global emissions to levels consistent with reaching the warming limits agreed upon. In the CP pathway emissions peak at around 2040, with CO₂ remaining by far the largest contributor to total CO₂-equivalent GHG emissions (Figure 4).

Table 1 Emissions of GHGs and other forcing agents from a scenario based on CP and a typical GHG mitigation scenario which limits warming to below 2°C (RCP3-PD).

Gas	Unit	2010	2020				2100			
		CP	CP		RCP3-PD		CP		RCP3-PD	
		abs.	abs.	rel. to 1990	abs.	rel. to 1990	abs.	rel. to 1990	abs.	rel. to 1990
Carbon dioxide	GtCO ₂	34.9	43.5	58%	37.7	37%	35.5	29%	-1.5	-106%
Methane	GtCO ₂ eq	7.0	8.9	24%	5.4	-25%	7.6	7%	3.0	-58%
Nitrous oxide	GtCO ₂ eq	3.8	4.6	24%	3.6	-3%	3.8	4%	2.6	-30%
F-gases	GtCO ₂ eq	0.9	1.3	322%	1.0	222%	1.9	506%	1.1	250%
Total WMGHG	GtCO ₂ eq	46.6	58.2	51%	47.6	23%	48.8	26%	5.1	-87%
Air pollutants										
SO _x	MtS	52.6	34.2	-47%	18.7	-71%	10.4	-84%	4.6	-93%
Black carbon	Mt	7.7	5.5	-31%	4.2	-47%	2.1	-73%	1.6	-80%
Organic carbon	Mt	33.5	28.8	-22%	26.3	-28%	13.1	-64%	12.5	-66%
NO _x	MtN	38.1	32.5	-14%	24.5	-35%	12.0	-68%	10.1	-73%

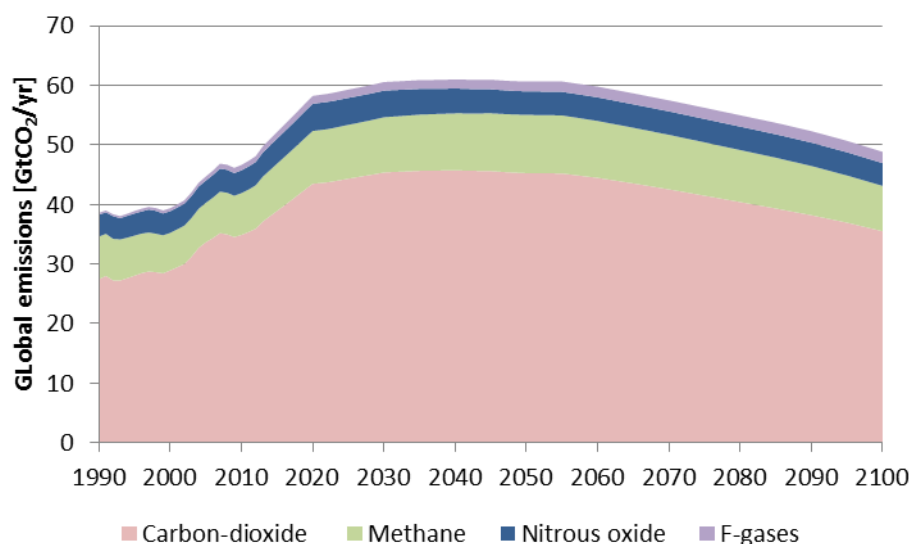


Figure 4: Estimated global WMGHG emissions based on the current pledges proposed by Parties (Climate Analytics et al. 2011).

The pledges of individual countries give an estimation of how the national or regional contributions to global GHG emissions could change from 2010 to 2020. In 2010 Non-Annex I accounted roughly for two-thirds of global energy and industry-related GHG emissions. Under the current pledges, by 2020 Non-Annex I emissions would significantly increase from 2010 to 2020, whereas emissions from Annex I countries are estimated to stay roughly constant or to decline slightly⁵. The share of Non-Annex I energy and industry-related emissions would therefore further increase by 2020.

2.3 What is the 2020 emissions gap?

The 2020 emissions gap can be roughly defined as the gap between where estimated emissions are heading in 2020 and where they need to be in order to place us on a global emissions path consistent with 1.5 and 2°C warming. The size of the gap depends primarily on the countries' pledges and in particular on their levels of ambition. In addition, for developed countries the main unknown consists of the accounting rules, for example on how to deal with surplus emissions allowances at the end of an accounting period, and the rules for accounting for emissions from land use, land-use change and forestry (LULUCF). For developing countries the main issue is the projection of BAU emissions, or baseline, emissions into the future, as their pledges are mostly expressed as deviations from baseline development, and the higher level of uncertainty in emissions inventories.

To a lesser extent the size of the gap depends on the assumptions used in calculating the global emissions pathway consistent with 1.5 and 2°C. Importantly, the emissions gap refers to the gap between pledged emissions and required levels of gases covered by the Kyoto Protocol. The 1.5 and 2°C-consistent pathways, however, by necessity need to take into account the emissions of air pollutants, ozone depleting substances, or other anthropogenic influences on climate, such as the large-scale changes in land use that impact Earth surface energy balance through changes in fluxes of radiation, heat and moisture (other than the GHG emissions and uptake associated with these changes, which are included in the country pledges and/or accounting). A difference in emissions in

⁵ Note that deforestation-related emissions are also important in Non-Annex I countries and are estimated to decline significantly under the current pledges as evaluated in this paper.

these non-Kyoto substances might lead to a somewhat smaller or larger gap. The extent to which such non-Kyoto substances can help in closing the gap is partly analyzed in section 2.4.

A recent review led by the UNEP (the “Bridging the Emissions Gap” – or BTG – report (UNEP 2011a)), provided a comparative study of emissions estimates based on the current pledges of countries under the UNFCCC together with a re-analysis of the GHG mitigation scenario literature.

The size of the gap depends on how the pledges are interpreted (for graphic illustration see Appendix Figure A2). The median emissions gap estimates range between 6 to 11 GtCO₂e/yr in 2020. The largest estimate of 11 GtCO₂e /yr is obtained if one assumes that the low-ambition range of the country pledges will be implemented and are combined with lenient international rules for GHG accounting. This gap could be reduced to 6 GtCO₂e/yr in 2020 if the high-ambition end of the country pledges were to be implemented in combination with stringent accounting rules that, for example, significantly limit the use of surplus credits available for developed countries.

The BTG report highlighted the availability of a wide portfolio of technically and economically viable measures, which make it feasible to implement the more ambitious “conditional” pledges and move significantly beyond these, as well as minimize the need for “lenient” LULUCF accounting options and surplus emissions allowances. In the most lenient case of rules for emissions credits, for example, surplus allowances from the first Kyoto commitment period can be saved for use and trading in subsequent commitment periods, hence allowing for higher emissions. Current climate negotiations are trying to solve the problem that an enormous amount of such surplus allowances are present in the current system and, if unrestricted, will deteriorate effective emissions targets in the next decades. Some Parties have proposed forfeiting such surplus allowances for future use and/or not buying surplus units from other Parties unless real and new emissions reductions are achieved to generate these surpluses. However, other Parties are looking for options available outside emissions trading schemes to allow the trading of units generated inside the Kyoto system, possibly keeping surplus emissions allowances from the first Kyoto commitment period and using these for compliance to achieve future emissions targets, even without signing up for a second commitment period of the Kyoto Protocol. There is large uncertainty in estimates of the effect of surplus credits on effective future emissions targets, providing room for improvement on the current situation, but on the other hand possibly allowing the use of surplus emissions credits outside of the system under which these were created.

The BTG report shows effective reductions in 2020 can be significantly improved by:

- Moving to the more ambitious, conditional pledges, both in Annex I and non-Annex I (2-3 GtCO₂e)
- Minimizing emissions credits for Annex-I countries from LULUCF accounting and the carry-over of surplus allowances (2-3 GtCO₂e)
- Avoiding double-counting of Clean Development Mechanism(CDM) credits, which will prevent the gap from increasing to 2 GtCO₂e

Policies and measures to enhance mitigation ambition include, but are not limited to:

- Increasing the global share of renewables in the energy supply,
- Shifting the mix of fossil fuels used in energy production,
- Reducing emissions from international aviation and shipping,
- Significantly reducing subsidies for fossil fuels,
- Intensifying energy efficiency improvements, and
- Strong action to reduce emissions from non-CO₂ gases, such as methane and HFCs.

Importantly, the emissions gap refers to pledged and required levels of Kyoto GHG emissions only, not to emissions of air pollutants.⁶ However, the potential mitigation contribution of such non-Kyoto gas emissions is included in the assumptions of the scenarios discussed in section 2.1. Therefore any assumed change in these assumptions affects the identified gap, since these changes need to be compensated for by GHG trajectories to achieve an equal probability of staying below 2°C.

For example, strong mitigation action on black carbon was already assumed in the calculations of the emissions gap through the underlying emissions scenarios consistent with the warming goals. Implementing these actions will not therefore reduce the size of the emissions gap. However, not implementing these actions will *widen* the gap, since the lack of action will need to be compensated for by enhanced measures in the Kyoto GHGs that the gap refers to explicitly (see section 2.4).

The general implications of reductions in CO₂, non-CO₂ GHGs and aerosols will be assessed in the remainder of this briefing, for both the short (2020) and longer term (2050 to 2100). In section 3 these and more measures will be further analyzed in the context of actual initiatives to achieve broad implementation.

2.4 Slowing the rate of warming and limiting absolute temperature increase

Different GHGs and other climate relevant agents affect the energy balance of the Earth (see Table 2) and act on the climate system over a wide range of timescales. These timescales are quite important in determining the level of long-term warming and in the short term the rate of warming resulting from a basket of GHG and forcing agent emissions. The longer the lifetime of a GHG in the atmosphere, the larger its long-term effect on the warming of the planet, and the slower its concentration declines after deep reductions are made. GHGs or climate forcing agents with short lifetimes respond quickly to emission changes.

Carbon dioxide has a relatively long lifetime in the atmosphere, although this is quite complicated (Archer 2005). A deep reduction in carbon dioxide emissions will only slowly be reflected in a declining atmospheric concentration of carbon dioxide. Carbon dioxide emissions are first taken up relatively quickly by the ocean surface and terrestrial biosphere, however a large fraction of these emissions takes many centuries to thousands of years to be removed from the atmosphere. Nitrous oxide (114 year lifetime) or a HFCs such as HFC143a (52 year lifetime), also responds relatively slowly to reductions. Perfluorocarbons and sulphur hexafluoride often have multi-thousand year lifetimes, and hence the concentrations, low as they are, are not affected quickly by even a complete elimination of emissions, but go on warming the planet for thousands of years after emissions have ceased.

On the other hand, deep reductions in emissions of a relatively short-lived gas such as methane, which has a lifetime of about 12 years, or a HFC such as HFC-134a (14 year lifetime) will quickly lead to a reduction in concentration and consequent warming. Therefore, generally speaking, reductions in short-lifetime GHG emissions are effective in reducing warming shortly before the target year in which warming needs to be limited, such as in the 2070s when warming peaks in most 1.5 and 2°C scenarios, including RCP3PD. By contrast, early reductions in longer-lifetime GHGs like CO₂ are crucial even long before the target year, given the build-up in the atmosphere and the limited options for later compensation for emissions that are too high early on.

⁶ In this paper we speak of “air pollutants” to group together emissions of sulphur (SO_x), black carbon (BC), organic carbon (OC), which lead to aerosol formation, and tropospheric ozone pre-cursors carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and ammonia (NH₃), which are involved in atmospheric chemistry processes that lead to tropospheric ozone formation, together with methane. Methane will be analyzed separately as a well-mixed GHG, albeit with a relatively short lifetime. See section 2.4.

There are also climate relevant air pollutants and some GHGs that have very short lifetimes in the atmosphere once emitted - significantly less than a year. Prominent amongst these are sulphur (SO_x), black carbon (BC) and organic carbon (OC) emissions, which lead to aerosol formation. Sulphate aerosols, whose main source is fossil-fuel combustion, have an overall cooling effect on the climate system, as they are reflective, masking a significant fraction of the radiative forcing effect of the long-lived GHGs. Black carbon, which is emitted from fossil-fuel combustion and biomass burning, has a warming effect, as it absorbs solar radiation in the atmosphere (direct aerosol effect), may impact cloud cover (the semi-direct aerosol effect), and leads to additional solar energy absorption when deposited on snow and ice, as it reduces the reflectivity of these surfaces. Organic carbon emissions, which come from biomass burning and which are often associated with black carbon emissions from the same source, appear to have a negative effect, however when taken together with black carbon emissions from the same source there appears to be a local net-positive radiative forcing effect, in particular from fossil-fuel sources (Kopp and Mauzerall 2010) (Myhre et al. 2011).

In a complex atmospheric chemistry process that involves methane as well, there are other pollutants with very short lifetimes such as carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organics (NMVOC). These are precursors to tropospheric ozone formation, which is a powerful radiative forcing agent in the lower atmosphere. Decreasing carbon monoxide and hydrocarbon emissions decreases tropospheric ozone, and also reduces the lifetime of methane in the atmosphere by improving its oxidizing capacity. Reductions in methane emissions reduce tropospheric ozone, and improve the oxidizing capacity of the atmosphere. Hence methane has both a direct warming effect through its own radiative forcing, and an indirect effect by influencing atmospheric chemistry and enhancing tropospheric ozone formation. A reduction in methane emissions will reduce both effects.

The climate forcing effect of the WMGHGs – CO₂, CH₄, N₂O and F-gases⁷ – is relatively well known and these gases all have a relatively uniform effect on the global climate (due to being “well mixed” in the atmosphere). Much less certain are the effects of the other agents, such as aerosol or ozone precursors, and often their effects are quite complex and regionally differentiated. The total climate forcing and regional climatic effects of aerosols deriving from SO_x, BC, OC emissions on warming and precipitation are less certain, and these are major air pollutants, affecting human health and agriculture. Tropospheric ozone precursors are also air pollutants that indirectly affect the lifetime of chemically active GHGs (such as CH₄).

Reducing sulphur emissions from present levels will quickly increase the net radiative forcing of the Earth, reducing the masking effect of historical sulphur dioxide emissions and leading to higher short-term warming (Hansen et al. 1980) (Wigley 1991). Due to the tight coupling of sulphur emissions with fossil-fuel combustions, strong mitigation in a 2/1.5°C scenario (RCP3PD) can lead to a *higher* radiative forcing in the very short term, which might produce a small initial warming above the CP scenario by the 2020s. We will come back to this later.

⁷ We follow the IPCC approach, which in its Fourth Assessment Report defined F-gases as the hydrofluorocarbons, perfluorocarbons, and sulphurhexafluoride which are covered under the Kyoto Protocol; see http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf.

Table 2 Radiative forcing contributions (in W.m^{-2} , differences in %). For individual aerosols only the direct effect is provided. The semi-direct and indirect effects are calculated in the model as a combined total effect.

	2010	2020			2100		
		CP	RCP3PD	RCP3PD compared to CP	CP	RCP3PD	RCP3PD compared to CP
Carbon dioxide	+1.86	+2.21	+2.18	-1%	+4.63	+2.44	-47%
Methane	+0.49	+0.54	+0.47	-13%	+0.56	+0.27	-52%
Nitrous oxide	+0.18	+0.20	+0.20	0%	+0.33	+0.24	-27%
F-gases	+0.03	+0.06	+0.05	-17%	+0.19	+0.14	-26%
Total Kyoto GHGs	+2.55	+3.01	+2.90	-4%	+5.71	+3.09	-46%
SOx	-0.51	-0.39	-0.24	-38%	-0.15	-0.10	-33%
BC	+0.48	+0.40	+0.32	-20%	+0.18	+0.16	-11%
BC on snows/ice	+0.11	+0.08	+0.06	-25%	+0.03	+0.02	-33%
OC	-0.11	-0.10	-0.08	-20%	-0.04	-0.04	0%
Total aerosol semi-indirect effects (clouds)	-0.75	-0.63	-0.51	-19%	-0.31	-0.24	-23%
Total aerosols	-0.78	-0.64	-0.45	-30%	-0.29	-0.20	-31%
Tropospheric Ozone	+0.44	+0.42	+0.35	-17%	+0.28	+0.18	-36%
Total	+2.21	+2.79	+2.80	0%	+5.70	+3.07	-46%
CO ₂ concentration (ppm)	390	420	420		660	440	
Total RF expressed in equivalent CO ₂ concentration (ppm CO ₂ eq)	400	450	450		760	460	
Warming above pre-industrial (°C)	0.9	1.2	1.2		3.2	1.7	

The scenarios discussed here – the CP scenario and the 2°C/1.5°C RCP3PD scenario – include policies and measures and actions that would reduce all of these GHGs and other forcing agents. The CP scenario includes the likely emissions pathways of emissions of sulphur, black carbon, organic carbon and other air pollutants based on integrated assessment model studies of GHG emissions in a similar range. RCP3PD also includes substantial action on air pollution, not only including the reductions in sulphur, black carbon and other air pollutants linked to fossil-fuel use and production, but also embedding assumptions that society in the future as it grows wealthier will invest in further air pollution controls. We test sensitivity to this assumption in the sections below, looking at examples of likely future air pollution emissions adjusted for energy-system transformations, consistent with the low-carbon scenario RCP3PD, and compare these with more advanced air-pollution policies such as those proposed in recent UNEP assessments on methane and black carbon (UNEP 2011d; UNEP 2011c). By disentangling the interactions of climate policy and air-quality measures, we hope to shed light on the mutual co-benefits of measures within these two policy realms.

For this exercise, we need to first exclude the effects of strong new air quality policy from our climate policy scenarios, since by default this is already assumed in the baseline scenarios – the CP and the low-carbon scenario RCP3PD. Excluding new air quality policies from our climate policy scenarios leads to higher projected future emissions of air pollutants, but because of the net global cooling effect of aerosols, these higher emissions lead to a net cooling in both scenarios: warming is

decreased by 0.2°C in the CP scenario and by 0.05°C in RCP3PD. These scenario variants will be tagged LAPS (Low Air-Pollutant Standards), as opposed to the original HAPS (High Air-Pollutant Standards) variants. Emissions of air pollutants in these 2x2 scenario variants rely on the recent work of McCollum (2011; 2012), who explicitly explored the co-benefits of climate and air quality measures in an innovative multi-criteria analysis framework.

The scientific literature over the last 15 years (Alcamo 2002; Alcamo et al. 2002; van Vuuren et al. 2003; Rao et al. 2005; Changhong et al. 2006; van Vuuren et al. 2006; Haines et al. 2007; Williams 2007; Markandya et al. 2009; Wilkinson et al. 2009; Shrestha and Pradhan 2010) (including the work of McCollum et al. 2011; McCollum et al. 2012) shows quite clearly that combining significant GHG reductions with air pollution policy has large co-benefits, substantially reducing both the cost of reducing air-pollution and the damages due to air pollution. One of the main reasons for this is that a low-carbon pathway leads to transformations in the primary-energy supply sector, like reduced deployment of high-pollution fossil-fuel technologies and reduced activity in sectors that are associated with infrastructure and production of fossil-fuel sources. In other words, adopting low carbon strategies produces substantial benefits in terms of reduced air pollution, and significantly reduces the cost of achieving air quality goals⁸.

The large reductions in air pollutants that can be expected from deep GHG mitigation scenarios will have both warming and cooling effects. Reduced SO_x emissions will lead to warming in the short term as the global warming masking effects of sulphate aerosols is reduced. On the other hand, reduced BC, OC and tropospheric ozone precursor emissions will have a short-term cooling effect.

In this work we assume that sulphur emissions are reduced substantially, consistent with the assumptions of the IAM models, and that there is no slow-down due to climate policy in these reductions. An alternative assumption could be made to the effect that there is a deliberate *exclusion* of sulphur controls from the larger portfolio of air quality measures and that countries, principally in the developing world, would accept the very large health, agriculture and ecosystem damage that would result. This alternative assumption seems implausible, but is the unintended implication of the assumptions in the recent UNEP reports (UNEP 2011d; UNEP 2011c). In these reports, air quality measures single out ozone precursors and black carbon producing activities and do not address sulphur emissions. For illustrative purposes we will include this assumption in sections 2.4.3 and 2.4.4.

2.4.1 Methane

Methane (CH₄) is one of the global WMGHGs, but has a relatively short lifetime of about 12 years (IPCC 2007). In a deep GHG reduction pathway, such as RCP3PD, methane emissions are already being reduced to, and beyond, the extent assessed by the above-mentioned UNEP report (UNEP 2011c) (see Figure 5). Hence, existing low-carbon pathways from IAM scenarios confirm that strong CH₄ measures identified in the UNEP report form part of the total package of mitigation efforts required. Since these IAM scenarios form the backbone of the “required” 2020 emissions level as part of the estimated emissions gap, strong CH₄ measures are assumed and must be implemented rapidly, along the lines as assumed in the RCP3PD scenario and UNEP report (UNEP 2011c). A lack of such measures would widen the emissions gap and would need to be compensated for by increased reductions in, for example, CO₂. As identified in the UNEP report, many of these CH₄ measures require specific action in sectors beyond energy.

⁸ <http://gains.iiasa.ac.at/index.php/gains-asia/298-p10>

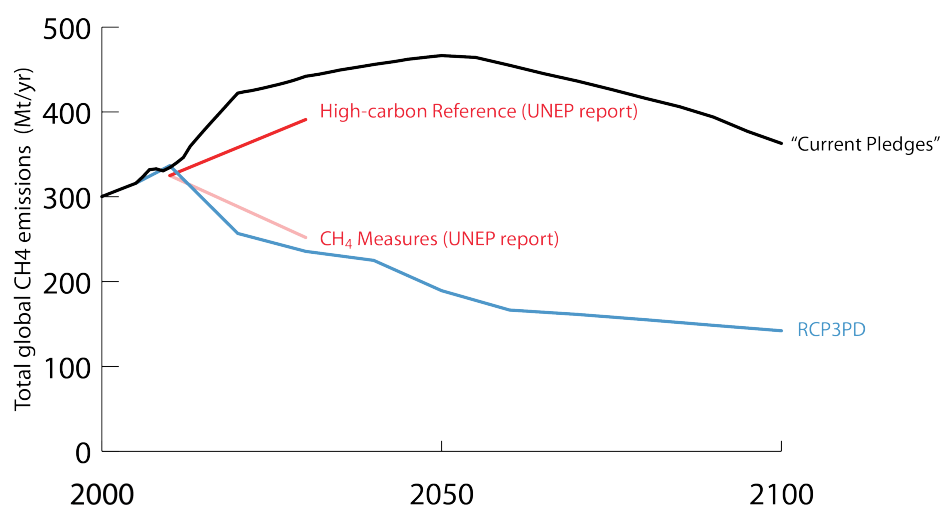


Figure 5: Methane (CH₄) emissions projections. The red lines show emissions for the high and low cases in the recent UNEP report “Integrated Assessment of Black Carbon and Tropospheric Ozone” (UNEP 2011c).

In the absence of a move towards deep GHG reductions, reducing global methane emissions from levels in the CP scenario by the full potential identified in RCP3PD, i.e. slightly more than assessed in the recent UNEP report (UNEP 2011d), would result in a global mean temperature increase of about 0.3°C lower than the 3.0°C otherwise projected⁹ in the period 2050 to 2100 (see [Figure 6](#)).

⁹ Besides the direct radiative forcing effect, methane emissions also influence the oxidizing capacity of the troposphere. The presence, and possible subsequent reduction, of methane emissions will therefore also influence the lifetime of other species in the atmosphere. Some of these interactions are covered in a simplified manner, but not those with, for example, sulphates. Interactions not included in our model setup are not likely to change the general picture.

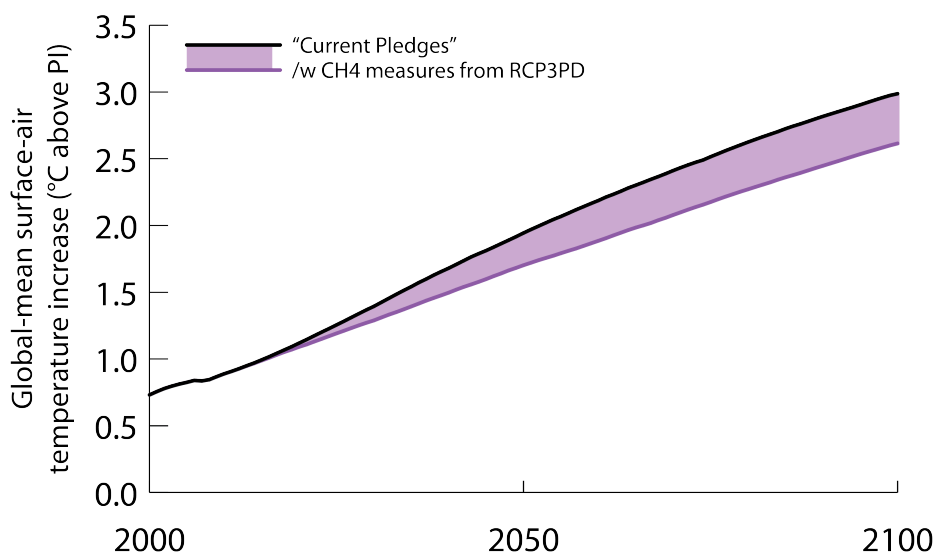


Figure 6: Global warming projections for the CP pathway (black) and with enhanced CH₄ emissions reductions (purple).

2.4.2 F-gases

In the CP scenario, total F-gas emissions are estimated to grow to 1.5 GtCO₂e in 2020 and 1.8 GtCO₂e in 2050¹⁰. Under the low emissions scenario RCP3PD, annual emissions are projected to be at least 20% lower (1.2 GtCO₂e) in 2020 and to decline further to about 1.4 GtCO₂e in the decades after 2050. Whilst the warming benefit in 2020 is relatively small, in the longer term, as is shown below, the benefits of reaching such relatively low emissions levels can be significant particularly if non-mitigated emissions were to be higher than assumed in the CP scenario after 2020. The IPCC SRES emissions scenarios (Nakicenovic and Swart 2000), which were used in the IPCC's Fourth Assessment Report in 2007, reached F-gas levels of 2-3 GtCO₂e/yr in 2050. More recently, several studies have updated projections of HFC-related activities leading to higher projected total F-gas emissions of 4 GtCO₂e/yr (Gschrey et al. 2011) to 6-9 GtCO₂e/yr (Velders et al. 2009) by 2050 (see Figure 7). If HFC emissions were to grow as rapidly after 2020 as projected in the work of Gschrey and Velders (Velders et al. 2009; Gschrey et al. 2011), then additional mitigation on top of the required reductions of carbon dioxide and other gases already identified in RCP3PD would be needed. The plausibility of such levels remains the subject of future work, however the risk of more rapid growth is real.

¹⁰ In this section we apply 100-year GWP values from IPCC AR4 to calculate total CO₂-equivalent emissions from the individual gases, in accordance with (Gschrey et al. 2011) and (Velders et al. 2009). Also, we define F-gases here as gases not regulated under a global agreement, or already included in the Kyoto basket of gases. Crucially, this definition does not include the so-called Ozone Depleting Substances (ODS) that are regulated under the Montreal Protocol, like the CFCs. ODS emissions are assumed to be reduced significantly in the scenarios assessed here, from around 1 GtCO₂e in the 2020s to about 0.2 GtCO₂e by the 2050s.

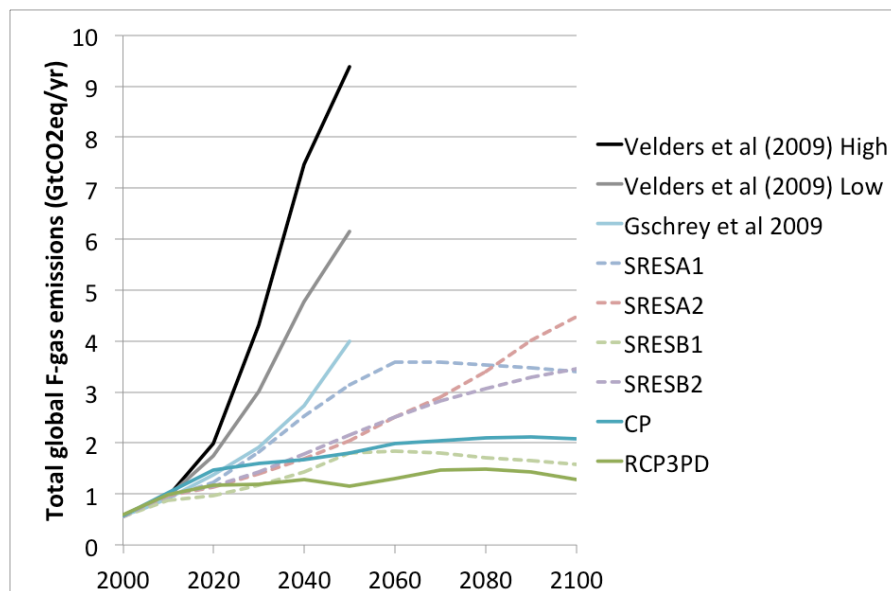


Figure 7: Estimated F-gas emissions from IPCC SRES and a range of newer projections (see text).

In the CP scenario, reductions in HFC emissions form an integral part of 2020 pledges and are reduced along with other GHGs to fulfil those pledges. This is also assumed for policies under the CP scenario after 2020 for those countries that have put forward longer-term ambitions (e.g. for 2050). Where this is not the case, F-gas emissions grow according to the SRES A1 scenario. In the CP scenario total F-gas emissions are projected to be 1.8 GtCO₂eq in 2050. As an upper bound on the effects of higher F-gas emissions, we assume that HFCs rise to values of the recent baseline projections, i.e. 4-9 GtCO₂eq/yr in 2050 and remain there until 2100. In this case, additional warming in 2100 would be 0.1-0.4°C (Figure 8), adding to the 3.0°C warming in the CP scenario.

If HFCs were reduced to lower levels found in RCP3PD (with all other gases left at CP levels), warming over the 21st century would be reduced by 0.05°C-0.5°C depending on the assumed non-mitigation growth in HFCs¹¹.

¹¹ The additional warming may not be as high as this, if it remains the case that F-gases are included in the basket of gases of pledges and policies. If we assume that Annex-I countries will comply with their 2020 emissions reduction pledges, of which HFCs are an integral part, given that they belong to a GWP weighted basket of gases, increased baseline projections of HFC emissions in developed countries will not widen the emissions gap (which assumes that the pledges will be met under any future circumstances), but pose a mitigation challenge larger than anticipated to still comply with the pledges of these countries. This would also apply under the CP scenario for the post-2020 period.

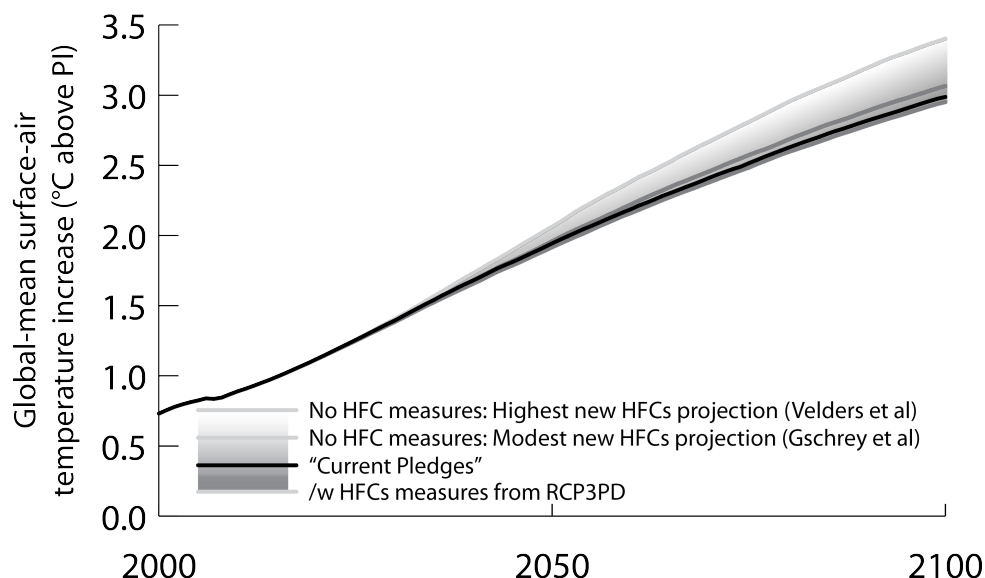


Figure 8: Global warming projections for the CP pathway (the black line) compared to cases with no effort to decrease HFC emissions relative to recent (high) baseline projections (Velders et al (2009) – High case; Gschrey et al (2009)). If HFC emissions are reduced from CP levels to those in RCP3PD, warming is reduced by about 0.1°C from the CP case, whereas if HFC emissions were higher than in the CP case, the benefit would be larger.

In relation to the 2020 emissions gap it is important to recall that the emissions reduction pledges in non-Annex-I countries are often phrased in terms of energy efficiency improvements, which do not affect HFCs, or as reductions below projected future baseline levels, which implies that the absolute emissions level under the pledge will grow if the baseline is adjusted upward. Therefore, the absolute level of emissions in 2020 under the non-Annex-I pledges might increase, and hence the global emissions gap might widen if HFC emissions growth in non-Annex I countries is higher than projected in the CP scenario. A wider gap is our key indicator that current pledges are even less sufficient to reach the 2/1.5°C goals in the long term than originally estimated by the UNEP gap reports. Again, as with methane, the IAM scenarios underlying the “required” 2020 emissions level as part of the estimated emissions gap assume that low HFC emissions levels over the 21st century are comparable to those in RCP3PD. Accelerated actions to phase out HFCs would have beneficial effects in terms of reducing the emissions gap, and in the longer term in avoiding significant additional warming. Action on HFCs for Annex I countries is an integral part of their pledges.

2.4.3 Air pollutants

The net climatic effect of air-pollutant reductions depends on the mix of pollutants and their geographic distribution. An important issue with air-pollutant measures in a climate mitigation context is the much higher uncertainty of the climate effects¹² of emissions reductions in aerosol

¹² A key parameter in assessments of the climate effects of, for example, black carbon emissions is the present-day radiative forcing. By default, our model applies a value consistent with IPCC AR4 (Forster et al. 2007) for the present-day direct forcing of fossil-fuel and biofuel combustion-related BC emissions (+0.2 W.m⁻²). However, higher values have been reported in the literature, including values of up to +0.26 and +0.33 W.m⁻² (Myhre et al. 2009). By contrast, the recent UNEP reports imply a value of roughly +0.4 W.m⁻², which would lead to an approximately two times stronger cooling effect from the same amount of reduction in BC emissions. For illustrative purposes, we show in several figures in sections 2.4.3 and 2.4.4 the results applying

precursors (SO_x, BC, OC) compared to WMGHGs, including CO₂. The ultimate climate benefits of air-pollution measures might be larger or smaller than estimated here and hence the “return on investment” for reducing warming is much more uncertain than that of measures to reduce WMGHG emissions.

As has been noted above, one important species of air pollutants, sulphur emissions, has an opposite climatic effect in the sense that it masks the warming produced by long-lived GHGs and other warming agents, such as black carbon or tropospheric ozone (Hansen et al. 1980; Wigley 1989; Shindell and Faluvegi 2009). Reducing sulphur emissions for local air quality and public health benefits and/or because fossil-fuel emissions are being reduced, would diminish this masking effect and hence lead to a relative warming. Most of the recent future scenarios and projections show reduced sulphur emissions at the global level. This is especially so for low carbon scenarios such as RCP3PD, driven largely by reductions in fossil-fuel use. However other recent scenarios, such as the other members of the IPCC AR5 RCP set with growing fossil-fuel use, also show reduced sulphur emissions.

In a low-carbon emissions pathway, fossil-fuel related emissions of BC and important tropospheric ozone precursors would be reduced significantly because of the reduction in fossil-fuel combustion and assumed efficiency and technology changes in end-use sectors (Figure 9). Most low scenarios, including the RCP3PD scenario, like higher scenarios, usually assume additional action (beyond those associated with energy-sector changes) on SO_x, BC, OC and other air pollutants. This reflects a general assumption that there will be growing societal concern with increasing income in relation to air quality and public health (van Vuuren et al. 2011). This is illustrated in Figure 9, which shows black-carbon emissions for both the CP and RCP3PD scenarios, each for both the Low and High Air-Pollutant Standards variants. The CP HAPS pathway (high-carbon / high air-pollutant standards) achieves early and deep reductions of black carbon by air quality policy alone (grey line), but comparable reductions are achieved in the RCP3PD LAPS pathway about 10 years later (dark-blue line), due to energy-system transformations even without high air-pollutant standards. The modest delay in pollutant reductions provides the option of an acceleration of these reductions to the extent proposed in this UNEP report. Indeed, in the longer term, a combination of climate policy and air quality measures would achieve the deepest reductions in air pollutants and would accelerate the black-carbon reductions in RCP3PD by 20 years, rather than 10 years.

Sulphur emissions are even more strongly linked to energy-system transformations, so that reductions in low-carbon pathways are even deeper than can be achieved by air-quality measures alone in a high-carbon pathway such as CP (see Figure 10). As sulphate emissions (Figure 9) are closely linked to fossil-fuel consumption it is most likely that emissions will indeed decrease very substantially in a world which reduces its carbon-dioxide emissions to the low levels consistent with limiting warming to below 2°C (van Vuuren et al. 2011). As is shown in the work of Cofala et al (2011) this may not happen at the same rate in all regions due to differences in the rates of decarbonization and policy differences, but in the longer term it can be expected that the global pattern will dominate.

Reducing the air pollutants considered here could have an important direct and indirect influence on regional and global temperature increases and on precipitation changes. Reductions will also without doubt improve local air quality, yielding important and unambiguous public health, agriculture and ecosystem benefits (Shindell et al. 2012).

such a high value. For higher values for present-day radiative forcing from BC, the cooling benefits from BC emissions reductions would be larger.

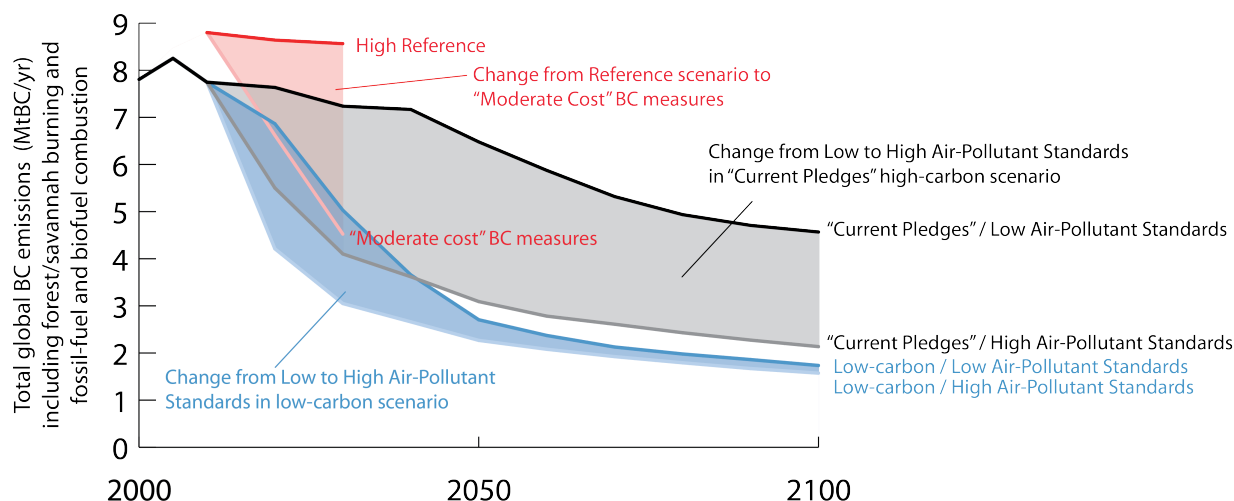


Figure 9: Black carbon emissions projections. The shaded areas show the reduction in BC emissions when air quality measures are strengthened from “Low” to “High” Air-Pollutant Standards. This reduction is much smaller in a low-carbon scenario (blue), because BC-producing technology and activities are strongly reduced as a result of the required energy-system transformations (McCollum et al. 2011; McCollum et al. 2012). The red lines show emissions for Low and High Air-Pollutant standards in the high-carbon (reference) scenario used in the UNEP report “Integrated Assessment of Black Carbon and Tropospheric Ozone” (UNEP 2011c).

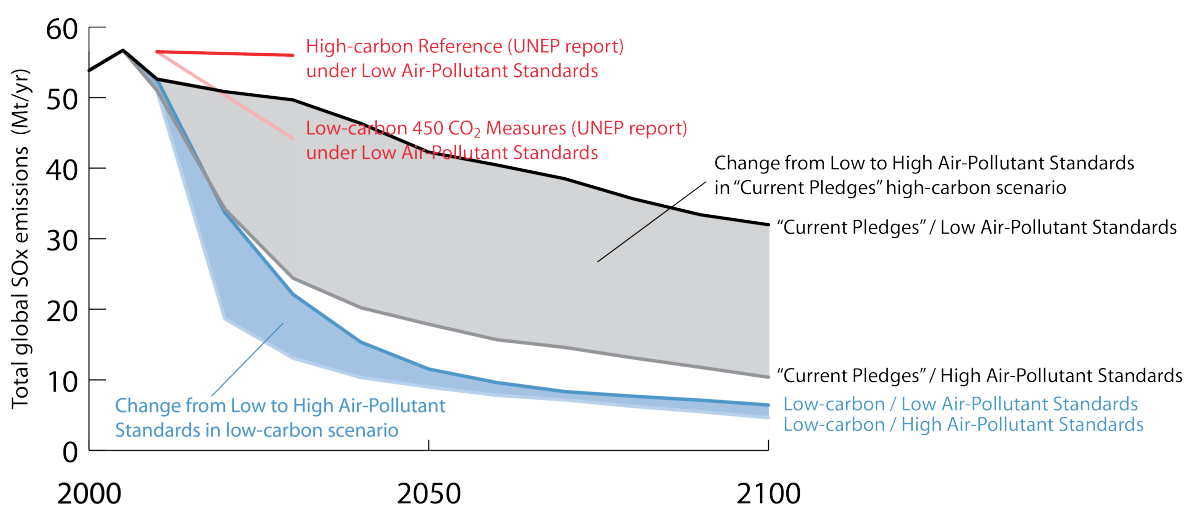


Figure 10: Sulphur (SOx) emissions projections. The shaded areas show the reduction in SOx emissions when air quality measures are strengthened from “Low” to “High” Air-Pollutant Standards. This reduction is much smaller in a low-carbon scenario (blue), because SOx-producing technology and activities are strongly reduced as a result of the required energy-system transformations (McCollum et al. 2011; McCollum et al. 2012). The red lines show emissions for Low Air-Pollutant standards in the high-carbon (reference) and low-carbon (450 ppm) scenarios used in the UNEP report “Integrated Assessment of Black Carbon and Tropospheric Ozone” (UNEP 2011c).

This issue has important consequences when considering the climate benefits of air-pollution motivated action on BC and OC emissions combined with global action towards a low-GHG emissions pathway consistent with limiting warming below 2°C. The climate warming-reducing benefits of black-carbon reductions (and of other pollutants) are likely to be offset by the diminishing cooling due to lower sulphate emissions. Unless sulphate emissions are kept at artificially high levels (for

example, through geo-engineering) the long-term climate benefits of reducing black-carbon emissions and other pollutants are cancelled out by reductions in fossil-fuel linked sulphate emissions on a path towards limiting global warming to below 2°C.

Figure 11 illustrates this issue, by combining variants of the low-emissions pathway RCP3PD and CP pathway. In both panels of Figure 11, the starting point is the high-pollution version of CP, i.e. its Low-Air Pollutant Standards variant LAPS (black line).

- In the upper panel we assume first that CO₂ measures are fully implemented and effective to the extent required in the RCP3PD scenario (and UNEP Emissions Gap reports UNEP 2010; UNEP 2011a). CO₂ measures reduce the projected 2100 warming by about 1.0°C – note that this includes the effects of reductions in pollutant emissions related to energy-system transformations such as the “unmasking” effect of reduced sulphur emissions. Without these related reductions in air pollutants, the reduction in projected warming would be 1.2°C. If in addition we assume further reductions in air pollutant emissions that resulted from a shift from Low to High Air-Pollutant Standards, while *deliberately excluding further reductions in sulphur emissions*, relative warming is not reduced in the long term, but a small temporary net cooling is achieved around the 2030s relative to the LAPS case. This is related to the acceleration in pollutant reductions shown in Figure 9. The net cooling is only visible for the high value of estimated present-day black-carbon direct radiative forcing (dashed lines). Even in this case, however, the net cooling is annulled if further sulphur reductions are included in the High Air-Pollutant Standards. Methane reductions achieve a larger and growing reduction in relative warming, reaching an additional 0.3°C by 2100 (see also section 2.4.1).
- The lower panel of Figure 11 illustrates a different perspective and is comparable to what was shown in the UNEP reports on black carbon and tropospheric ozone (UNEP 2011d; UNEP 2011c) if a high value is assumed for the estimated present-day black-carbon direct radiative forcing (dashed lines). In this lower panel, we assume that first and foremost, High Air-Pollutant Standards are introduced, which initially *exclude reductions in sulphur*, leading to a reduction in projected warming that reaches a maximum of between 0.1 and 0.2°C relative to the CP LAPS case, but this effect is much lower in the default estimated present-day black-carbon direct radiative forcing from IPCC AR4 (Forster et al. 2007). When sulphur is included in High Air-Pollutant Standards, a relative increase in projected warming of about 0.4°C results. Reducing CH₄ achieves a 0.3°C reduction in projected warming, while finally reducing CO₂ leads to a 0.9°C additional reduction in projected warming. Note that this reduction in projected warming due to CO₂ measures is somewhat smaller than the 1.0°C in the upper panel, because associated reductions in air-pollutants are already taken care of by the “earlier” shift to High Air-Pollutant Standards (excluding sulphur). A conclusion to be drawn here is that with only reductions from HFCs, CH₄, N₂O and air pollutants and without strong CO₂ reductions the warming goals (either 1.5°C or 2°C) cannot be achieved.

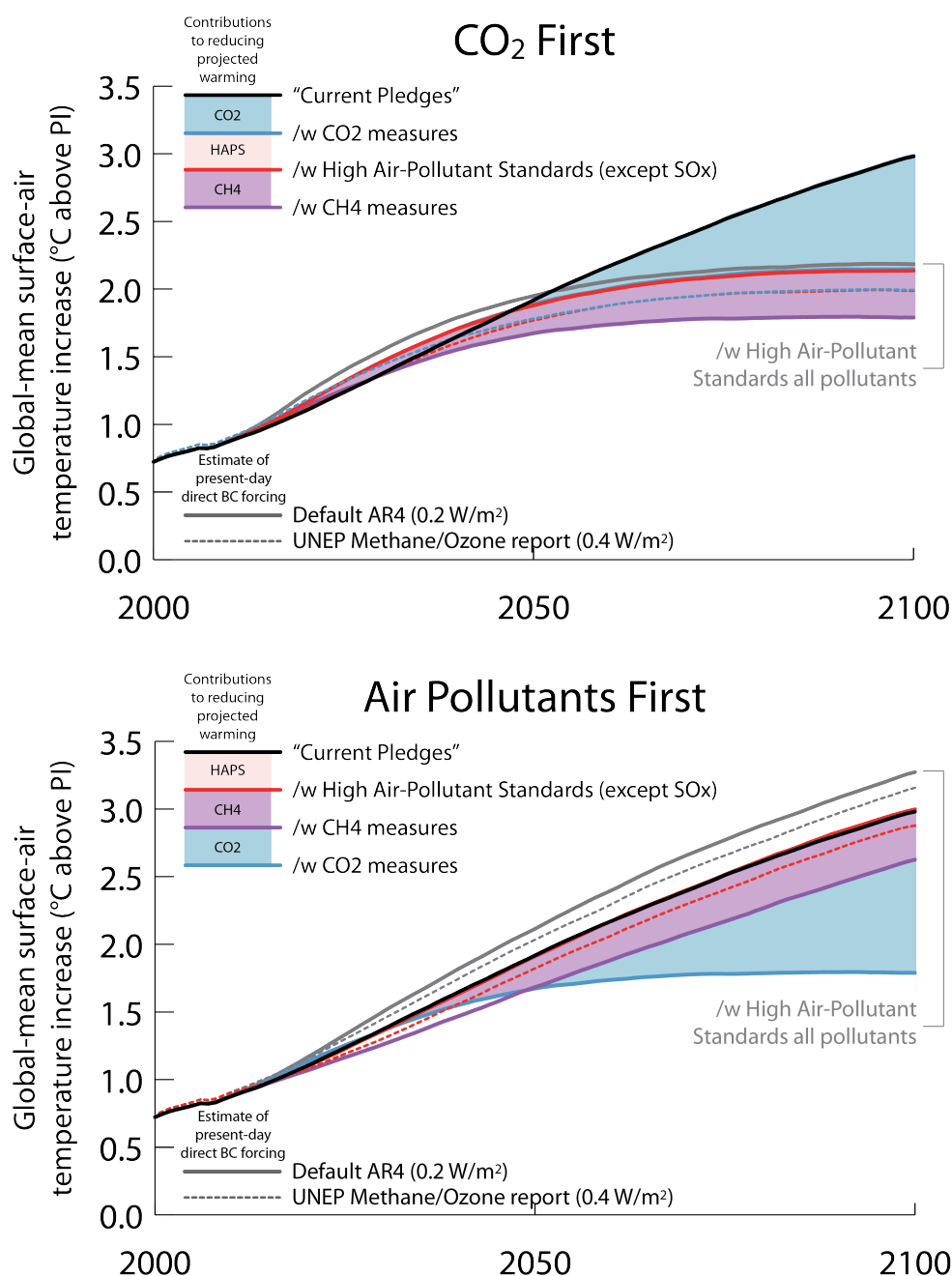


Figure 11: Global warming projections for variants of the CP pathway (black line). Reductions in GHGs and air pollutants are introduced in a different incremental order in the upper and lower panels. In the upper panel CO₂ measures are taken first, followed by a shift from Low to High Air-Pollutant Standards and CH₄ reductions. In the lower panel CO₂ measures are taken last. The shift from Low to High Air-Pollutant Standards excludes reductions in SO_x additional to those associated with CO₂ measures. The grey line shows the case if High Air-Pollutant Standards apply to all pollutants, including SO_x. For comparison, the dashed lines show results for a few cases, applying present-day direct radiative forcing from BC as assumed in the UNEP Methane and Ozone reports (UNEP 2011d; UNEP 2011c), which is about double the estimate in IPCC AR4 (Forster et al. 2007).

2.4.4 Potential total climate effect of non-CO₂ measures

In this section we put together the combined effect of the measures analyzed in the preceding sections. Figure 12 summarizes the incremental contributions of reductions in the range of climate forcing agents to limit global warming needed to take emissions from the CP to the RCP3PD low carbon scenario. According to our estimates of the consequences of CP, projected warming in 2100 is about 3°C above pre-industrial levels: obviously if the pledges are not met and emissions are higher, so would the extent of warming.

Action to limit HFCs can reduce projected warming by 0.05-0.5°C, depending upon the assumed future growth of emissions of these gases. If growth is restricted to the levels assumed in the CP case avoided warming is at the lower end of the scale, however if HFC emissions increase faster than assumed here then total warming could be 0.1-0.4°C higher. Clearly, given the risk of more rapid growth of HFCs, early and concerted action can prevent a large future problem.

Nitrous oxide (N₂O) reductions play a relatively small role, reducing warming by about 0.1°C.

Reductions in methane (CH₄) emissions are very important, and lower projected warming by approximately 0.3°C by 2100. Apart from the direct effect of lower methane concentrations on radiative forcing, reduced methane also reduces tropospheric ozone concentration.

Assuming all these reductions materialize, global warming would be limited to approximately 2.6°C by 2100 (best-estimate projection based on a 50% probability level). It is clear from Figure 12 that to reach a 'likely' probability of maintaining warming below 2°C, deep reductions in CO₂ are required¹³ and this does not occur in the CP scenario. All the non-CO₂ measures fully implemented cannot compensate for a lack of, or inadequate, action on CO₂: non-CO₂ measures are necessary but are by no means sufficient.

The strong CO₂ reductions needed to limit warming to 2°C or below are associated with substantial reductions in air pollutants. The blue curve in Figure 12 shows the integrated effects on global warming of the low carbon scenario (/wCO₂ measures) with air pollutant reductions deriving from energy system changes. This is slightly warmer for a decade or so than the CP pathway due to the combined effect of all of the air pollution reductions. In the same scenario but with accelerated reductions in all air pollutants including SO_x, black carbon and associated species (shift from Low to High Air-Pollutant Standards¹⁴) this small warming for around a decade (grey curve) compared to the CP pathway is slightly increased. This is mainly due to the more rapid drop in sulphur emissions that act to "mask" GHG warming in the High Air-Pollutant Standards case. If the rate of reduction in SO_x emissions is slowed to that of the Low Air-Pollutant Standards case, but all other reductions are according to the High Air-Pollutant Standards (e.g. large reductions in black carbon and associated species) then warming does not exceed the CP case at any time. The peak difference between the blue and the red curves is about 0-0.07°C, the high end of this range resulting from an assumed high value for present-day radiative forcing from BC: this is the maximum estimated benefit in terms of lower warming deriving from slower action on SO_x emissions, whilst taking maximum action on BC and related pollutants. The peak difference between the grey (High Air-Pollutant Standards) and blue (Low Air-Pollutant Standards) curves is 0.03°C-0.1°C, which is the maximum relative warming compared to the energy-system transformation case due to comprehensive action on all air pollutants.

¹³ Obviously, either CO₂ or non-CO₂ reduction efforts need to be even greater if emissions for any of these (not just HFCs) turn out to be higher than currently projected.

¹⁴ Comparable to the UNEP modest-cost scenario of BC measures.

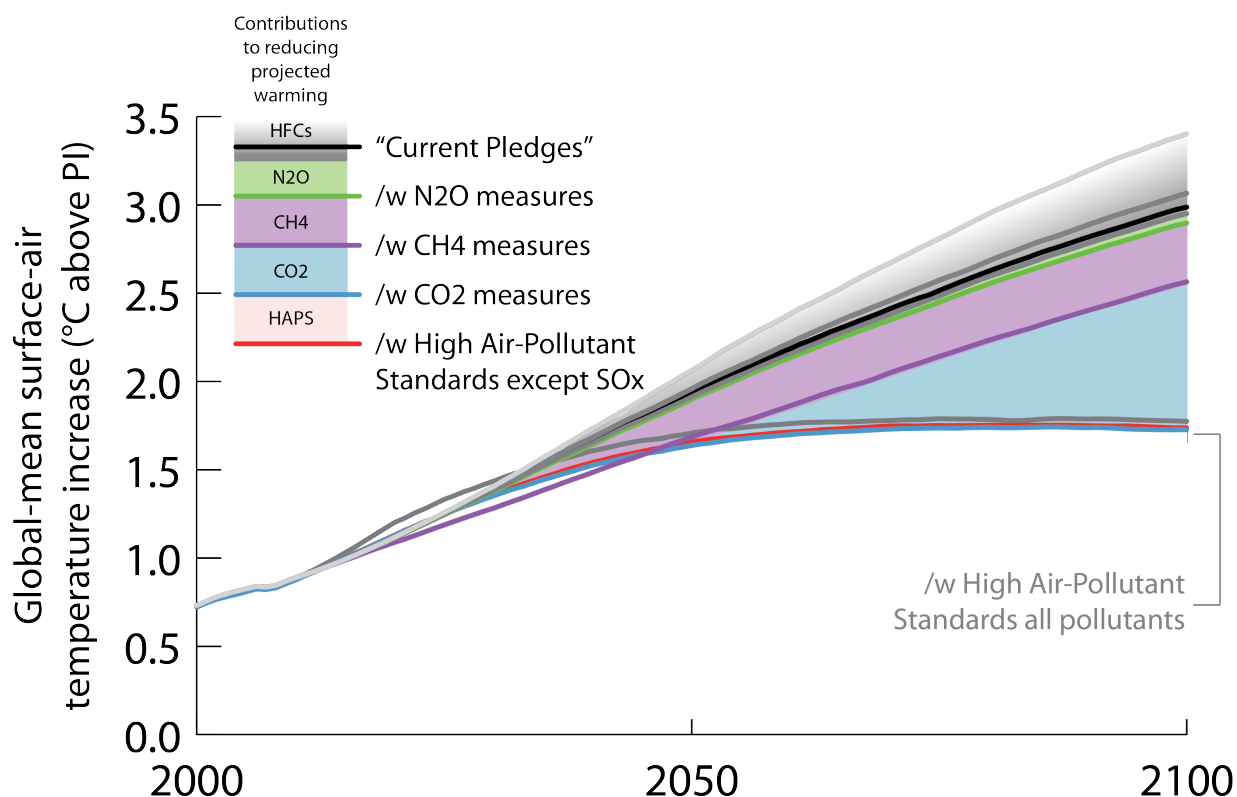


Figure 12: Incremental effects of emissions reductions of different GHGs - HFCs, N₂O, CH₄, CO₂ - as well as air pollutants, the latter in line with High Air-Pollutant Standards in the "CO₂ First" case (red – see Figure 11). The /wCO₂ measures includes only those air pollution reductions consistent with energy system changes. This can be compared to low CO₂ emissions with high air pollutant standards including SO_x (grey) and without additional SO_x controls (red). The difference between the red and the blue curves is thus due mainly to additional action on BC. The difference between the grey and the red is essentially the effect of lower SO_x emissions under a high air-pollutant standards scenario.

A very different and much less beneficial picture emerges if non-CO₂ measures are interpreted as a means for "buying time"¹⁵ for later, delayed reductions in CO₂. This can be seen by considering a scenario where the full implementation of all of the accelerated air-pollutant measures outlined above is accompanied by CO₂ (and related sulphur) emissions being allowed to follow a CP pathway until 2030, instead of a low-emissions pathway such as RCP3PD. After 2030, CO₂ (and N₂O) emissions¹⁶ are reduced rapidly below the CP scenario to ultimately reach the same level as in RCP3PD by 2100. In the short term, warming is lower (here up to 0.1°C by the 2020s) than in the low-emissions RCP3PD scenario (Figure 13). The relative cooling is mainly the result of higher SO_x emissions (due to delayed low-carbon related reductions), but if a high value for present-day radiative forcing from BC is assumed, a roughly equal part of relative cooling is a result of lower BC and related emissions (due to air-quality policy). However, such a pathway has two disadvantages.

Firstly, the probability of exceeding 2°C of warming in the 21st century more than doubles from 20% (RCP3PD) to 50%. Median warming is projected to be 0.3°C higher in 2100 and, crucially, given the

¹⁵ See, for example, <http://www.foreignaffairs.com/articles/137523/david-g-victor-charles-f-kennel-veerabhadran-ramanathan/the-climate-threat-we-can-beat>.

¹⁶ SO_x emissions would follow this downward path.

slow removal of CO₂ from the atmosphere, this effect is set to linger for centuries. Note that this delayed CO₂ pathway still includes fully all of the incremental effects of reductions in HFCs, CH₄ and others as shown in Figure 12 and the higher warming by 2100 is solely the effect of the 10-year delay in CO₂ measures.

Secondly, after the delay to 2030, energy-related CO₂ reduction rates until 2050 on average need to be 2.4% of 2010 levels per year, rather than the 1.5% per year in the original RCP3PD pathway with early CO₂ measures. Without these higher reduction rates to “catch up”, the CO₂ concentration and warming by 2100 will be even higher. From a multi-decadal perspective, delay scenarios have been shown to be riskier, with required faster CO₂ reductions after a 10-year delay too expensive and/or technically infeasible (IEA 2011; van Vliet et al. 2012).

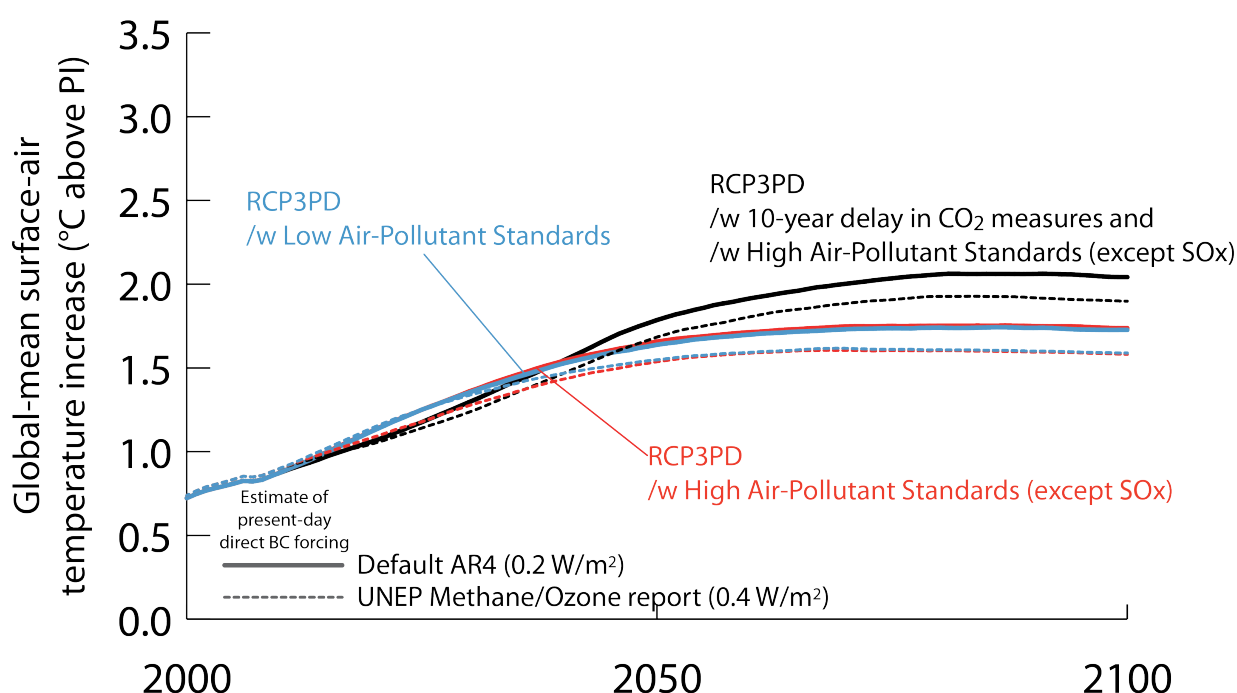


Figure 13: Global warming projections for low-carbon pathway RCP3PD (blue line) and a scenario where CO₂ reductions are delayed until 2030 but with large reductions in BC and related air pollutants, according to a shift from Low to High Air-Pollutant Standards, which exclude sulphur (black). In the delay case CO₂ and SO_x emissions follow the CP scenario until 2030, thereafter they are reduced rapidly towards RCP3PD levels by 2100. The red line shows the relative cooling benefits of only implementing accelerated air-pollutant reductions, without a delay in CO₂ measures. For comparison, the dashed lines show results for a few cases, applying present-day direct radiative forcing from BC as assumed in the UNEP Methane and Ozone reports (UNEP 2011d; UNEP 2011c), which is about double the estimate in IPCC AR4 (Forster et al. 2007).

There are large air-pollutant reduction benefits from the energy-system transformation required to reach a low-carbon development pathway. Given the large associated health-related and other benefits of improved air quality, this reduces the net costs of CO₂ measures (McCollum et al. 2011; McCollum et al. 2012). Reducing black carbon emissions, particularly from fossil-fuel sources, will decrease the net radiative forcing of the Earth and lead to slower or lower short-term warming. Reductions in these and other pollutants, such as SO_x, have major benefits for air quality (including SO_x) and significant regional climatic consequences. The scenarios examined here show that more rapid air-pollutant reductions beyond those achieved from energy system transformation alone

contribute relatively little to reducing warming, even when excluding comparably rapid action on SO_x emissions. However such deep reductions in air pollutants have large human health and other benefits.

It is likely only in a scenario where CO₂ measures were limited to what is implied by current emissions reduction pledges **and** where air-quality measures exclude SO_x, that accelerated action on BC and other air-quality measures can lead to a slower rate of warming for a few decades in a continuously warming world.

A comprehensive and effective mitigation strategy requires deep CO₂ reduction and non-CO₂ measures to work side-by-side to provide the most technically and economically feasible package that leads to the most effective and politically feasible strategy for implementation. This is important to bear in mind as in some cases there is confusion about the role of non-CO₂ gases in keeping to a 2°C and lower pathway. The most promising strategy from a climate-policy perspective would be to combine deep reductions of CO₂ and other long-lived GHGs with accelerated action on air pollutants. Without strong CO₂ reductions the warming goals considered here cannot be achieved.

2.5 Is it still possible to meet the 2°C and 1.5°C limits?

There have been an increasing number of statements from some in the scientific community and other commentators that meeting the 2°C warming goal is now beyond reach. It is clear that emissions are rising at such a rate that present trends are jeopardizing the world's ability to meet these warming goals. Present emissions trends place the world on a trajectory to exceed 3°C warming by 2100 by a wide margin. The International Energy Agency has repeatedly warned that we are running out of time to adopt the required measures to get onto a low emissions pathway and that there is a growing risk of locking into high emissions infrastructure that would be inconsistent with limiting warming to 2°C or lower.

Nevertheless, as the preceding discussion demonstrates, there are technically and economically feasible options (outlined in greater detail below) that with the right political will and urgency of action can limit warming to these levels. These goals are still more than feasible. This is not to underestimate the gravity and difficulty of the task, but simply to say that whether or not 2°C or 1.5°C warming limits are possible remains a political judgment about the likelihood of future action at the scale required. Great care therefore needs to be taken by scientific commentators on this issue to ensure that their political judgment about the likelihood of future action is carefully distinguished from the underlying science. There is a risk otherwise that assertions from the scientific community about the infeasibility of these goals will become a self-fulfilling prophecy which will serve only to undermine the development of the political will to put in place the policies required to close the emissions gap by 2020, and then move beyond that into the deeper emissions reductions required for the rest of this century.

3 Scaling up of existing initiatives can significantly narrow the 2020 gap

With the "Wedging the Gap" approach Ecofys has identified twenty-one initiatives that together have substantial potential to narrow the emissions gap, supporting and going beyond what national governments have pledged thus far under the UNFCCC. We estimate that the combined effect of scaling-up the initiatives could be in the order of 10 GtCO₂e reductions below BAU in 2020 plus the effect of enhanced reductions in methane and air-pollutant emissions (excluding sulphur). Roughly half the effect can be beyond what national governments have pledged.

Selection of only a few of these initiatives would not result in sufficient reductions. For each area of possible reduction, initiatives are already underway by actors other than national governments and often driven by interests outside of climate change. As such it is a green growth approach to global action on climate change.

Many initiatives can be implemented independently of direct national government intervention while for some, success may depend to an extent on intervention to remove barriers, reduce risk or provide other support. A varying degree of effort and resources will be needed to enhance action enough to fully exploit the available mitigation potential in each case.

We propose to build a coalition or coalitions formed from scaled-up initiatives as a green growth approach to global action on climate change. Working together on a coalition or coalitions of such initiatives could serve as a catalyst, greatly enhancing the willingness of non-state actors to engage in activity which reduces global GHG emissions and supports the implementation and strengthening of the pledges, for which national governments remain responsible.

A more detailed analysis of different organizations, business and civil society (supported where possible and necessary by governments) is now required in order to design an effective strategy to closing the mitigation gap.

Climate change is a global commons problem and this has given rise to two treaties and a multitude of secondary rules pursuant to the 1992 UNFCCC and the 1997 Kyoto Protocol (see e.g. den Elzen and Höhne 2010). Treaties are based on a sequence of steps that take time to deliver results: Sovereign national governments must agree on emissions policies they can commit to under the UNFCCC with other parties; if an agreement results then they subsequently introduce in their jurisdiction the right incentives for emissions reductions; and finally, companies, municipalities, other organizations and individual citizens must be induced or incentivized to take measures to reduce their GHG emissions.

Whilst over 90 countries have come forward with emissions pledges since the 2009 UN climate conference in Copenhagen, these fall short of keeping emissions levels within striking distance of 2°C. Additionally, there is evidence that governments are not taking the steps needed domestically to ensure implementation of pledges or are going too slow to keep up with their pledged commitments. Relying on the negotiation that is due to end in 2015 with commitments to take effect in 2020 may be a risky strategy.

It is increasingly clear that a top-down approach alone may be too risky, a bottom-up or a mixed approach should be favoured where countries or other actors propose actions (see for example the comments by the executive secretary of the UNFCCC, AFP 2012). So far, however, no concrete proposals relating to how a mixed approach might work have been put forward. Nor are concrete proposals on the table on a credible approach to strengthen the ambition of a top down approach.

This section presents some initial ideas to start strategic discussions for what a mixed approach might look like. This comprises a range of initiatives with coordinated additional action from bottom up – the "Wedging the Gap" approach (further developed from Blok et al. 2012) which drives early

and additional gains to those covered by formal pledges in the UNFCCC. We first identify and assess possible new initiatives and then quantify their effect on emissions.

3.1 The “Wedging the Gap” approach

Emissions reduction pledges of countries under the UNFCCC and “bottom up” initiatives by players other than national governments reinforce each other. Both have the objective to eventually bridge the emissions gap, but from two different angles. Ultimately, the objective is to close this gap and both sides are essential. Emissions reduction pledges of governments under the UNFCCC are not sufficient to close the gap and their ambition has not changed for over 2.5 years. While recognizing that national governments remain responsible for implementing and increasing the ambition of their pledges and actions, a new coalition or coalitions of scaled-up “bottom up” initiatives driven by sub-sovereign and non-state actors, motivated by interests additional to emissions reductions could give new momentum to international action on climate change - a green growth approach to global action on climate change.

The growing impact of “bottom-up” leadership from sub-sovereign, private sector and non-governmental actors indicates that now is an ideal time for converging this leadership into a global coalition of actors, which when combined with the leadership of national governments through the UN process can create sufficient momentum to bridge the 2020 emissions gap.

This paper provides an opportunity to refine the Wedging the Gap approach (Blok et al. 2012). The briefing examines twenty-one major global initiatives, with a variety of organizations involved, e.g. major cities, large companies or individual citizens. These initiatives all support the global effort to reduce GHG emissions. For each of the initiatives the following requirements hold:

- There is a concrete starting position from which a significant up scaling until the year 2020 is possible.
- There are significant additional benefits next to a reduction of GHG emissions.
- There is an organization (or a combination of organizations) that can lead the global initiative. The key is that actors in the initiative are driven by self-interest or internal motivation, not by external pressure.
- The initiative has the potential to reach a sizable emissions reduction by 2020, usually in the order of 0.5 GtCO₂e.

Why will this work? Action by an individual citizen, a municipality or even a large multinational company may be considered ‘a drop in the ocean’. Even individual actions by large companies or big cities will rarely have an impact of more than a few megatonnes CO₂e. What is now required is a coordinated global effort to motivate, accelerate and scale-up such individual “bottom-up” actions to create sufficient momentum to bridge the emissions gap in 2020. Acknowledging the limitations of national government led action through the UN process, it now appears increasingly important that leadership from non-state actors be strengthened and coordinated if we are to successfully bridge the emissions gap by 2020. Harnessing the benefits promised by green growth (UNEP, 2011) is increasingly motivating but acting alone or in isolation to achieve this is less attractive due to the risks presented by first-mover disadvantage in uncertain policy environments (Zenghelis, 2012). Instead, with bold leadership, acting as part of a larger coalition that has the potential to completely bridge the emissions gap will provide confidence and a sense of pioneering, ‘front-runner’ or first-mover advantage, making it more attractive to participate and take action.

Breaking the problem into thematic areas offers stronger potential for motivating and ultimately delivering the necessary emissions reductions needed to bridge the gap. The international negotiations have so far been very difficult due to fundamental disagreements between some countries on ambition and timing of actions. Many countries have made their action conditional to actions by others be it equally stringent reductions or financial contributions. Hopes to solve these

disagreements before 2015 are relatively low. Instead, working on thematic initiatives with sub-sovereign and non-state actors, offers a fresh hope that progress can be achieved immediately.

Working with those that are intrinsically motivated to act is a fundamentally different approach compared to getting agreement among countries that are to a large extent resistant to action. The international business community is increasingly clear of the massive opportunities which exist to do more with less and that business-as-usual can no longer sustain secure economic and social prosperity (WBCSD, 2010). Similarly, coalitions of sub-national leaders at regional and city level are demonstrating that by working together and learning from each other much more can be achieved than through working in isolation (C40, 2011).

To this end, it is necessary that globally leading organizations in the world of business, sub-sovereign and non-governmental organizations participate to form a coalition or theme specific coalitions so together they take responsibility for bridging the gap. Therefore, the key to the success of the Wedging the Gap approach is in forming and sustaining the coalition or coalitions.

The successes of the coalition or coalitions of initiatives have to be fed back into the UNFCCC process and have to have an impact on national government pledges. Otherwise national governments may feel that they are released of the pressure to implement and strengthen their pledge as they could rely on the success of the action elsewhere. This feedback can be achieved by inviting the coalition of initiatives to communicate with the UNFCCC process on a regular basis and a clear mandate for countries to revise their pledges in light of the new information.

3.2 Which initiatives could realize mitigation potential?

We generated a list of twenty-one prominent initiatives, further evolving the Wedging the Gap approach (Blok et al. 2012), reviewing submissions (by Parties and intergovernmental organizations) to the UNFCCC Durban Platform for enhanced Action¹⁷. These are presented in Table 3 under two broad categories covering 'actors' other than national governments (e.g. private companies, NGOs, IGOs, sub-national government) and 'sectors' covering specific themes (e.g. energy efficiency, renewable energy) and niche areas with high potential for mitigation (e.g. phasing out fossil-fuel subsidies, efficient cookstoves). This initial list may be supplemented by additional initiatives not yet included here.

For each initiative we consider a number of important issues which when combined, enable the reader to make an initial assessment of their feasibility for fast scaling up. These are included in Table 3 and described below.

Our initial review of existing global activity covering each of these initiatives reveals a lot is happening on the ground already. Many initiatives are being developed and delivered by parties other than national governments and often driven by interests outside of climate change. Many of them have already significant political momentum to be taken forward. These activities provide a good basis or starting point for enhanced action and in Table 3 we include a brief comment or example for each initiative.

Despite a great deal of activity, our initial desk research reveals that there appears to be a lack of clear quantified commitments or targets covering each of the existing initiatives. In a number of cases we found quantified targets¹⁸ but these are largely the exception and in their absence are more general statements of intent¹⁹.

¹⁷ <http://unfccc.int/bodies/awg/items/6656.php>

¹⁸ For example, The Global Alliance for Clean Cookstoves target of '100 million homes to adopt clean and efficient stoves and fuels by 2020' or the UN-SG's Sustainable Energy for All initiative's aim of 'universal access to modern energy services...and doubling the global rate of improvement in energy efficiency and share of renewable energy...by 2030'

¹⁹ For example: the UNEP/Greenpeace supported private sector partnership to reduce 'f-gas' emissions stated goals : <http://www.refrigerantsnaturally.com/about-us/what-we-do.htm>

Identifying the additional benefits each initiative offers to the actors and their stakeholders is crucial for understanding the drivers which motivate wider engagement and enhanced action. This is the 'self-interest' element – if not motivated to engage in these initiatives to address climate change, then perhaps the promise of increased competitiveness, local air quality or energy security will provide a stronger incentive, elements which are usually subsumed under the heading of green growth.

Many of these initiatives are not new and will come as little surprise to most engaged climate change policy professionals. Each suffers from one or more barriers to implementation which explains (at least in part) why more progress has not been made in realizing their full mitigation potential. Table 3 includes examples of many of these known barriers.

For each initiative we have identified potential lead organization(s) that based on our understanding of the sectors, consultation with sector experts and further desk research we consider to have sufficient capacity and motivation to lead efforts to scale up the initiative.

While initiatives and lead organizations identified here specifically exclude national governments, it is important to acknowledge that while they may not drive these initiatives, national governments can both help or hinder the pace and extent of their implementation. For example through implementing (or supporting) market and non-market based mechanisms to influence business and consumer behaviour (World Bank, 2012). We therefore also include an assessment of what extent of government intervention is likely to be required for effective implementation of these initiatives. While delivered in parallel to the activity national governments have already pledged through the UNFCCC process, most initiatives can be implemented independently of direct government intervention. However for some, success may depend to an extent on government intervention to remove barriers or provide other support. For example, national governments would have to regulate the access of renewable electricity generation to the electricity grid (where this is a barrier), but would not necessarily have to provide financial incentives. In this case some administrative but no direct financial burden is put on the national governments, which may be particularly relevant for developing country governments. Initiatives on e.g. voluntary offsetting or commitments for companies can be implemented largely independent of national government interventions.

We also include an indication of the importance of these activities for long-term emissions reductions beyond 2020 consistent with 2°C/1.5°C pathways. Some initiatives may achieve few emissions reductions by 2020, but may be essential for being able to reduce global emissions drastically by the middle of the century.

A final element is an indication of a proposed commitment or action for each initiative (see [Table 4](#)). For each initiative we elaborated a possible action or commitment. These actions are based on what we considered feasible given technical mitigation potential and conservative assumptions on participation. For example we considered that 30% of the top 1000 companies could commit to reduce their emissions 10% below BAU 2020. Another example could be for the wind initiative, to analyze the region specific barriers to implementation of wind power and then develop strategies to lift these barriers in order to achieve 1070GW of installed wind capacity by 2020.

In this briefing we do not assess the feasibility (or 'likelihood of success') for scaling up these initiatives in order to effectively realize their full mitigation potential as this briefing is intended to catalyze discussion and further analytic work and dialogue among a wide variety of actors. Such assessment should however take into account the starting point including the political momentum, additional benefits, known barriers, potential lead organization(s), government intervention required, the proposed actions and costs. These are also likely to be influenced by historical activity and current circumstances in each case. Any such assessment would also depend on the exact details of implementation of the initiatives. The assessment of feasibility reflects the varying degree of effort and resources which are likely to be required to enhance action enough to fully exploit the available mitigation potential in each case.

Table 3. Possible initiatives

Initiatives	Starting point	Additional benefits for the actors	Known barriers	Possible lead organization(s)	Government intervention required?	Importance for reductions beyond 2020
Actors						
Top-1000 companies emissions reduction	Many initiatives with companies adopting GHG reduction targets	Competitiveness, corporate social responsibility, front runner	Business often unwilling to invest beyond a 2 year payback period	World Business Council for Sustainable Development (WBCSD) ²⁰	No	
Supply chain emissions reductions	Several companies have social and environmental requirements for their suppliers	Competitiveness, corporate social responsibility, front runner	Perceived unwillingness of customers to pay the additional price	Consumer Goods Forum (CGF) ²¹	No	
Green financial institutions	200+ financial organization members of UNEP-FI	Corporate social responsibility, investor certainty, emerging markets	Perceived higher risks and lower rate of return	UNEP Finance Initiative (UNEP-FI) ²²	No	
Voluntary offset companies	Many companies already offset their emissions	Corporate social responsibility	Reoccurring additional costs	The Gold Standard Foundation ²³	No	
Voluntary offset consumers	Offsetting becomes more and more available	Individual responsibility	Reoccurring additional costs	The Gold Standard Foundation	No	
Major cities initiative	Major cities implementing GHG reduction action	Local air quality, attractiveness of the city, creation of local jobs	Perceived additional costs	C40 Cities Climate Leadership Group (C40) ²⁴ International Council for Local Environmental Initiatives (ICLEI) ²⁵	Sub-national	High
Sub-national governments	Sub-national programmes already well underway in key regions with R20	Local competitiveness, jobs and energy security	Lack of legislative power. Lack of finance.	Regions20 (R20) ²⁶	Sub-national	
Sectors						
Building heating and cooling	Current theme for UN-SG 5-year term + strong calls for action from IEA and others	Increased comfort, net savings	Uncertainty of new technologies, uncertainty of payback	UN Secretary General's Sustainable Energy for All Initiative (SE4All) ²⁷	Supportive	High

²⁰ <http://www.wbcsd.org>

²¹ <http://www.theconsumergoodsforum.com/>

²² <http://www.unepfi.org>

²³ <http://www.cdmgoldstandard.org>

²⁴ <http://live.c40cities.org/>

²⁵ <http://www.iclei.org/index.php?id=10829>

²⁶ <http://www.regions20.org/>

²⁷ <http://www.sustainableenergyforall.org>

Initiatives	Starting point	Additional benefits for the actors	Known barriers	Possible lead organization(s)	Government intervention required?	Importance for reductions beyond 2020
Ban of incandescent lamps	Progress already good with many countries already banning them	Net savings	Habit	UNEP/GEF en.lighten initiative ²⁸	Yes	
Electric appliances	Many labelling schemes and standards	Net savings	Uncertainty of new technologies, uncertainty of payback	The Collaborative Labelling & Appliance Standards Program (CLASP) ²⁹ Super-efficient Equipment and Appliance Deployment (SEAD) Initiative ³⁰	Supportive	
Cars & trucks emissions reduction	Many manufacturers developing more efficient vehicles, electric vehicles are seen as the future	Long-term competitive position, Local air quality	Long standing resistance from established manufacturers	UNEP Partnership for Clean Fuels and Vehicles (PCFV) ³¹ International Organizations of Motor Vehicle Manufacturers (OICA) ³²	Supportive	
Boost solar photovoltaic energy	Average unit cost/price has declined rapidly in recent years	Export market and local value added, security of energy supply	Lack of grid access and net metering rules	International Renewable Energy Agency (IRENA) ³³ International Renewable Energy Alliance (IREA) ³⁴	Removal of barriers	High
Boost wind energy	Steady global growth	Export market and local value added, security of energy supply	Stable investment environment; Planning consent; grid access;	Global Wind Energy Council (GWEC) ³⁵	Removal of barriers	High
Access to energy through low-emissions options	Current theme for UN-SG 5-year term + strong calls for action from IEA and others	Access to energy, development goals	Additional costs	UN Secretary General's Sustainable Energy for All Initiative (SE4All) ³⁶	Removal of barriers	
Phasing out subsidies for fossil fuels	Highly recognized option to reduce emissions (see joint IEA/OECD/World Bank report ³⁷)	Improve investment in clean energy. Other environmental and health and security benefits from reduction in fossil-fuel use	Social and political difficulties	International Energy Agency (IEA) ³⁸ World Trade Organization (WTO) -Committee on Trade and Environment (CTE) ³⁹	Yes	

²⁸ <http://www.enlighten-initiative.org>

²⁹ <http://www.clasponline.org/>

³⁰ <http://www.superefficient.org>

³¹ <http://www.unep.org/transport/pcfV/>

³² <http://oica.net/category/climate-change-and-co2/>

³³ <http://www.irena.org> Note: Only likely if combined into a broader 'Renewable energy' initiative

³⁴ <http://baringo.invotech.se/>

³⁵ <http://www.gwec.net>

³⁶ <http://www.sustainableenergyforall.org>

³⁷ http://www.worldenergyoutlook.org/docs/second_joint_report.pdf

³⁸ <http://www.iea.org/>

Initiatives	Starting point	Additional benefits for the actors	Known barriers	Possible lead organization(s)	Government intervention required?	Importance for reductions beyond 2020
International aviation and maritime transport	Aviation and shipping industry are seriously considering efficiency measures and biofuels	Competitive advantage	Higher investment costs, unknown technology, longer travel times (shipping)	Leading airplane and ship manufacturers	Supportive	High
Fluorinated gases (HFCs, PFCs, SF6)	Recent industry led initiative underway	Competitive advantage	Unknown technology	Refrigerants, Naturally! ⁴⁰	Supportive	High
Reduce deforestation	Reduce with an integrated approach	Local air pollution, biodiversity and support for local population	Capacity to enforce law	Prince of Wales International Sustainability Unit (PCFISU) ⁴¹	Yes	
Agriculture	Clear will to act from environmental NGOs, IFAP members and REDD+ partnership etc.	Cost reductions through energy efficiency; Potential new markets in bioenergy and sequestration; Rural development benefits;	Land rights/ ownership issues. Market distortions (e.g. subsidies, uncoded environmental externalities)	International Federation of Agricultural Producers (IFAP) ⁴² The Global Research Alliance on Agricultural Greenhouse Gases ⁴³	Supportive	
Enhanced reductions methane and air-pollutants (excl. SOx)	New UNEP initiative just launched with strong US backing	Health, local air quality		UNEP Climate and Clean Air Coalition To Reduce Short-Lived Climate Pollutants ⁴⁴	Supportive	
Efficient cookstoves	Many programmes for scaling up	Health, local air quality and pressure on forests from fuel wood demand	Cultural habits	The Global Alliance for Clean Cookstoves ⁴⁵	No	

3.3 By how much could emissions be reduced in 2020?

We have made a first attempt to quantify the reduction potential, based on an assumed commitment for each initiative, see [Table 4](#). These commitments are set in a conservative manner, e.g. assuming that only a small share of the total theoretical potential is realized. We assume that only part of the full technical mitigation potential is likely to be realized through self-interest. For example, we assumed that only the front-runner 30% of the top 1000 companies will take on a commitment.

We also made a rough first order estimation of the overlap of the initiatives with each other and also with the pledges made by countries, for details see Appendix.

³⁹ http://www.wto.org/english/tratop_e/envir_e/envt_intro_e.htm

⁴⁰ <http://www.refrigerantsnaturally.com/>

⁴¹ <http://www.pcfisu.org/>

⁴² <http://www.ifap.org/issues/climate-change/en/>

⁴³ <http://www.globalresearchalliance.org>

⁴⁴ http://www.unep.org/gc/gcss-xii/docs/20th_SideEvents_03.asp

⁴⁵ <http://cleancookstoves.org/>

Table 4. Estimation of the possible impact of the initiatives

	Initiative	Proposed commitment	Emissions reductions in 2020 (GtCO ₂ e)
Actors	Top-1000 companies emissions reduction	30% of the top 1000 companies 10% below BAU 2020 and all to reduce their non-CO ₂ by 50%	0.7
	Supply chain emissions reductions	30% of companies require their supply chains to reduce 10% below BAU 2020	0.2
	Green financial institutions	The 20 largest banks reduce the carbon footprint of 10% of their assets by 80%.	0.4
	Voluntary offset companies	Light industry and commercial first reduce their own emissions and then offset 20% of their emissions (retire credits)	2.0
	Voluntary offset consumers	10% of families in high-income countries first reduce and then offset their emissions (retire credits)	1.6
	Major cities initiative	C40 (or equivalent) reduce 20% BAU 2020	0.7
Sectors	Sub-national governments	15 to 20% below BAU in 2020	0.6
	Building heating and cooling	Full reduction potential realized for 30% of all buildings	0.6
	Ban of incandescent lamps	Ban of incandescent lamps by 2016	0.5
	Electric appliances	Use of most energy efficient appliances on the market	0.6
	Cars & trucks emissions reduction	Globally save one additional litre per 100 km in 2020	0.7
	Boost solar photovoltaic energy	Remove barriers by introducing good grid access and net metering rules to achieve 1600 GW by 2020	1.4
	Boost wind energy	Risk reduction for investments in wind energy to achieve 1070 GW by 2020	1.2
	Access to energy through low-emissions options	All people currently without access to electricity get access through low-emissions options	0.4
	Phasing out subsidies for fossil fuels	Half of all fossil-fuel subsidies are phased out	0.9
	International aviation and maritime transport	Half of the mitigation potential is realized	0.2
Total	Fluorinated gases initiative (HFCs, PFCs, SF ₆)	Half of the mitigation potential is realized	0.3
	Reduce deforestation	Halving global deforestation	1.8
	Agriculture	30% of the mitigation potential is realized	0.8
	Enhanced reductions methane and air-pollutants (excl. SO _x)	Implement half of the potential	*
	Efficient cookstoves	Replace half of the existing cookstoves	*
			**9.7

*: Cannot be estimated consistent with the definition of the emissions gap

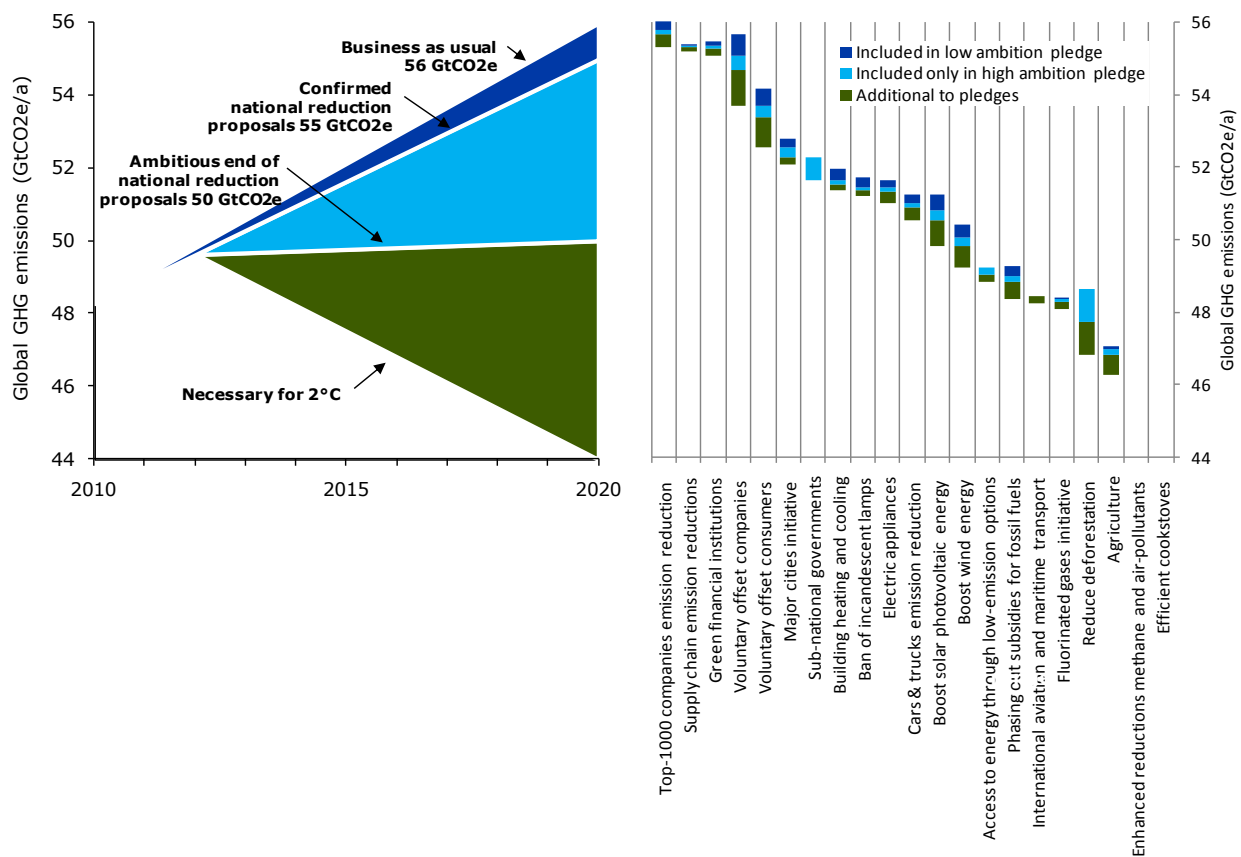
**: Accounting for overlaps, see appendix

The initiatives have in sum substantial potential to narrow the gap, going beyond what governments have pledged. The combined effect of the initiatives can be quite substantial: roughly 10 GtCO₂e reductions below BAU in 2020 plus the effect of enhanced reductions in methane and air-pollutant emissions (excluding sulphur). This can be compared to the gap of around 12 GtCO₂e between BAU and what would be necessary for the 2°C limit. The combined effect of the initiatives could also result in reductions significantly beyond high ambition pledges: roughly 4-5 GtCO₂e.

It also shows that it is not sufficient to concentrate on only a small number of these initiatives. Every effort has to be made to scale up as many of these initiatives as possible to realize a significant effect, because the gap is large, overlaps with pledges by national governments exist and some initiatives may fail along the way.

A rough estimate of impact, overlaps and combined contributions are depicted in Figure 14. It shows the size of the emissions gap in 2020 (left) compared to the potential emissions reductions by the initiatives (right). The effect of initiatives on emissions overlap, indicated by the fact that the effect of individual initiatives are not stacked. For the reduction of each individual initiative, the figure shows also the estimated share that is already in low ambition pledges, in high ambition pledges and which goes beyond the pledges.

Figure 14: Gap and possible cumulative impact of the initiatives



4 Next steps

We see the following next steps as necessary:

- **Systematic assessment of uncertainties in relation to air pollutants and climate policy:** A substantial scientific issue in relation to air pollutants and climate change policy is that of the uncertainty in aerosol properties and from different sources of precursors such as fossil-fuel and biofuel black carbon, biomass black carbon and SO_x.
- **Deeper evaluation and quantification of measures:** There is a need to quantify and evaluate the feasibility of measures identified and to place them within an integrated framework to assess their efficacy in meeting climate and sustainable development goals.
- **Identify a convener or conveners of a coalition of initiatives:** We have shown how initiatives can contribute significantly to closing the gap and that these initiatives would benefit from being part of a global coalition. Such initiatives could be brought together by one convener or could be a loose coalition of initiatives with a secretariat.
- **Seeking commitments from the sectors and associations involved:** As a next step, existing initiatives have to be effectively engaged to bring them together into a coalition.
- **Presenting an overall agreement in December 2012:** If the process is successful, a coalition or coalitions of initiatives could be presented in December 2012 at the margins of the UNFCCC COP.

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Appendix A: Supplementary Figures

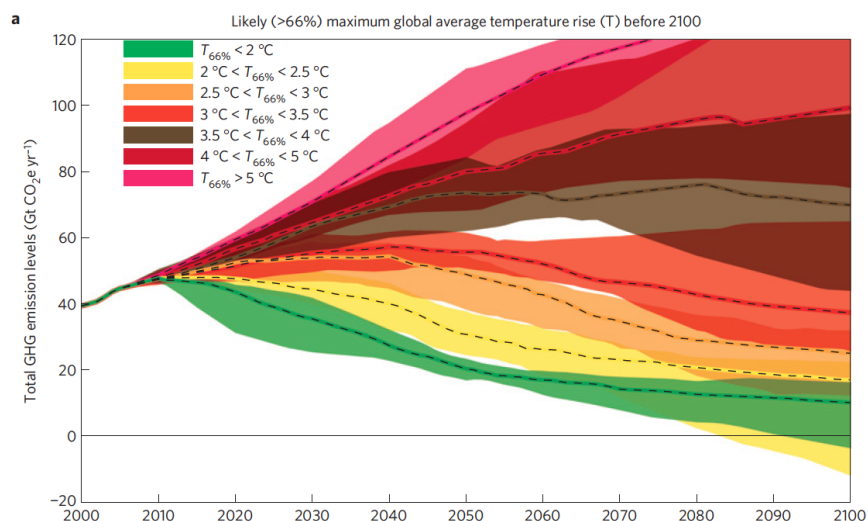


Figure A1: Range of emissions pathways from published integrated assessment models (Rogelj et al. 2011b)

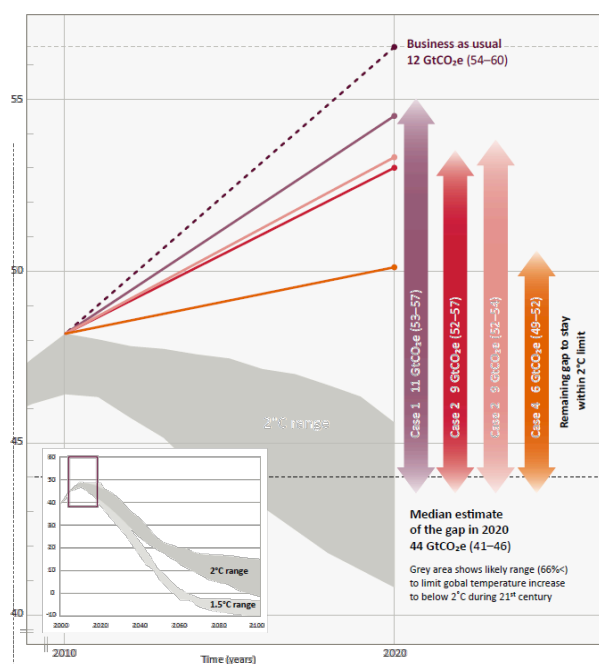


Figure A2: Estimates of the emissions gap between projected emissions in 2020 based on the CP scenario, and the range of total GHG emissions in 2020 of integrated assessment modelling (IAM) scenarios from the literature that hold global temperature increase to below 2°C during the 21st century with at least 66% chance, from (UNEP 2011a). The four arrows at the right-hand side illustrate four ways of interpreting the CP scenario. Case 1 and 2 assume that the lower ambition end of the pledges is implemented in combination with lenient and stringent emissions accounting rules, respectively. Case 3 and 4 assume that higher ambition end of the pledges is implement, also in combination with lenient and stringent accounting rules, respectively.

Appendix B: Details of the quantification of impacts of, and overlaps between, initiatives

For the quantification of the total impacts of the initiatives on global GHG emissions, we applied the following three steps:

- Quantification of the impact on GHG emissions of each initiative separately
- Calculation of the effect additional to pledges by assuming factors of overlap between the initiatives and pledges
- Calculation of the cumulative effect of the initiatives by assuming factors of overlap between initiatives

The quantification of the effect of individual initiatives is based on simple assumptions. For example, we assumed that half of the deforestation potential stated in the literature can be achieved.

The overlap of the initiatives to the pledges is taken into account by assuming overlap factors, see [Table 5](#). Pledges of countries are only in rare cases specified by sector, so it is not apparent from the pledges how exactly they will overlap with the initiatives. Based on our knowledge of the pledges, we assumed the overlap factors given in the last columns in [Table 5](#).

The overlap between initiatives is also estimated by assuming overlap factors, see last column of [Table 5](#). Moving from top to bottom of the table, we assumed which share of the effect of the initiative is additional to all of the initiatives above. Summing this additional effect from top to bottom gives the total effect of all initiatives.

Table 5. Assumptions on the overlaps

			Emissi ons reducti ons (GtCO 2e)	Addit ional to low ambi tion pled ges	Addit ional to high ambi tion pled ges	Addit ional to all initia tives abov e
Actors	Initiative	Assumed commitment				
	Top-1000 companies emissions reduction	30% of the top 1000 companies 10% below BAU 2020 and all to reduce their non-CO2 by 50%	0.7	70%	50%	
	Supply chain emissions reductions	30% of companies require their supply chains to reduce 10% below BAU 2020	0.2	70%	50%	50%
	Green financial institutions	The 20 largest banks reduce the carbon footprint of 10% of their assets by 80%.	0.4	70%	50%	30%
	Voluntary offset companies	20% of light industry and commercial offset emissions	2.0	70%	50%	70%
Sectors	Voluntary offset consumers	10% of families in high-income countries offset their emissions	1.6	70%	50%	70%
	Major cities initiative	C40 (or equivalent) 20% BAU 2020	0.7	70%	30%	70%
	Sub-national governments	15 to 20% below BAU in 2020	0.6	100%	0%	70%
	Building heating and cooling	The full reduction potential is realized for 30% of all buildings	0.6	50%	30%	50%
	Ban of incandescent lamps	Ban of incandescent lamps by 2016	0.5	50%	30%	30%
	Electric appliances	Use of most energy efficient appliances on the market	0.6	70%	50%	30%
	Cars & trucks emissions reduction	Globally save one additional litre per 100 km in 2020	0.7	70%	50%	70%
	Boost solar photovoltaic energy	Remove barriers by introducing good grid access and net metering rules	1.4	70%	50%	50%
	Boost wind energy	Risk reduction for investments in wind energy	1.2	70%	50%	50%
	Access to energy through low-emissions options	All people currently without access to electricity get access through low-emissions options	0.4	100%	50%	100%
	Phasing out subsidies for fossil fuels	Half of all fossil-fuel subsidies are phased out	0.9	70%	50%	50%
	International aviation and maritime transport	Half of the mitigation potential is realized	0.2	100%	100%	70%
	Fluorinated gases initiative	Half of the mitigation potential is realized	0.3	90%	70%	50%
	Reduce deforestation	Halving global deforestation	1.8	100%	50%	70%
	Agriculture	30% of the mitigation potential is realized	0.8	90%	70%	70%
	Enhanced reductions methane and air-pollutants (excl. SOx)	Implement half of the potential		100%	100%	100%
	Efficient cookstoves	Replace half of the existing cookstoves		100%	100%	100%
Total			*9.7			

*: Accounting for overlaps