PBL Netherlands Environmental Assessment Agency

# LONG-TERM CLIMATE POLICY TARGETS AND IMPLICATIONS FOR 2030

PBL Policy Brief

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This policy brief summarises some of the key findings of the work of the IMAGE and FAIR research teams in various climate policy research projects. It also has benefited from the DG Climate and DG Research, funding of the projects AMPERE, LIMITS and COMBINE.

**Long-term climate policy targets and implications for 2030**

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# Main Findings

- **In order to achieve the 2 °C climate target with a likely probability (>67%), cumulative global $CO_2$ emissions over in the 2010–2100 period need to be constrained to about 1000 $GtCO_2$ (range of 800–1200 $GtCO_2$).** The range depends on several important uncertainties, including those on long-term non-$CO_2$ emission reduction options and the climate system.

- **The projected global 2020 greenhouse gas emission level is around 10% above the 2010 level, also taking currently implemented and/or planned policies into account. This is considerably higher than the emission level of the least-cost mitigation scenarios consistent with a likely chance of achieving the 2 °C target, as discussed in the literature.** For our analysis, we assessed current emission trends and climate policies in key countries and regions worldwide. The resulting global greenhouse gas emission level by 2020 would be about 53 $GtCO_2eq$, with an uncertainty range of about 2.5 $GtCO_2eq$ in both directions. The 'least-cost' 2 °C scenarios show lower 2020 emission levels, in the range of 38 to 47 $GtCO_2eq$. These scenarios, however, typically assume immediate implementation of cost-optimal mitigation policies (often from 2010 onwards) in all countries and sectors and, therefore, are only useful as theoretical references.

- **Inertia in the implementation of enhanced policies (beyond planned policies) implies that large emission reductions by 2020 are unlikely. This poses the question of what emission reductions would be required *after* 2020 to still achieve the 2 °C target with a likely chance.** The required emission reductions post-2020 will play a key role in future climate policy, as well as in the negotiations at the 21st Conference of the Parties on Climate Change 2015 (COP21) in Paris in 2015. New scenarios can explore the required emission reduction levels by taking the expected 2020 emissions levels implied by current implemented and planned policies as a starting point. Optimal scenarios from 2020 and 2030 onwards can serve as a new point of reference, answering the question of whether ambitious climate targets are still possible, from a technical and economic point of view.

- **Model analysis suggests that it is possible to achieve the 2 °C climate target with a likely chance, given the estimated 2020 emission level, based on current implemented and planned policies. However, immediate and strongly enhanced international climate action is needed to implement stringent and comprehensive reduction measures.** More specifically, a likely chance of achieving the 2 °C target requires global emission to peak in the 2020–2030 period, and 2030 emission levels to be near the current level, followed by rapid reductions thereafter. This requires an average annual global decarbonisation rate of 4% to 6% for the period from 2020 to 2050.

- **Further delay in reducing emissions beyond 2020, i.e. continuing current and planned policies until 2030, will make it increasingly more difficult to achieve the 2 °C target; global emission reduction rates will need to be much higher, mitigation costs are also expected to be higher, the risk of overshooting the 2 °C target then becomes greater and so will the dependence on technologies that often meet with public resistance.** Models typically indicate that it is still possible to achieve the 2 °C target if no additional policies are implemented before 2030. However, reaching the target would become increasingly more difficult and costly, and would increasingly rely on negative emissions in the second half of the century.

- **Overall, the results show that achieving the 2 °C target critically depends on well organised international policies, in the short term, to realise stringent reductions during the 2020–2030 period.** This not only encompasses formulating ambitious mitigation goals and increasing the participation of parties in climate policy, but above all also involves taking real action; implementing long-term incentive structures to reduce emissions (given the inertia in economic and energy systems) and stimulating innovation. A key question is how to increase the willingness in implementing ambitious climate mitigation policies. In this context, it useful to explore additional routes that would lead to a reduction in greenhouse gas emissions (e.g. maximising synergies with other policy areas).

# 1 Introduction

**Countries, worldwide, have agreed that international efforts should be aimed at keeping the global mean temperature increase below 2 °C, compared to pre-industrial levels.** In 2011, they agreed to the so-called Durban Platform for Enhanced Action in designing post-2020 international climate policy. The platform sets out a strategy to adopt a new legal framework for international climate policy during the climate conference COP21, in Paris in 2015, building upon earlier international efforts including the Cancun Agreements of 2010. The Cancun Agreements define both *long-* and *short-term* targets. For the long term, the Cancun Agreements state that international efforts should be aimed at keeping global mean temperature increase below 2 °C, compared to pre-industrial levels. They also state that still needs to be evaluated whether, alternatively, a 1.5 °C target should be set. For the short term, the Cancun Agreements rely on the emission reduction proposals (pledges) made by many countries for 2020.

**Current and planned policies are inconsistent with emission levels based on least-costs pathways to achieve the 2 °C target.** Several reports (most noteworthy the UNEP Emissions Gap Reports (UNEP, 2013, 2014)) have evaluated short-term reduction pledges against the agreed long-term target of 2 °C. The UNEP Emissions Gap Report 2013 pointed out that there will be an 'emission gap' by 2020, defined as the difference between the emission level in 2020 resulting from the full implementation of pledges and commitments and the emission level required to achieve the 2 °C target. The last are based on long-term least-cost global emission pathways as published widely in the scientific literature. However, these least-cost pathways are somewhat hypothetical, as many of them assume cost-optimal implementation of emission reductions in all countries and all sectors, often even as early as from 2010 onwards. These conditions, obviously, cannot be met in the near term, given the currently formulated and planned policies (including the commitments and pledges made by developed and developing nations) and the time involved in implementing these policies (see also Box 1.1). Although countries may still increase the ambition levels of their existing 2020 pledges and policies, expectations are that the probability and possibility of major further reductions (to close the gap) for 2020 are low. Based on these considerations, the emerging crucial question is whether it is still possible to reconcile near-term policies with the long-term 2 °C target after 2020 by introducing more stringent policies. More specifically, the question explored in this brief is that of ***what level of emission reduction would be needed within the 2020-2030 time frame, based on an assessments of current and planned policies, in order to still be able to achieve the 2 °C climate target?*** From this overall question, we derived three related questions (which are elaborated in the subsequent three chapters):

- What long-term (cumulative) emission levels are consistent with achieving the 2 °C target?
- What 2020 and 2030 emission levels will result from implementing the existing current and planned climate policies?
- Is it possible to reconcile the 2020 and 2030 emissions levels with a pathway towards achieving the 2 °C target, assuming that after 2020 or 2030 it will be possible to formulate a more effective climate policy?

**Box 1.1: The use of model-based scenarios to explore future climate policy**

Quantitative scenarios are often used as a means to explore possible pathways for future climate policy. These scenarios are based on models that combine information on projected trends in activity levels in different economic sectors, expected costs of different technologies to supply energy and reduce greenhouse gas emissions, with the expected consequences for climate change. Obviously, these models are only a simplification of reality. A key simplification often made in models that emission reductions can be made in all sectors and regions on the basis of cost-effectiveness. This assumption aims to provide a theoretical lower-bound estimate of the overall climate costs and the time needed for society to respond to climate change. It intends to respond to the questions of how, based on the model assumptions, an optimal mitigation strategy should be designed and whether targets are still achievable. Clearly, there are reasons to assume that these conditions cannot be achieved in reality. First, it seems likely that many countries and regions will not be participating in climate policy in the short-term, among other things, due to political and equity considerations. Furthermore, other factors not included in the models, such as a lack of full information, a limited ability to provide investments, and inertia in decision-making processes, could slow down the process and thus reality may deviate from the model outcomes. It should be noted that models can also be regarded as conservative; they typically do not include break-through technologies.

The scenarios presented in this study assume that climate policy will be fragmented up to 2020 or 2030, to explore the impact of the current delay in implementing ambitious international climate policies. In this way, they take the political situation into account more effectively, for the short-term. From 2020 or 2030 onwards, an effective policy response is assumed, to explore the consequences of the current delays. They key question is whether the current delay will make the 2 °C target unfeasible, even if an effective policy response is possible after 2020 or 2030. The question of whether, in the real world, more ambitious climate policies can be formulated after 2020 or 2030 depends on factors such as observed climate impacts, new policy initiatives and/or progress in establishing sufficient support for international climate policy.

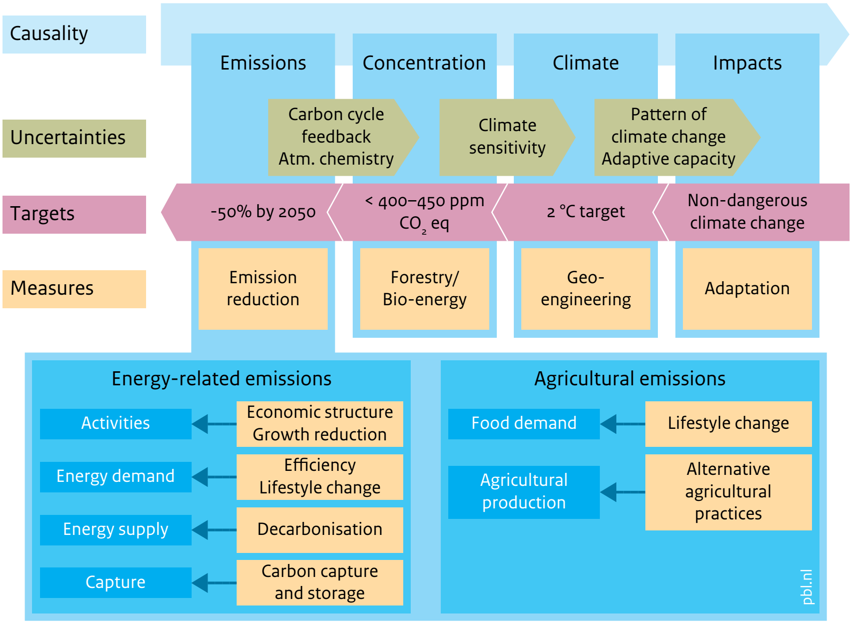
# 2 What long-term (cumulative) emission levels are consistent with achieving the 2 °C target?

**The IPCC Fifth Assessment Report (IPCC, 2013) concludes that anthropogenic greenhouse gas emissions are extremely likely to be the main cause of the temperature increase observed since the mid-20th century and that further warming is expected.** The same report also indicates that $CO_2$ forms the most important anthropogenic greenhouse gas, while other, non-$CO_2$ greenhouse gases contribute for 20% to 30% to total global warming (see also Box 2.1). Scenario studies can provide insight into the consequences of future greenhouse gas emissions. This chapter discusses the implications of different temperature targets for required emission levels, in order to evaluate emission trends in the next decades in subsequent chapters.

**Measures to mitigate or adapt to climate change can be introduced in various parts of the causal chain of climate change.** As indicated in Figure 2.1, the climate problem can be expressed in terms of a causal chain of climate change that runs from emissions via concentrations to climate change and finally impacts.

Article 2 of the UNFCCC (UNFCCC, 1992) states that the objective of international climate policy is to prevent dangerous anthropogenic interference in the climate system. One possible interpretation of this objective is that policies should be formulated aiming to avoid an increase in global mean temperature of above 2 °C (Cancun Agreement). Models can be used to derive the emission implications of such a target. Clearly, in each step of the causal chain, also the uncertainties that play a role must be taken into account. Key uncertainties, for instance, include the relationship between greenhouse gas concentrations and global warming (the so-called climate sensitivity) and between warming and the impacts of climate change (e.g. water scarcity).

Figure 2.1
**Causality, targets and measures of climate change**




Source: PBL

*Overview of the causal chain of climate change.*

As indicated in Figure 2.1, there are several leverage points in the system to respond to climate change:

– Reducing greenhouse gas emissions (mitigation).
– Removing $CO_2$ from the atmosphere (often called carbon-dioxide removal, CDR);
– Limiting climate change by breaking the link between greenhouse gas concentrations and warming (often called solar radiation management, SRM);
– Limiting climate impacts through adaptation measures;

This policy brief concentrates on the first response option. This chapter derives the long-term emission pathways that would be consistent with achieving the 2 °C target.

**Climate research indicates that higher levels of warming are associated with more severe impacts and higher risks of extreme events. The probability of high levels of warming is a function of the concentration of greenhouse gases in the atmosphere and its change over time.** Based on earlier assessments of the scientific evidence of climate impacts and risks, countries worldwide have decided that national and international climate policies should be aimed at limiting global mean temperature

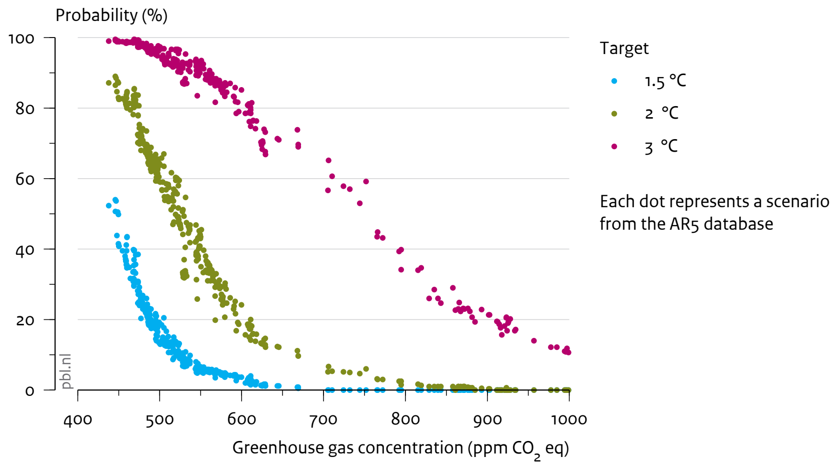
**Box 2.1: Greenhouse gas forcing, emissions and concentrations**

Not only $CO_2$, but also several other greenhouse gases contribute to climate change. These gases have different atmospheric lifetimes and radiative properties. Several metrics have been introduced that allow comparison between the impacts of these gases on global warming in a common unit ($CO_2$ equivalent emissions). The metric that has been used in policy-making is the global warming potential (GWP), which integrates the radiative forcing of a gas over a chosen time horizon, relative to that of $CO_2$. Most often, a time horizon of 100 years is used, which is a somewhat arbitrary choice. Radiative forcing is a measure of the contribution to warming at a certain point in time, which is a direct function of the concentration of greenhouse gases in the atmosphere. Forcing is typically expressed in terms of $W/m^2$. Alternatively, however, it could also be express in terms of the $CO_2$ concentration level that would have caused the same level of warming of all gases together. This is called the $CO_2$ equivalent concentration level. Although both $CO_2$ equivalent emissions and $CO_2$ equivalent concentrations are designed to compare across various gases, there is a clear distinction between them.

increase to a maximum of 2 °C above pre-industrial levels (see also introduction). Unfortunately, the exact relationship between greenhouse gas concentrations (the main cause of climate change) and a change in global mean temperature is subject to considerable uncertainty. As a result, it is not possible to directly indicate which greenhouse gas concentration level would be consistent with achieving the 2 °C target. Instead, only probabilities can be given. Earlier reports have argued that achieving the 2 °C target with a high probability requires keeping greenhouse gas concentrations at a level of around 450 ppm $CO_2$ eq (Meinshausen et al., 2009).

It is important to realise that stabilising greenhouse gases at low concentration levels also decreases the probability of exceeding increases in temperature levels over 2 °C – thereby reducing more serious risks associated with these higher temperatures, as well. For instance, a concentration level of 450 ppm $CO_2$ eq has a high probability of keeping this increase below 2 °C, and even a more than 95% probability keeping it below 3 °C. For 650 ppm $CO_2$ eq, the probability of keeping it below 2 °C is less than 20%, but there is also a more than 5% probability of overshooting 4 °C, leading to much more severe climate impacts (see Figure 2.2). The option of negative emissions implies that scenarios can also, to some degree, first overshoot a certain concentration level, and subsequently return to lower concentration levels. In fact, very few scenarios can be found in the literature that prevent an overshoot of the 450/500 ppm $CO_2$ eq level, given the lifetime of $CO_2$ in the atmosphere and the inertia in the socio-economic system.

Figure 2.2
**Probability of achieving temperature targets as a function of greenhouse gas concentration levels**



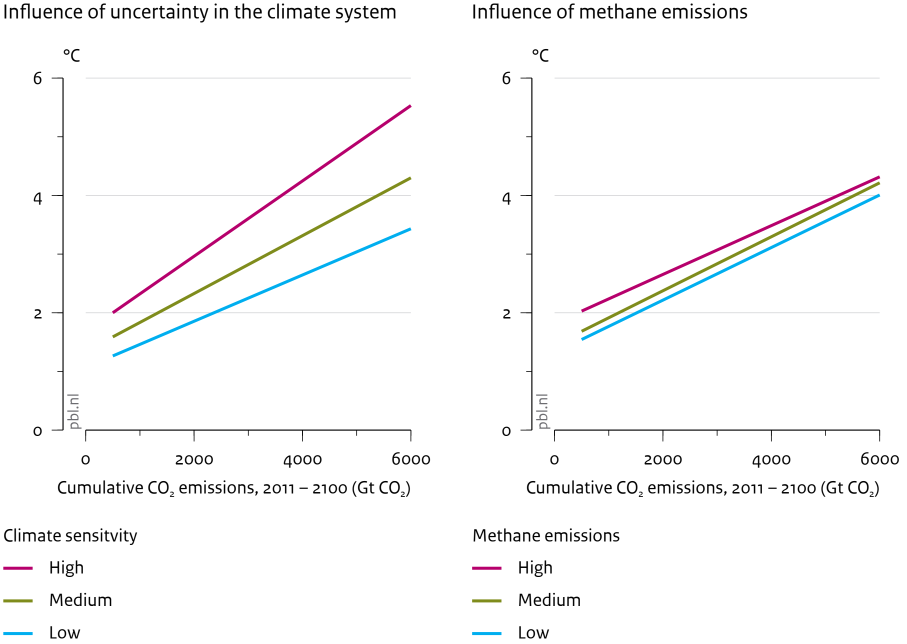

Source: MAGICC6 calculations using IPCC AR5 WG III database 2014

*Probability of achieving different temperature targets as a function of greenhouse gas concentration levels (see also Box 2.1). Figure shows the probability to remain below a temperature target (transient warming) versus the maximum $CO_2$ eq concentration level during the entire 21th century.*

**Limiting climate change to a 2 °C increase in temperature requires restricting cumulative future $CO_2$ emissions to a tight carbon emissions budget of about 1000 GtCO2 beyond 2010.** Scientific publications and assessments, including Meinshausen et al. (2009) and the 2013 IPCC Working Group I report (IPCC, 2013) have emphasised the strong relationship between cumulative $CO_2$ emissions and temperature increases. This means that the 'carbon budget' required for achieving the 2 °C target with a high probability can be determined. Figure 2.3 shows the relationship between cumulative emissions and increases in global mean temperature, using a large set of scenarios. Although the figure confirms the relationship between cumulative emissions and temperature, there is a wide range of uncertainty as the relationship is contingent on the level of uncertainty about the climate system[1] and non-$CO_2$ emissions:

– *The uncertainty in the climate system.* As shown in Figure 2.2, there is considerable uncertainty about the relation between greenhouse gas concentrations and global warming. For instance, a concentration level of 500 ppm $CO_2$ eq has a probability of around 20% to remain below 1.5 °C and 60% to remain below 2 °C, but could also lead to a warming of over 3 °C. This uncertainty in the climate system, dominated by the so-called climate sensitivity (equilibrium temperature warming) is by far the most important uncertainty factor when determining a carbon budget for achieving a 2 °C target. This uncertainty also impacts the relationship between carbon budget estimates for the 2011–2100 period, as shown in the left panel of Figure 2.3.

Figure 2.3
**Relationship between cumulative $CO_2$ emissions and temperature increase**




Source: MAGICC6 calculations using IPCC AR5 WG III database 2014

*Relationship between cumulative $CO_2$ emissions over the 2011–2100 period and temperature increase (based on MAGICC model runs). The figure also illustrates the uncertainty, i.e. the influence of uncertainty in the climate system (16, 50 and 84 percentile of model runs) (left panel) and methane emission scenarios within the AR5 WGIII database (low, medium and high 2100 methane emission levels) (right panel).*

- *Uncertainty due to emissions of non-$CO_2$ gases*. Although $CO_2$ dominates overall anthropogenic warming, components other than $CO_2$ also have positive or negative contributions to climate change. Greenhouse gases such as methane and $N_2O$ have a warming effect, while some of the aerosols have a cooling effect. Overall, $CH_4$, $N_2O$, HFCs, PFCs and $SF_6$ (all of which are included in the Kyoto Protocol) contributed around 25% to the radiative forcing in 2010. Future emissions of non-$CO_2$, including methane, are uncertain and, therefore, impact the relationship between carbon budget and temperature. The right panel of Figure 2.3 shows the effect on the carbon budget of the uncertainty about methane emissions as captured in the set of scenarios included in the AR5 database. The figure indicates that methane emissions (and policies aimed to reduce them) still play a noticeable role for the carbon budgets to be consistent with achieving the 2 °C target. Although methane is the most important non-$CO_2$ greenhouse gas, the carbon budgets to a certain degree also depend on other non-$CO_2$ emission trajectories.

Table 2.1
**Carbon budgets for certain probabilities of achieving the 2 °C target (based on Figure 2.3)**

| Probability of achieving 2 °C | 2010–2100 budget (Gt$CO_2$ eq) |
|---|---|
| 66% | 1000 |
| 50% | 1250 |
| 33% | 1620 |

From Figure 2.3, $CO_2$ budgets consistent with achieving the 2 °C target can be derived, which are presented in Table 2.1. These budgets are consistent with those from other studies, taking the differences in methodologies into account. More specifically, the IPCC WGI report (IPCC, 2013) estimates do not take the uncertainty in non-$CO_2$ emissions into account, whereas the IPCC WGIII report provides a wide range and partly does take climate system uncertainties into account other than those included in the models.

**Recent evidence shows that potential feedbacks in the earth system could further constrain carbon budgets.** There are several climate change feedbacks that here have not been taken into account in current estimates of carbon budgets – but this is also true for most of the estimates presented elsewhere. The excluded feedbacks, for instance, include the impact on wetlands, tundras, and forest fires. Such feedbacks are subject to large uncertainties, but could lead to increased greenhouse gas concentration levels, limiting the anthropogenic budgets for temperature targets. However, the recent IPCC WGI report (IPCC, 2013) provides some evidence that the probability of very high temperature increases is less likely than assumed earlier. It reformulated the likely (>66%) range of the climate sensitivity from between 2 and 4.5 °C to between 1.5 and 4.5 °C, and removed the central estimate of 3 °C. This could have a slightly downward impact on the carbon budgets that would have a high probability of achieving the 2 °C target.

**Although the strength of the carbon budget concept is that it emphasises the 'cumulative' nature of the climate problem, budgets still need to be translated into annual emission levels, for policy-making purposes.** The budget concept emphasises that delays in policy formulation will cause the need for more stringent action after 2020 or 2030 than would be needed today, to compensate for the additional emissions over the period of delay. For policy-making, however, budgets are not sufficient as they give no indication of the emission trajectory, thus requiring more easily interpretable emission levels to be agreed on in the short-term.

## Note

1 For medium-term (e.g. up to 2050) emissions budgets also the timing of *emission reductions* plays a role. The possibility of deep emission reductions or even negative emissions in the second half of the century may lead to higher $CO_2$ emissions in the first part of the century.

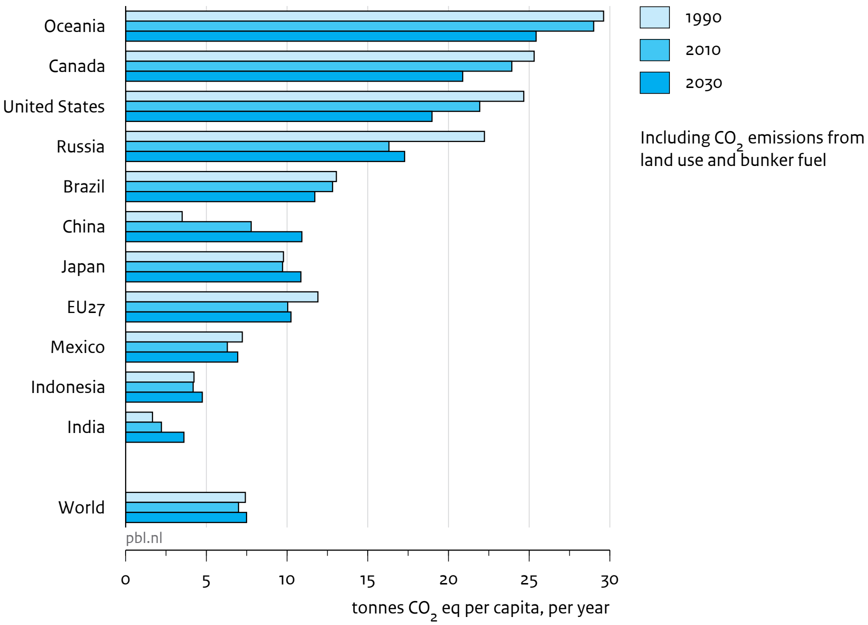
# 3 Which 2020 and 2030 emission levels would result from implementing proposed climate policies?

**Countries, over the past decade, have implemented domestic energy and climate policies and/or pledged actions as part of the Cancun Agreement.** In some cases, domestic policies are even more ambitious than the pledges they made under the Agreement . The success of their domestic policies differs per country; some are on track to meet their pledged emission level, or may even overachieve it. In a few other cases, however, current and planned domestic policies are not expected to achieve the pledged targets. The question arises how these national trends add up on a global level and how this compares to the budgets discussed in the previous section. This chapter looks into the expected outcomes of current and planned climate policies for 2020 and, using extrapolation, for 2030. We used countries' emission projections for 2020 resulting from current and planned policies. In this way, we derived a best estimate for the global emission level of 2020. We developed two emission scenarios up to 2020:

- a **baseline scenario**, showing trends under the assumption that no new policies will be implemented. The baseline scenario includes national energy policies as implemented before the cut-off year 2010;
- a **current and planned policy scenario** that determines the development of emissions under current and planned policies (planned policies only include those that have been included in well-established policy proposals);

**Without new implemented climate policies, emissions are expected to increase further, especially in low-income countries, leading to a global emission level of between 56 and 61 Gt$CO_2$ eq by 2020 and of one likely above 65 Gt$CO_2$ eq by 2030.** Models can be used to explore scenarios with and without new climate policies. These scenarios take into account the projections for population, economic activity levels, historical rates in technology change and expected supply of renewable and non-renewable energy resources. Current new scenarios in the scientific literature that depict development without new climate policies (so-called baseline scenarios, see above)

Figure 3.1
**Per-capita greenhouse gas emissions under the baseline scenario**




Source: PBL 2012

*Per-capita emissions in 1990 and 2010 and under a baseline scenario without new climate policies in 2030.*

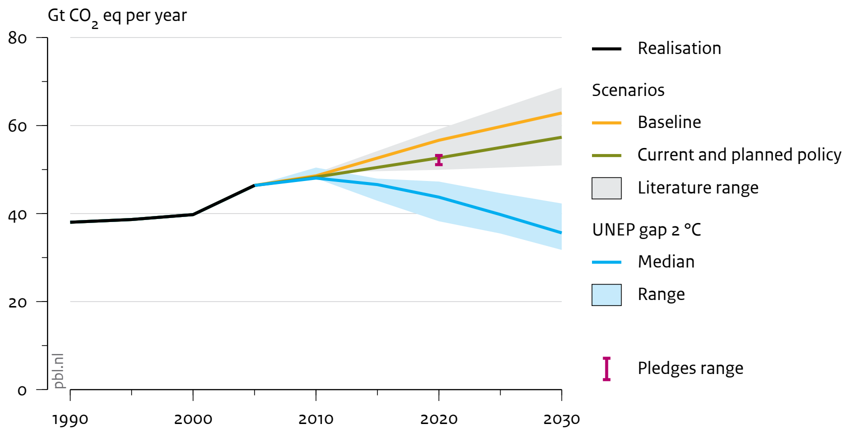
show emissions to increase to a level of 56 to 61 $GtCO_2eq$ by 2020 and of one likely above 65 $GtCO_2eq$ by 2030, compared to about 50 $GtCO_2eq$ in 2010. This increase is projected to occur mostly in developing countries, driven by a fast increase in economic activities. However, per-capita emission levels are projected to remain considerably higher in high-income countries than in developing countries (see Figure 3.1). Clearly, these trends represent a significant challenge to international policymakers, as these trends imply that achieving the 2 °C target will not be possible without substantial emission reductions in developing countries. In addition, equity concerns also play an important role.

**Implementation of the pledges of different countries under the Cancun Agreement are expected to reduce global emission levels to between 52 and 54 $GtCO_2eq$ by 2020 (updated according to the latest PBL calculations, see UNEP , 2014).** Countries have pledged mitigation actions as part of the Cancun Agreement. Several countries have made two pledges; one indicating actions without any preconditions, while the other, more stringent, pledge, is subject to certain conditions, mostly regarding actions taken in other countries or the availability of finance. If all pledges are achieved, global

**Box 3.1: Evaluation of current and planned emission policies, worldwide**

- The domestic policies of Brazil, India, China and Russia are projected to lead to lower emission levels than those pledged.
- The legally binding policy framework of the EU is likely to overachieve its unconditional pledge, but not its conditional pledge.
- For Japan, South Korea, Brazil, Indonesia and South Africa, the situation is rather unclear. Japan revised its 2020 pledge on 15 November 2013 and now aims to reduce emissions by 3.8% by 2020, compared with 2005 levels. This represents a strong decrease in ambition in comparison to the previous mitigation target of 25% below 1990 levels. Japan's emission reductions by 2020 largely depend on the country's new energy plan following the Fukushima accident, and our first calculations show that Japan is now on track to achieve its revised pledge. Whether South Korea will achieve its unconditional pledge depends on the final design and implementation of the agreed emissions trading system. Uncertainty in both historical and future emissions from land use, land-use change and forestry (LULUCF) has made it difficult to make a valid assessment for Indonesia. South Africa's policies have not yet been implemented, and the final design of a carbon tax is still under discussion; therefore, it also was very difficult to make a quantitative assessment for this country.
- The policies adopted by Australia, Canada, the United States and Mexico are projected to reduce emission levels by 2020, but additional policies are needed to deliver these pledges in full. Australia initially was on track to achieve its unconditional pledge, in part through its carbon pricing mechanism, but this mechanism was abolished in 2014. Emission levels projected for the United States for 2020 are lower than previously assumed, due to economic decline, low natural gas prices and the implementation of various policies, but are still likely to exceed the level needed to achieve its unconditional pledge. Both the United States and Mexico are developing additional measures that could bring emissions closer to the pledged level.
- Argentina has submitted actions and has policies in place, but these are not expected to lead to large emission reductions.
- Turkey, Egypt, Saudi Arabia and Malaysia have not made international pledges. Turkey's proposed policies, if implemented, are expected to lead to emission levels below those under the baseline scenario. Egypt and Saudi Arabia have renewable energy policies in place that are likely to lead to lower emission levels compared to those under the baseline scenario. Malaysia's energy efficiency target could lead to emission reductions, but would still require supporting measures to be effective.

Figure 3.2
**Global greenhouse gas emission scenarios**



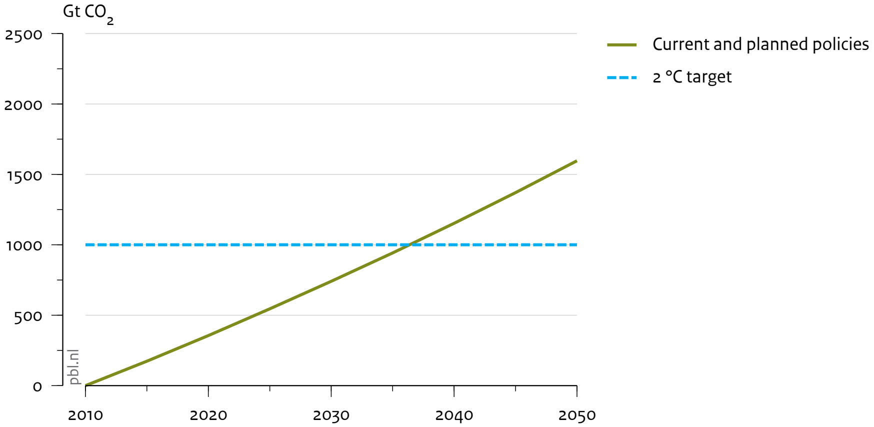

Source: PBL; UNEP 2013; LIMITS project

*The development in global greenhouse gas emissions up to 2030, under the baseline scenario and current and planned policy scenario. The literature range shown is based on the LIMITS projection for baseline and reference scenarios. For comparison, the graphs also include emission levels for the range in 'early-action' least-costs 2 °C scenarios, as reported in the UNEP Emissions Gap Report 2013 (UNEP, 2013). These last scenarios assume immediate action from 2010 onwards.*

emissions by 2020 will be about 6 to 8 Gt$CO_2$ eq lower than the baseline projections (without new climate policies) of around 60 Gt$CO_2$ eq (Hof et al., 2013). The range results from whether the unconditional or conditional pledges are achieved, but also depends on the use of so-called surplus emission allowances. The UNEP Emissions Gap Report 2014 (UNEP, 2014) has the same 2020 global emission range based on the median estimates of 12 model studies, adding confidence to these numbers.

**Detailed assessments of current and planned climate policies of major emitting countries show that some countries are expected to achieve more than their pledge, while others are projected not to achieve their pledged targets.** Policies have been formulated in many countries around the world to mitigate greenhouse gas emissions, including carbon taxes, feed-in tariffs, and emission standards. The effectiveness of policies not only depends on the projected policy impact, but also on the degree to which supporting communication, voluntary, regulatory and economic policy instruments are in place. For major emitting countries, Roelfsema et al. (2014) have analysed the impact of the most important domestic climate policies on greenhouse gas emissions. Particularly for larger countries, implementation barriers, domestic legislation and other policy instruments were taken into account in the assessment of the policies. The analysis shows that countries are implementing policies and/or setting targets in varying areas and to varying degrees. All of the major greenhouse gas

Figure 3.3
**Cumulative $CO_2$ emissions as a result of current and planned policies**




Source: PBL

*Cumulative emissions resulting from the current and planned policy scenario in comparison to the carbon budget needed to achieve the 2 °C target. The budget from 1990 includes 700 $GtCO_2$ emissions between 1990 and 2010 and is therefore equal to 1000 $GtCO_2$ + 700 = 1700 $GtO_2$.*

emitting countries have set renewable energy targets, many have recently implemented efficiency standards for cars, and new emission trading systems are emerging. Some main conclusions on country level are indicated in Box 3.1.

**The assessment of current and planned policies in all major emitting countries combined leads to an expected global emission level of about 53 $GtCO_2$ eq in 2020 – which is in the range of the global emission level resulting from the pledges.** The impact of current and planned policies is expected to lead to a global 2020 emission level of about 53 $GtCO_2$ eq (see Figure 3.2). In order to estimate the uncertainty range, we also added other recently published estimates of the emission consequences of the pledges or domestic policies (see Figure 3.2), based on the LIMITS project (grey area). Although for the LIMITS model calculations less detailed approaches were used to estimate the 2020 emission levels, they confirm the order of magnitude resulting from current policies and the implementation of planned policies – showing an overall range of between 50 and 58 $GtCO_2$ by 2020.

**Based on the assessment for 2020, it is expected that emissions will be around 57 $GtCO_2$ eq by 2030 (with a full uncertainty range from 51 to 68 $GtCO_2$ eq across various studies, including reference scenarios).** There are different ways to estimate the 2030 emission level from the trend up to 2020, such as keeping marginal abatement costs per region constant, keeping reduction ratios constant (compared to the baseline scenario), or comparing the emission trends with existing mitigation scenarios. For our study, we kept the marginal abatement costs at a constant level, leading to a gradually increasing reduction in greenhouse gas emissions, over time. This leads to projected emission levels for 2030 of around 57 $GtCO_2$ eq, for the current and planned policies scenario (the overall ranges in the literature are indicated by the grey-coloured area in Figure 3.2).

**Extending current and planned policies for the long term will clearly not be enough to achieve the 2 °C target with a high probability.** Figure 3.3 compares the budget for achieving the 2 °C target with a 66% likelihood with the current emission scenarios. It shows that the current policies scenarios will have used the larger part of the total emission budget already in 2030, and a simple extrapolation shows that before 2040 the total budget will be exhausted. It should be noted that negative emissions in the second half of the century could possibly compensate some overshoot. Still, the current policies scenario is clearly not on track to achieve the 2 °C target. This can also be concluded from an alternative approach, namely by comparing the 2010–2030 emission level to published long-term scenarios, such as those assessed in the recent IPCC report. This approach showed that the current trend is consistent with scenarios that would lead to a 3 °C warming or more, by 2100.

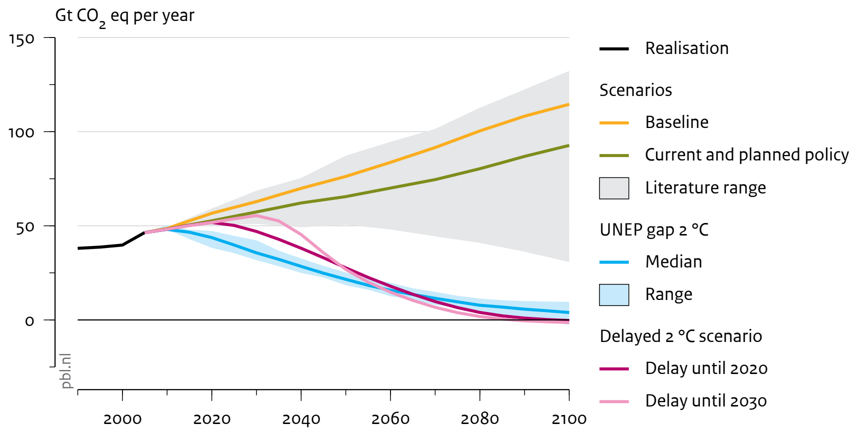
# 4 Is it possible to reconcile the 2020 and 2030 emission levels with a pathway towards achieving the 2 °C target?

**A key question for the climate negotiations, in the next few years, is which 2020 and 2030 emission levels would be still consistent with achieving the long-term 2 °C target.** The previous chapter has shown that current and planned policies are not consistent with achieving this target. A key question therefore is that of what needs to be done to reconcile current and planned policies with the overall target. Would it still be possible to achieve the target by strengthening mitigation policies after 2030? Or should policies be made more stringent already from 2020 onwards? And what are the costs and the benefits of delaying or strengthening climate policy directly after 2020?

Several international projects, including AMPERE and LIMITS, have recently addressed this question (Kriegler et al., 2014; Riahi et al., 2013). This Brief discusses this key question on the basis of IMAGE model results and uses the wider ranges from the literature to discuss the full uncertainty ranges. Starting points of our analyses were the emission levels in 2020 and 2030, as discussed in Chapter 3. We focused on two scenarios:

A. Optimal pathway from 2020 onwards. Emissions follow the currently formulated policies scenario up to 2020. After 2020, policies are assumed to have been strengthened directly based on a least-cost mitigation pathway, leading to a radiative forcing level of 2.8 $W/m^2$ by 2100, assuming full participation of all countries and sectors.
B. Optimal pathway from 2030 onwards. The same as the previous scenario, but emissions follow the current policy scenario up to 2030.

Figure 4.1
**Global greenhouse gas emission scenarios**




Source: PBL; UNEP 2013; LIMITS project

*Delayed pathways up to 2020 and 2030, compared with cost-optimal pathways from 2010 onwards.*

## 4.1 Scenarios of post-2020 policies

**An optimal pathway from 2020 onwards (starting with a 2020 emission level that results from current and planned policies) towards achieving the 2 °C target in 2100 requires an annual reduction in emissions by 1.5-2.0% globally.** Scenario A assumes that, before 2020, only the currently formulated and planned policies will be implemented, while after 2020 optimal climate policies will be implemented in all world regions and sectors. The calculations show that such a pathway could still achieve the 2 °C target with high probability, but that more rapid emission reductions are needed than under the least-costs 2 °C scenarios (Figure 4.1).

**A further delay until 2030 would need to be compensated by even faster emission reductions thereafter and – in fact – an even lower emission level to achieve by the year 2100.** At a certain point in time, emission levels of delaying action until 2030 would need to be below those in the optimal pathway from 2020. In several models reported in the literature, this is already the case before 2050, requiring extremely rapid annual reduction rates of 4% or more. In the IMAGE calculations (Figure 4.1), emission reductions over the 2030–2050 period are restricted by inertia, partly caused by lock-in effects due to delaying action. Although reduction rates under the 2030 scenario are already higher than under the 2020 scenario for 2040, absolute compensation will only be achieved in the second half of the century. This implies less extreme reductions over the 2030–2050 period compared to other models, but also an increased risk of over-shooting the 2 °C target. Although the radiative forcing target is the same under the delayed scenarios, the peak in forcing is higher under the delayed scenario up to 2030 (by about 0.1 $W/m^2$). More sizeable delays would require additional compensation, given the cumulative nature of the climate problem.

**Decarbonisation rates under the 2020 and 2030 scenarios are about three times higher than those historically achieved over the last 40 years.** The decarbonization rate – defined as the annual decrease in the ratio between $CO_2$ emissions and GDP – associated with the reductions shown in Figure 4.1 provides insight into the challenge posed by such reductions. Historically, this rate has been between 1% and 2% annually, driven by energy efficiency improvements and sectoral changes (notably a change from industry to service). Higher rates have historically only occurred during the oil crises in response to prices and government policies in OECD countries that aimed to conserve energy. For achieing the 2 °C target, the decarbonisation rate would need to be between 4% and 6%. This level is around 3 times higher than the values historically achieved over the last 40 years.

**A further delay in implementing climate policies leads to higher costs.** The additional costs that result from mitigation scenarios aimed at the 2 °C target are projected to be of the order of 1% to 3% of GDP (Kriegler et al., 2014). It should be noted that estimates of the required level of investment in the energy system over the 2010–2050 period are substantial, even without a transition towards a more sustainable energy system. As such, the 2 °C scenarios, first of all, are mainly a redirection of investments, but secondly, also require these investments to be somewhat higher than under scenarios without climate policy. Reduction options tend to be capital-intensive and also more expensive than fossil-fuel based alternatives. It will be necessary to raise the required level of investment to finance the transition, both in developed and developing countries. Our model results also show that delayed action scenarios are more expensive; delay until 2030 increases direct mitigation costs over the whole century by 17%, relative to a delay until 2020 (as measured in terms of the discounted 21st century costs).

**The portfolio of emission reduction measures for delayed response scenarios is quite similar to those of early action scenarios. However, the importance of negative emissions – notably bio-energy in combination with carbon capture and storage (BECCS) – in the second half of this century would increase significantly for the delayed scenarios.** There is some flexibility, in the technology portfolio, in achieving the 2 °C target, as becomes apparent by comparing the results from different models. Nevertheless, some technologies play a more important role than others. Some key mitigation options are discussed in Box 4.1. Negative emissions in the second half of the century can help to stay within the cumulative $CO_2$ budget; they thus provide the option of implementing emission reductions (somewhat) more slowly. Scenarios that introduce forms of delay (in order to account for short-term limitations in implementing policies) will depend more strongly on such technologies (van Vliet et al., 2014). However, the most likely technologies for creating negative emissions (afforestation and BECCS) are both limited in potential. For afforestation/reforestation, most estimates are around a

**Box 4.1: Key mitigation measures**
Based on the existing scenario literature, the following mitigation options can be identified as critical components of a mitigation strategy:

1. *Reducing non-$CO_2$ greenhouse gases*, such as by cutting gas flaring and industrial $N_2O$ emissions and the recovery of $CH_4$ from landfills, are relatively inexpensive. An important consideration with respect to the reduction in certain non-$CO_2$ gases are the co-benefits: reducing $CH_4$ and black carbon emissions would lead to relatively quick gains for climate change and immediate gains in reducing ozone levels and avoiding damage to human health. However, the potential for reductions in non-$CO_2$ greenhouse gas emissions is only limited, as emissions from some sources are very difficult to reduce to zero (e.g. $N_2O$ emissions from fertiliser use and $CH_4$ emissions from ruminant livestock).
2. *Energy efficiency improvements* play a key role. In fact, to achieve the climate targets, energy efficiency improvements need to occur at double the historical rate. There is considerable scope within the construction, transport and industrial sectors, although progress in this area has proven to be difficult in the past. However, there is evidence of a combination of standards (e.g. related to appliances or construction) and financial instruments (also to address possible rebound effects) being effective in this field. Potential exists in various sectors.
3. On the supply side, *low- and zero-carbon energy* would need to provide 50% to 90% of the world's primary energy by 2050. This could be in the form of non-combustible renewables, bio-energy, carbon capture and storage (CCS) and/or nuclear energy. Many of these options come with their own challenges, with respect to implementation and/or sustainability. In any case, their implementation would require the further development of storage, conversion and end-use technologies and infrastructures, such as smart grids and super grids, and, in general, the rapid decarbonisation of energy systems. It is most likely that financial instruments – such as, first and foremost, fossil-fuel subsidy removal, emission trading schemes and taxation – supported by regulation, could be successful to stimulate a transition.

Analysis in which the use of various technologies are constrained shows that, within the total mix of options discussed above, bio-energy, CCS and energy efficiency seem to play a more important role in the total portfolio than do other options.

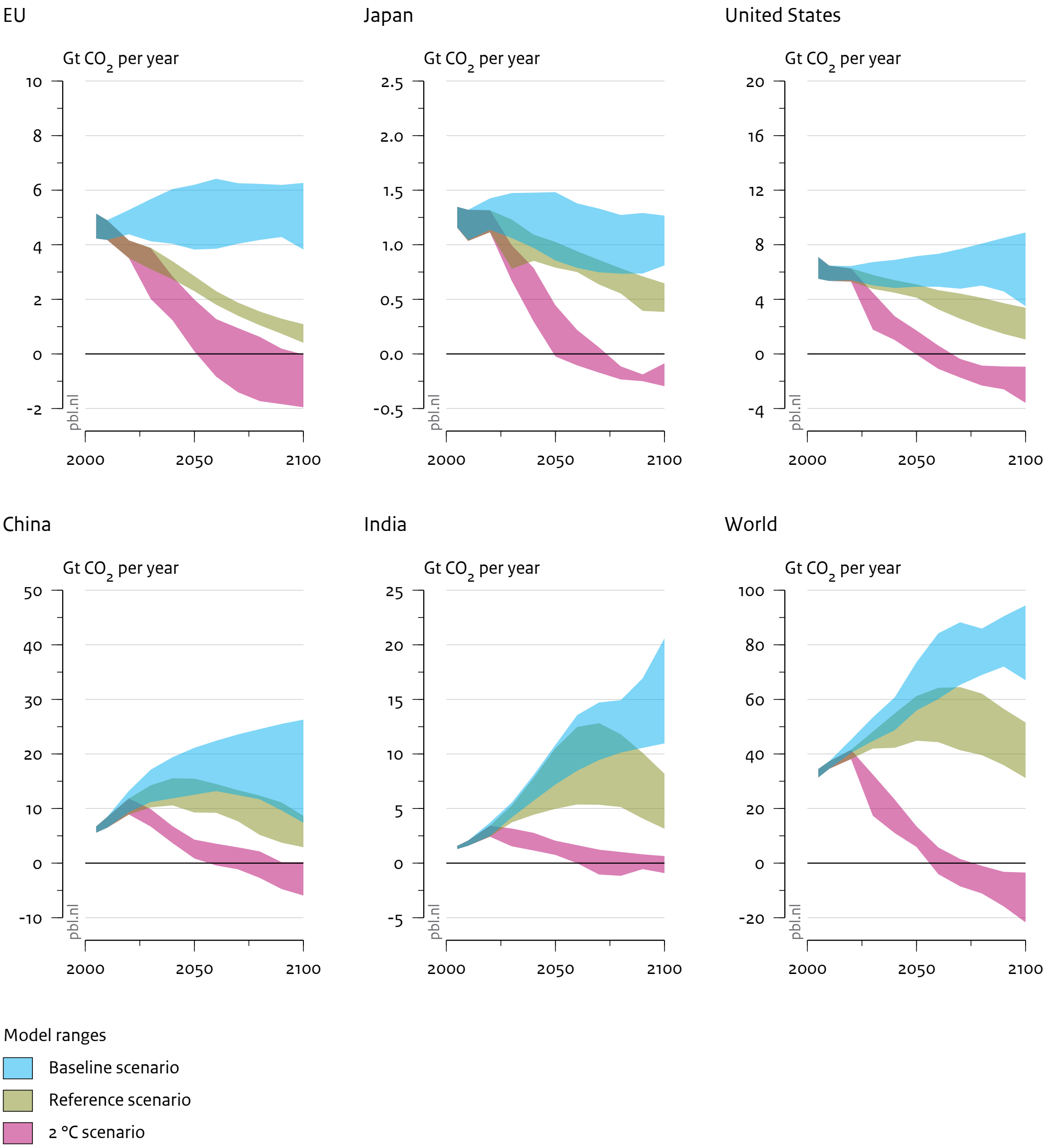
maximum of 1 to 4 $GtCO_2eq$, annually. For BECCS, key constraints are the potential for sustainable bio-energy and the potential to safely store $CO_2$. No consensus exists about the sustainable potential of bio-energy for the energy sector related to competing claims over scarce land resources, limitations posed by biodiversity protection, water scarcity and potential greenhouse gas emissions associated with bio-energy production. As a result, it has been estimated that the maximum potential for negative emissions from BECCS may be in the order of 10 $GtCO_2$, annually, by 2050, but could also be close to zero. A second key factor is the CCS potential. In this respect, technological and economic challenges and societal acceptance have been key issues, to date.
It should be noted that policies, ultimately, will be implemented on a national scale (see Box 4.2).

**Box 4.2: Emission reductions in major economies**

Without climate policies, emissions are likely to increase further after 2020 in developing countries, peaking around 2050 in China and even later in India. In order to stay in line with the 2 °C target, a sustained decarbonisation rate of 4% to 6%, annually) is required in all regions, employing vigorous decarbonisation of the energy supply system and achieving negative emissions during the second half of the century (Figure 4.2). In all regions, in the long run, decarbonisation of energy production – in particular power generation – contributes more to emission reductions than would a decrease in energy demand. Some differences in abatement strategies can clearly be noted (Van Sluisveld et al., 2014).
For instance, in China and the EU, there is a larger role for renewables than in India and the United States, where there is more emphasis on prolonging fossil-fuel use by coupling conventional technologies with carbon storage. Furthermore, regions with access to large amounts of bio-energy (including the United States, the European Union and China) can make a trade-off between energy emissions and land-use emissions. Especially in China, recent rapid economic growth will limit emission reductions in the coming decades, assuming that recently built coal-based facilities are in use for the next decades (Van Ruijven et al., 2012). This effect would be even stronger if more coal-fired plants are built towards 2020. Furthermore, in China, the growth in energy demand is projected to decrease over the coming years, in turn decreasing the demand for new facilities. Inertia is less of an obstacle in India, where ongoing growth in energy demand is creating continuing potential for decarbonisation (Lucas et al., 2013).

Figure 4.2

## Regional $CO_2$ emission pathways




Source: LIMITS project 2014

*Regional $CO_2$ emission pathways, under the baseline scenario, the reference scenario (LIMITS reference scenario depicting current and planned policies) and the 2 °C scenario (adapted from Van Sluisveld et al., 2014).*

## 4.2 Key policy implications

**In the short-term, credible climate policies are needed to encourage investments in innovation and transition towards a low-carbon economy.** Although emission pathways and emission budgets provide insight into the relationship between climate consequences and emission reductions, they should not de-emphasise the importance of stimulating investments in the underlying transition. In particular, although reduced emissions, in the short-term, as a result of lower economic growth (e.g. the economic crisis) contribute to a reduction in cumulative $CO_2$ emissions, they also reduce the possible long-term impact of current and planned climate policy via increased innovation. This is a critical factor for long-term emission trends.

**Short-term emission targets within the context of the 2 °C target need to be assessed, in terms of expected short-term emission reductions and costs as well as expectations on long-term technology development and associated costs.** In the short term, emission reductions are clearly not only bound by economic and technical factors but also by governments' ability to agree on climate policy on national and international levels. BECCS allows for a certain delay in emission reductions. However, although economically attractive, given the double contribution to mitigation as this leads to negative emissions, it does require a near-term assessment of the long-term availability and impact of BECCS. The discussion in Section 3 also indicates that the availability of BECCS technology is far from certain. This implies that current decisions need to be taken within the context of this uncertainty. More reductions in the short run (with additional costs) allow for more flexible portfolios in the long run (also those that include BECCS). Furthermore, bio-energy markets will be heavily influenced by the presence of BECCS. Without BECCS, most bio-energy is used in the transport sector, whereas otherwise a substantial amount of bio-energy will shift towards the power sector.

**For low-cost scenarios towards the 2 °C target, global emissions need to peak within the next 10 years.** Although it may be impossible to create the exact conditions assumed in the optimal scenarios, policymakers nevertheless may wish to try and come close to such conditions. This would include broadening participation, creating a wide sectoral coverage, and aiming for synergies with other policies. The costs of meeting the 2 °C target with a high probability would be lowest if the global emission level were to peak within the next 10 years.

**Given the difficulty of reaching an overall international agreement, so-far, it will be important to focus on domestic interests in climate policy and seek progress through pragmatic approaches that aim to achieve multiple targets.** The energy and land-use sectors play a key role in development policies in regions around the world. These sectors are also directly related to key challenges, such as those of energy security, economic opportunities and risks, air pollution and ecosystem degradation. Often, synergetic policies can be defined that achieve various targets at the same time;

i.e. that achieve short-term objectives while also reducing greenhouse gas emissions. To identify such policies, it would be important to concentrate on sectors and policies with the clearest room for progress, such as the power sector, smart infrastructure investments, the abolition of fossil-fuel subsidies and improving energy efficiency. In the short term, in high-income countries, there could be an additional key role for innovation in low-carbon technologies, partly because stimulating innovation probably would meet with less public resistance than other measures. On the demand side, policies could be considered that address energy-intensive consumption patterns.

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