Executive Summary

The world is moving towards a crucial new climate agreement in 2015, which could provide the long-needed global plan to slow down climate change and enable humanity to adapt to the unavoidable part of a changing climate. While recognizing that some climate change is unavoidable, global leaders at the 2010 Cancun Climate Conference[1] agreed to limit global warming to 2 °C in this century, relative to the pre-industrial period. They also decided to review this limit to see if it should be further lowered to 1.5 °C.

Given the aim to limit global temperature, the critical question has now become what level of global emissions would make this possible? The United Nations Environment Programme (UNEP) has tackled this question since 2010 by convening a large group of knowledgeable scientists to prepare the *Emissions Gap* reports. These reports have examined the gap in 2020 between emission levels consistent with the 2 °C limit, and levels expected if country pledges/commitments are met. In earlier reports the scientists conveyed the message that indeed a large gap exists, but also that there were many promising opportunities for bridging the gap.

1. What is the focus of this year's report?

The focus of this year's update is on the emissions budget for staying within the 2°C limit.

This fifth *Emissions Gap* report has a different focus from previous years. While it updates the 2020 emissions gap analysis, it gives particular attention to the implications of the global carbon dioxide emissions budget for staying within the 2 °C limit beyond 2020. It does so because countries are giving increasing attention to where they need to be in 2025, 2030 and beyond. Furthermore, this year's update of the report benefits from the findings on the emissions budget from the latest series of Intergovernmental Panel on Climate Change (IPCC) reports[2].

As noted by the IPCC, scientists have determined that an increase in global temperature is proportional to the build-up of long-lasting greenhouse gases in the atmosphere, especially carbon dioxide. Based on this finding, they have estimated the maximum amount of carbon dioxide that could be emitted over time to the atmosphere and still stay within the 2 °C limit. This is called the carbon dioxide emissions budget because, if the world stays within this budget, it should be possible to stay within the 2 °C global warming limit. In the hypothetical case that carbon dioxide was the only human-made greenhouse gas, the IPCC estimated a total carbon dioxide budget

[1] The 16th Conference of Parties of the United Nations Framework Convention on Climate Change.

[2] Another reason for changing the report's focus is that previous reports have concentrated on findings from least-cost scenarios that begin in 2010 or earlier. However, these scenarios have become decreasingly useful because emissions in recent years have been consistently higher than, and thus not in line with, these scenarios. Second, it will be increasingly difficult to implement new large-scale emission control measures by 2020. Hence, looking beyond 2020 becomes even more important. Third, the move towards sustainable development goals will directly or indirectly influence climate targets, with countries likely to settle on 2025 and 2030 as the target year for these goals.

of about 3 670 gigatonnes of carbon dioxide (Gt CO_2) for a likely chance of staying within the 2 °C limit[3]. Since emissions began rapidly growing in the late 19th century, the world has already emitted around 1 900 Gt CO_2 and so has used up a large part of this budget. Moreover, human activities also result in emissions of a variety of other substances that have an impact on global warming and these substances also reduce the total available budget to about 2 900 Gt CO_2. This leaves less than about 1 000 Gt CO_2 to "spend" in the future[4]. The key questions are: how can these emissions best be spread out over time; at what point in time should net carbon dioxide emissions fall to zero – that is, when should we become budget neutral in the sense that we sequester as much as we emit; and how much can we spend of the budget at different points in the future and still stay within the temperature limit? To tackle these questions this year's *Emissions Gap* report analyses the scenarios published in the latest IPCC reports. It also examines the great potential for improving energy efficiency, which would not only reduce greenhouse gas emissions but also meet many other societal goals. Key findings from these analyses are presented in the following sections.

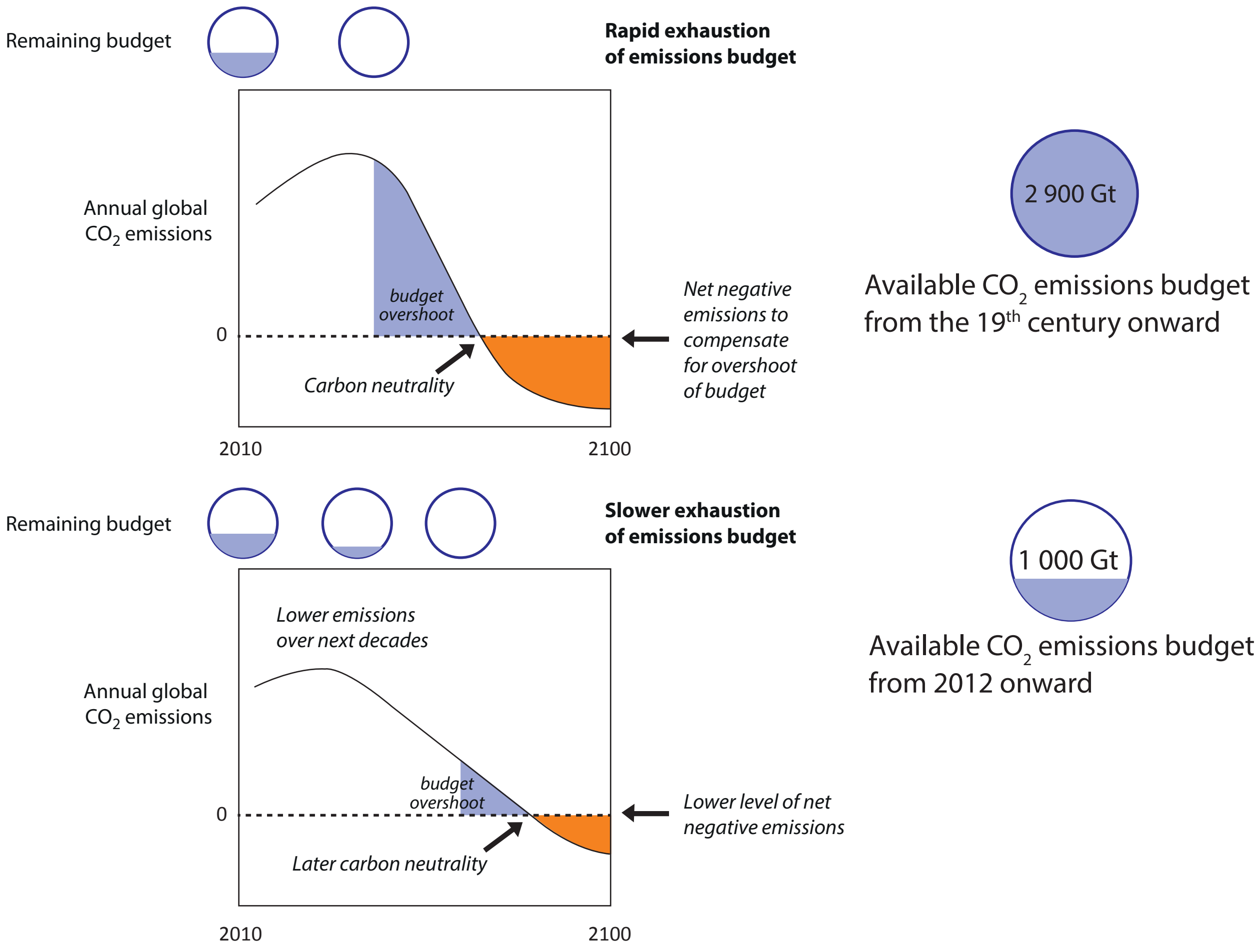

Figure ES.1: Carbon neutrality

[3] A *likely chance* denotes a greater than 66 per cent chance, as specified by the IPCC.

[4] The Working Group III contribution to the IPCC AR5 reports that scenarios in its category which is consistent with limiting warming to below 2 °C have carbon dioxide budgets between 2011 and 2100 of about 630-1 180 Gt CO_2. See main text.

2. What does the budget approach say about emission levels and their timing to meet the 2 °C limit?

To stay within the 2 °C limit, global carbon neutrality will need to be achieved sometime between 2055 and 2070.

Using the carbon budget approach and information from integrated assessment models it is possible to estimate when or if global carbon neutrality will need to be reached during the 21st century in order to have a likely chance of staying within the 2 °C limit.

Here global carbon neutrality means that annual anthropogenic carbon dioxide emissions[5] are *net zero* on the global scale (Figure ES.1). Net zero implies that some remaining carbon dioxide emissions could be compensated by the same amount of carbon dioxide uptake (negative emissions) so long as the net input of carbon dioxide to the atmosphere due to human activities is zero.

The fact that global emissions will continue to be larger than zero in the immediate future means that at some point we will exhaust the carbon dioxide emissions budget and *annual net* emissions will have to drop to zero to avoid exceeding the budget. If we do exceed the budget, then negative emissions will be required to stay within the 2 °C limit (Figure ES.1).

Based on a subset of scenarios from the IPCC *Fifth Assessment Report* (AR5) scenario database[6], the best estimate is that global carbon neutrality is reached between 2055 and 2070 in order to have a likely chance of staying within the 2 °C limit. This same subset of scenarios is used throughout this Summary for calculating emissions consistent with the 2 °C limit, with the exception of the calculation of the 2020 gap, as explained in Section 5 of the Summary.

To stay within the 2 °C limit, total global greenhouse gas emissions need to shrink to net zero some time between 2080 and 2100.

An important point about carbon neutrality is that it only refers to carbon dioxide emissions. Nonetheless, it is well known that other greenhouse gases also cause global temperature increases. Among these are methane, nitrous oxide and hydrofluorocarbons. Current and likely future emissions of these and other non-carbon dioxide greenhouse gases have been taken into account in the above estimation of when carbon neutrality should be reached. The next question is, when must *total* greenhouse gas emissions (carbon dioxide plus non-carbon dioxide)[7] reach net zero in order to stay within the emissions budget?

Based on additional assumptions about non-carbon dioxide emissions[8], it has been estimated that global total greenhouse gas emissions will need to reach net zero sometime between

[5] In this Summary emissions always refer to anthropogenic emissions.

[6] This subset (called Least-cost 2020 scenarios in this report) consists of scenarios that begin in 2010, have a likely chance of staying within the 2 °C limit, have modest emission reductions up to 2020, assume country pledges are fully implemented in 2020, and follow least-cost emission pathways leading to rapid reductions after 2020. Modest here means that the pace of emission reductions up to 2020 is significantly slower than in scenarios that have a likely chance of staying within the 2 °C limit and follow a least-cost emission pathway beginning in 2010. A least-cost emission pathway is an emissions pathway that takes advantage of lowest cost options for emission reductions and minimizes total costs of reduction up to 2100. These scenarios are often called delayed action or later action scenarios because they begin their least-cost pathway in 2020 rather than 2010.

This subset of scenarios is used for three main reasons. First, because actual emissions since 2010 have been higher than in other types of scenarios in the IPCC scenarios database, particularly those that meet the 2 °C target and have a least-cost pathway beginning in 2010 rather than 2020. (These are called Least-cost 2010 scenarios in this report. These scenarios have lower global emissions up to 2020 than the Least-cost 2020 scenarios because they follow a least-cost pathway from 2010 rather than 2020.) Second, because the Least-cost 2020 scenarios seem to be more in accord with current projections of emissions for 2020. Global emissions in 2020 under various pledge cases are estimated to be about 52–54 Gt CO_2e. The Least-cost 2020 scenarios used here have global emissions close to this range (50–53 Gt CO_2e). The Least-cost 2010 scenarios have much lower global emissions in 2020 (41–47 Gt CO_2e). Third, the Least-cost 2020 scenarios are consistent with negotiations to deliver a new climate agreement, which provides a framework for higher ambition beginning in 2020. (Current negotiations aim to "further raise the existing level of ... action and stated ambition to bring greenhouse gas emissions down.") For these reasons, the Least-cost 2020 scenarios are used for calculating emissions consistent with the 2 °C limit, with the exception of the 2020 gap, as explained in Section 5 of the Summary.

[7] Total greenhouse gas emissions here and elsewhere in the report refer to the sum of the six greenhouse gases covered by the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorinated compounds and sulphur hexaflouride).

[8] Since most scenarios assume that it will be difficult to remove 100 per cent of non-carbon dioxide emissions (for example, all of methane from agriculture) the scenarios assume that these residual emissions will be compensated for by net negative carbon dioxide emissions after total net zero greenhouse gas emissions are achieved. Under these circumstances, it is logical that first carbon neutrality is reached, and then net zero total greenhouse gas emissions.

2080 and 2100. Although this is somewhat later than the timing for carbon neutrality it does not assume slower reductions of non-carbon dioxide emissions. On the contrary, non-carbon dioxide and carbon dioxide emissions are assumed to be reduced with about the same level of effort[9].

The estimates here are again based on a subset of scenarios that have a likely chance of staying within the 2 °C limit[10]. As in the case of carbon neutrality, the net part of net zero emissions means that any global residual emissions from society could be compensated by enough uptake of carbon dioxide and other greenhouse gases from the atmosphere (negative emissions) to make sure that the net input of total greenhouse gases to the atmosphere is zero.

Bringing global emissions down to below the pledge range in 2020 allows us to postpone the timing of carbon neutrality and net zero total emissions.

An important consequence of the carbon budget is that the lower the annual emissions in the immediate future, including in the years up to 2020, the relatively higher they can be later, and the longer the time we have before exhausting the emissions budget. This would allow us to push back the timing of carbon neutrality and net-zero total emissions. Hence taking more action now reduces the need for taking more extreme action later to stay within the 2 °C limit.

Following the budget approach, the levels of annual global emissions consistent with the 2 °C limit have been estimated. Under these circumstances, global emissions in 2050 are around 55 per cent below 2010 levels. By 2030 global emissions have already turned the corner and are more than 10 per cent below 2010 levels after earlier peaking.

Countries took the important decision at the Durban Climate Conference[11] to pursue a new climate agreement, expected to enter into effect in 2020. This raises the crucial question about which global emission levels after 2020 are consistent with staying within the 2 °C limit. The estimates in the following table (Table ES.1) were made with this question in mind[12].

These estimates are based on the same subset of scenarios from the IPCC AR5 database as used

Table ES.1: Required greenhouse gas emission levels (Gt CO_2e) for a likely chance of staying within the 2 °C limit

Year	Median (Gt CO_2e)	Relative to 1990 emissions	Relative to 2010 emissions	Range (Gt CO_2e)	Relative to 1990 emissions	Relative to 2010 emissions
2025	47	+27%	-4%	40 to 48	+8 to +30%	- 2 to -18%
2030	42	+14%	-14%	30 to 44	-19 to +19%	-10 to -39%
2050	22	-40%	-55%	18 to 25	-32 to -51%	- 49 to -63%

Notes: Since current emissions are 54 Gt CO_2e and rising (Section 4 of the Summary), substantial emission reductions will be needed to reach these levels.

9 "About the same level of effort" means that both non-carbon dioxide and carbon dioxide emissions are assumed to be reduced in the scenarios if they have similar costs (per carbon-equivalent) of reduction. The reason for the later timing of net zero total greenhouse gas emissions is explained in Footnote 8.

10 The same scenarios described in Footnote 6.

11 The 17th Conference of the Parties of the United Nations Framework Convention on Climate Change.

12 Emission levels in this table are higher than those reported in the *Emissions Gap* report 2013. The reason is that the 2013 report used scenarios that assumed least-cost emission pathways (with stringent reductions of global emissions) beginning in 2010. Hence, emission levels in that report for the time frame up to 2050 were lower than in this report. It is worth noting, that because the scenarios used in this report have higher emissions over the next few years, they also assume that a much higher level of ***negative*** emissions will be needed to compensate for them later in the 21st century (see Section 3 of the Summary).

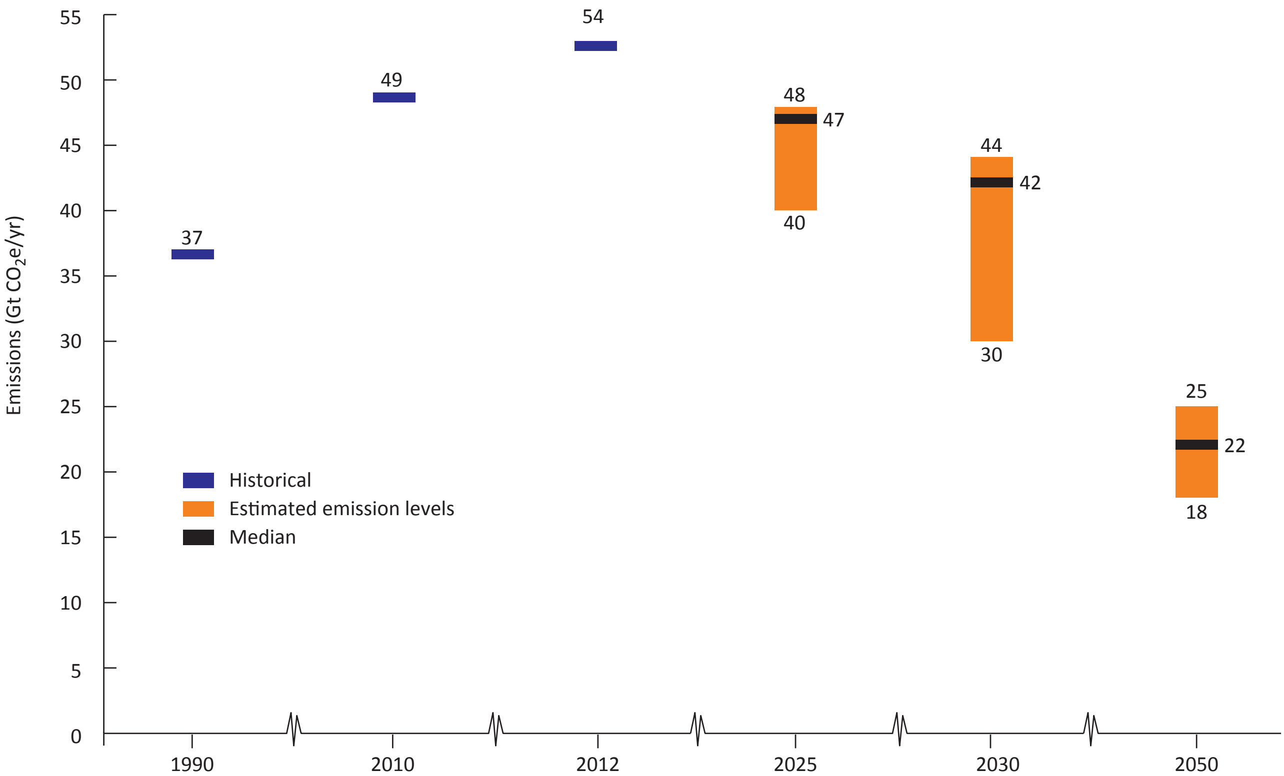

Figure ES.2: Emission levels consistent with the 2 °C target

above. They have a likely chance of staying within the 2 °C limit, assume pledge implementation in 2020, and then follow a least-cost emissions pathway after 2020[13].

3. What are the consequences of delayed action?

The consequences of postponing stringent emission reductions will be additional costs and higher risks to society.

The current pathway of global emissions is consistent with scenarios that assume only modest emission reductions up to 2020 and then stringent mitigation thereafter[14]. By postponing rigorous action until 2020, this pathway will save on costs of mitigation in the near term. But it will bring much higher costs and risks later on, such as:

i: much higher rates of global emission reductions in the medium term;
ii: greater lock-in of carbon-intensive infrastructure;
iii: greater dependence on using all available mitigation technologies in the medium-term;
iv: greater costs of mitigation in the medium- and long-term, and greater risks of economic disruption;
v: greater reliance on negative emissions; and
vi: greater risks of failing to meet the 2 °C target, which would lead to substantially higher adaptation challenges and costs.

13 These are the scenarios described in Footnote 6.

14 These are the scenarios described in Footnote 6.

Delaying stringent action till 2030 will further aggravate these risks and reduce the likelihood of meeting the 2 °C target to 50 per cent or less. Conversely, putting greater effort into reducing emissions over the next few years would reduce all of these risks and would bring many co-benefits along with climate mitigation (Section 7 of the Summary).

The higher the emissions level in the near term, the higher the level of negative emissions needed later in the century as compensation. Although scenarios routinely assume a substantial amount of global negative emissions, the feasibility of these assumptions still needs to be explored.

Another consequence of the current pathway of emissions (Section 2 of the Summary) is that it implies that net negative emissions are needed to stay within the 2 °C limit, to compensate for higher emissions in 2020 and following decades. Theoretically, carbon uptake or net negative emissions could be achieved by extensive reforestation and forest growth, or by schemes that combine bioenergy use with carbon capture and storage[15]. But the feasibility of such large-scale schemes is still uncertain. Even though they seem feasible on a small scale, the question remains as to how much they can be scaled up without having unacceptable social, economic or environmental consequences. As noted above, the quicker emissions are reduced now, the less society will be dependent on negative emissions later.

4. Where are we headed under business-as-usual conditions?

Although it is clear from the science that emissions soon need to peak to stay within the 2 °C target[16], global greenhouse gas emissions continue to rise. Without additional climate policies global emissions will increase hugely up to at least 2050.

Since 1990, global emissions have grown by more than 45 per cent and were approximately 54 Gt CO_2e in 2012. Looking to the future, scientists have produced business-as-usual scenarios as benchmarks to see what emission levels would be like in the absence of additional climate policies, also assuming country pledges would not be implemented. Under these scenarios, global greenhouse gas emissions would rise to about 59 Gt CO_2e in 2020, 68 Gt CO_2e in 2030 and 87 Gt CO_2e in 2050. It is clear that global emissions are not expected to peak unless additional emission reduction policies are introduced.

5. What about the 2020 emissions gap?

The 2020 gap is not becoming smaller. Country pledges and commitments for 2020 result in only a moderate reduction in global emissions below business-as-usual levels.

As an update of previous *Emissions Gap* reports, we have again estimated the expected level of global greenhouse gas emissions in 2020 under five pledge cases, which cover a range of variants for complying with country pledges and commitments. The range of median estimates is 52–54 Gt CO_2e, about the same as in the 2013 report. It is 6–12 per cent above 2010 emissions of 49 Gt CO_2e and about 7–12 per cent lower than the business-as-usual level in 2020.

The 2020 emissions gap has been updated in this report. The gap in 2020 is defined as the difference between global emission levels consistent with the 2 °C target and the emission levels expected if country pledge cases are implemented. Global

[15] Here and elsewhere in this Summary we refer to *net* negative emissions, meaning that on a global level, the sum of negative emissions exceeds any residual positive emissions to the atmosphere. Also, these are *anthropogenic* negative emissions and would have to be additional to any *natural* uptake of greenhouse gases by the biosphere or oceans.

[16] About 85 per cent of scenarios in the IPCC scenario database with a likely chance of staying within the 2 °C limit have peak global greenhouse gas emissions in 2020 or before.

emissions in 2020 should not be higher than 44 Gt CO_2e to have a likely chance of staying within the 2 °C target[17]. However, the range of expected global emissions (median estimates) from the pledge cases is 52–54 Gt CO_2e in 2020, as noted above. The gap in 2020 is therefore 8–10 Gt CO_2e (52 minus 44 and 54 minus 44). This is of the same magnitude as given in the 2013 report.

For continuity, we base these estimates on the same kind of scenarios used in previous reports[18]. But these scenarios were computed some years ago and assume that a least-cost pathway with stringent emission reductions begins in 2010, whereas actual global emissions in recent years have been consistently higher. Hence, the 2020 gap estimate is becoming increasingly uncertain.

Previous *Emissions Gap* reports pointed out that the potential exists to reduce emissions and narrow the gap in 2020, although this is becoming increasingly difficult as we get closer to that year. Nevertheless, the lower the emissions between now and 2020, the lower the risks caused by delaying emission reductions, as noted above.

Without further action current pledges will not be met by a number of countries and global emissions could be above the top end of the pledge range.

Above we saw that the current implementation level of pledges is not adequate for bridging the 2020 emissions gap, but it does slow down the growth in emissions. A further important question is whether countries are on track to realize the pledges.

After reviewing available evidence from the G20 (with the EU 28 taken as a group) it appears that five parties to the United Nations Framework Convention on Climate Change – Brazil, China, the EU28, India and the Russian Federation – are on track to meet their pledges. Four parties – Australia, Canada, Mexico and the USA – are likely to require further action and/or purchased offsets to meet their pledges, according to government and independent estimates of projected national emissions in 2020. Conclusions are not drawn for Japan, the Republic of Korea, Indonesia and South Africa because of various uncertainties, nor for Argentina, Turkey and Saudi Arabia because they have not proposed pledges.

On the global scale, this report estimates that emissions will rise to 55 (rounded from 54.5) Gt CO_2e in 2020 if countries do not go beyond their current climate policies. This is above the top of the pledge range of 54 Gt CO_2e (rounded median estimate).

6. What about the emissions gap in 2030?

The emissions gap in 2030 is estimated to be about 14–17 Gt CO_2e but can be closed if the available global emissions reduction potential is exploited.

As countries discuss the contours of a new climate agreement for the period after 2020, the question arises whether an emissions gap will occur in 2030. The gap in 2030 is defined as the difference between global emission levels consistent with the 2 °C target versus the emissions levels expected if the pledge cases are extrapolated to 2030.

This report estimates that global emissions in 2030 consistent with having a likely chance of staying within the 2 °C target are about 42 Gt CO_2e[19].

As for expected emissions in 2030, the range of the pledge cases in 2020 (52–54 Gt CO_2e) was extrapolated to give median estimates of 56–59 Gt CO_2e in 2030.

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17 This estimate is based on the subset of emission scenarios from the IPCC AR5 database (called Least-cost 2010 scenarios in this report). These are the same type of scenarios used in previous *Emissions Gap* reports to compute the 2020 emissions gap. These scenarios begin in 2010, have a likely chance of staying within the 2 °C limit, and follow a least-cost emissions pathway with stringent reductions (exceeding current pledges and commitments) after 2010. Least-cost emission pathway is defined in Footnote 6.

18 See Footnote 17.

19 This estimate is based on the subset of emission scenarios from the IPCC AR5 database described in Footnote 6. A different subset of scenarios was used for estimating the 2020 gap in order to be consistent with previous reports.

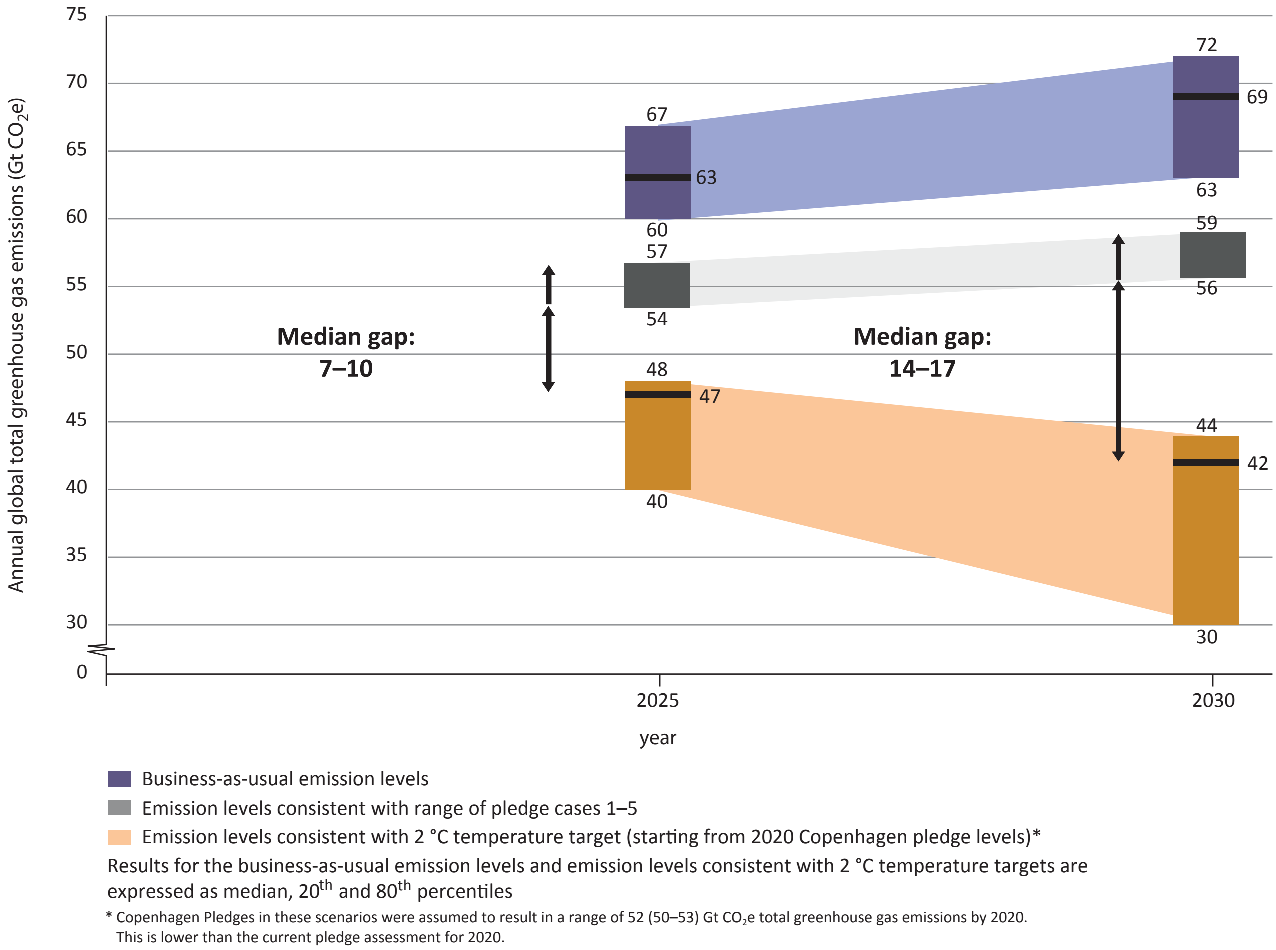

Figure ES.3: The emissions gap in 2030

Box S-1 The IPCC AR5 Synthesis Report*

The findings in this report are consistent with those of the IPCC AR5 Synthesis Report, but not identical.

Global emission reductions by 2050. The IPCC Synthesis report states, "scenarios that are *likely* to maintain warming at below 2 °C are characterized by a 40–70 per cent reduction in greenhouse gas emissions by 2050, relative to 2010 levels". The numbers in this report (49–63 per cent) are consistent with the IPCC estimate.

Timing of carbon neutrality. The IPCC Synthesis Report does not make an explicit statement about the timing of carbon neutrality. However, it can be inferred from Figure SPM.5a in the IPCC report that carbon neutrality is reached in the second half of the 21st century in scenarios of the IPCC's lowest scenario category, in line with a likely chance of limiting warming to below 2 °C. This is consistent with estimates here that carbon neutrality is reached between 2055 and 2070 (for scenarios that begin a least-cost pathway in 2020, as described in Footnote 6.)

Timing of net zero global greenhouse gas emissions. The IPCC Synthesis report states, "scenarios that are *likely* to maintain warming at below 2 °C are characterized by ... emissions level[s] near zero or below in 2100". In this report it is estimated that global greenhouse gas emissions would reach net zero between 2080 and 2100, also based on scenarios that are likely to maintain warming at below 2 °C, but that specifically begin a least-cost pathway in 2020 (Footnote 6).

* The Synthesis Report is available online at: http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf

The emissions gap in 2030 is therefore estimated to be 14–17 Gt CO_2e (56 minus 42 and 59 minus 42). This is equivalent to about a third of current global greenhouse emissions (or 26–32 per cent of 2012 emission levels).

As a reference point, the gap in 2030 relative to business-as-usual emissions in that year (68 Gt CO_2e) is 26 Gt CO_2e. The good news is that the potential to reduce global emissions relative to the baseline is estimated to be 29 Gt CO_2e, that is, larger than this gap. This means that it is feasible to close the 2030 gap and stay within the 2 °C limit.

7. How can climate change mitigation be linked with actions to promote sustainable development?

There is a strong case for integrating climate change mitigation in a policy framework that can deliver economic growth, social development and climate and environmental protection.

Actions to mitigate climate change often have close synergies with policies that countries need for achieving domestic goals of improved energy access and energy security, or reduction in air pollution. The Sustainable Development Goals presented in the report of the Open Working Group[20] underscore the many synergies between development goals and climate change mitigation goals. For example, efforts to eradicate energy poverty, promote universal access to cleaner forms of energy, and double energy efficiency, if fully realised, would go a long way towards bringing the world back to a path consistent with the temperature target set by the United Nations Framework Convention on Climate Change. Linking development with climate mitigation also helps countries build energy efficient and low-emissions infrastructure for the coming decades, and achieve deep transformational changes in the economy and society worldwide.

Policies and measures are being applied worldwide that promote both sustainable development and reduce greenhouse gas emissions.

The good news is that countries and other actors are already widely applying policies that are very beneficial to both sustainable development and climate mitigation. About half the countries in the world have national policies for promoting more efficient use of energy in buildings, such as heating and/or cooling. About half are working on raising the efficiency of appliances and lighting. Other national policies and measures are promoting electricity generation with renewable energy, reducing transport demand and shifting transport modes, reducing process-related emissions from industry, and advancing sustainable agriculture. Significant public and private investments are flowing into energy efficiency (US$ 310–360 billion in 2012) and renewable energy (US$ 244 billion in the same year).

Non-state actors such as regions, cities and companies are also promoting policies that advance both sustainable development and emission reductions. Some of these non-state actors have come together (in some cases with governments) to form international cooperative initiatives (ICIs) for pursuing specific sustainable development, energy, environmental and climate mitigation objectives. These ICIs have the potential to significantly reduce greenhouse gas emissions in support of, and potentially beyond, national emission reduction pledges. The interest and importance of these initiatives is increasing and a plethora of new such initiatives were proposed at the UN Secretary General's Climate Summit in New York in September 2014[21].

[20] The report is available online at: http://sustainabledevelopment.un.org/focussdgs.html

[21] Further details are available online at: http://sustainabledevelopment.un.org/index.html

If climate mitigation actions already taking place were to be replicated and scaled up, they would provide a huge potential to reduce greenhouse gas emissions.

Experience shows that countries can make rapid progress in climate mitigation when they integrate climate policy into their core development strategy, lay out a long-term strategic vision, and build wide-ranging political support for those changes. Scaling up the many feasible actions that reduce emissions and promote sustainable development yields a large potential for reducing global emissions. In 2030 this potential adds up to no less than 29 Gt CO_2e. As a reference point, this is equivalent to nearly 60 per cent of global emissions in 2010.

New polices and measures based on proven approaches can provide the necessary incentives to achieve the full potential of climate mitigation and the associated short-term development benefits.

New government policies are needed to overcome barriers and create the right incentives for climate mitigation. One approach is to adjust fuel prices, through carbon taxes or emissions trading systems, so that they incorporate the costs of climate change and other environmental damages. Another is to reduce or abolish subsidies on fossil fuels, estimated to be more than US$ 600 billion annually, and thereby avoid this huge annual governmental expenditure. To make investments in low-carbon and resource-efficient assets attractive, risks need to be reduced, the general investment climate improved, financing costs lowered and government budget support made available. New policies are needed to promote the diffusion of innovative technologies in order to overcome the risk aversion of potential users, and other obstacles. But the transition to a low-carbon future may create losers in some companies and segments of the population. The impact of new policies on these groups needs to be considered and enterprises and society need to be given time to adjust to the new paradigm.

8. How can energy efficiency help to promote development while contributing to emission reductions?

Energy efficiency has multiple social, economic and environmental benefits.

Past *Emissions Gap* reports have focused on good practices in different sectors and their ability to stimulate economic activity and development, while reducing emissions. Following this tradition, this report focuses on the vast potential to improve energy efficiency across many different sectors.

Globally the energy intensity between 2002 and 2012 was estimated to have improved on average by 1.6 per cent annually[22]. Improvements in energy efficiency in 18 Organisation of Economic Co-operation and Development (OECD) countries over the period 2001–2011 have resulted in cumulative energy savings of 1 731 million tonnes of oil equivalent (Mtoe) – more than the equivalent of the total energy demand of the EU in 2011. As a result, energy efficiency is increasingly called the 'first fuel'.

Improving energy efficiency comes with substantial multiple benefits. Not only does it reduce or avoid greenhouse emissions, but it has long been considered a main way to increase productivity and sustainability, primarily through the delivery of energy savings. Moreover, energy efficiency measures can contribute to economic growth and social development by increasing economic output, employment and energy security. In a scenario with carbon prices of US$ 70 per tonne, for example, improvements in energy efficiency are estimated to result in a

[22] Energy intensity and energy efficiency are not exactly equivalent since energy intensity is a function of both the economic structure and energy efficiency of an economy. However, as is often the case, if the economic structure does not change significantly over time, then the changes in energy intensity can be used as a proxy for changes in energy efficiency.

0.2–0.5 per cent increase in gross domestic product (GDP) in 2030, relative to a baseline level[23].

Improving energy efficiency also has important positive social impacts. It reduces, for example, air pollution and its public health risks: nearly 100 000 premature deaths related to air pollution in six regions – Brazil, China, the EU, India, Mexico and the USA – could be avoided annually by 2030 through energy efficiency measures in the transport, buildings and industrial sectors. In many cases these benefits have a higher priority for governments than climate change mitigation. Hence improving energy efficiency can be seen as an excellent opportunity for linking sustainable development with climate mitigation.

Improving energy efficiency has a high potential for reducing global emissions, and in a very cost effective way.

Between 2015 and 2030, energy efficiency improvements worldwide could avoid 22–24 Gt CO_2e (or 2.5–3.3 Gt CO_2e annually in 2030) relative to a baseline scenario and assuming a carbon price of US$ 70 per tonne. This corresponds to a reduction in primary energy demand of about 5–7 per cent over the same 15-year period and relative to the same baseline scenario. Improvements in energy efficiency represent about one-fifth of all cost-effective emission reduction measures over the same 15-year period[24]. Depending on the assumptions, estimates are higher. For example, the International Energy Agency reports that end-use fuel and electricity efficiency could save 6.8 Gt CO_2e in 2030, and power generation efficiency and fossil fuel switching could save 0.3 Gt CO_2e, also in 2030. An assessment by the German Aerospace Centre estimates that 13 Gt CO_2e could be saved in 2030 through energy efficiency improvements alone.

Many energy efficiency measures can be implemented with negative or very low long-term costs due to reduced energy bills that offset the sometimes higher upfront costs, compared to less efficient technologies, not even considering positive economic effects and multiple societal benefits.

There are great opportunities for improving the energy efficiency of heating, cooling, appliances and lighting in the buildings sector.

There is tremendous potential for improving energy efficiency in the buildings sector. Because of advances in materials and know-how, new energy efficient buildings use 60–90 per cent less energy than conventional buildings of a similar type and configuration, and are cost-effective in all countries and climate zones.

As compared to developed countries, the rate of new building construction in developing countries is much higher, which means that energy efficiency in buildings can best be achieved through regulations for building energy performance or codes for new construction. Several developing countries, and virtually all OECD countries, have some form of building code in place. Because they have an older building stock with a low rate of turnover, most developed countries also need to pay special attention to renovating their existing buildings in an energy efficient manner.

The provision of heating, cooling and hot water is estimated to account for roughly half the global energy consumption in buildings. Some cities are providing both thermal and electrical energy to buildings in a very efficient manner through district energy systems. Although these systems have been used mostly in cooler climates in the northern hemisphere, they are also becoming a popular way to cool buildings efficiently, for example in Dubai, Kuwait and Singapore.

Appliances and lighting also account for a significant amount of energy use in buildings, and

[23] These improvements correspond to a reduction in primary energy demand of nearly 10 per cent and a reduction in final energy consumption of 6–8 per cent, compared with a baseline scenario in 2030.

[24] These emission reduction estimates relate to abatement costs that would be economically efficient to incur in the period to 2030 (on average, worldwide) if carbon emissions were priced at US$ 70 per tonne over that same period.

great progress has been made in improving their energy efficiency through national standards and labelling programmes. The number of countries with these programmes has grown rapidly from 50–81 between 2004 and 2013. The two key policy measures used to improve energy efficiency of appliances and lighting include:

i: mandating the energy performance of equipment through standards and regulation; and
ii: labelling their energy performance.

An important task is to acknowledge and tackle the many barriers to saving energy in buildings, including uneven dissemination of information, limited access to capital, high discount rates and market fragmentation. To overcome these and other barriers there are many successful and time-tested policies that can be drawn upon, including energy and carbon taxes, energy performance standards and regulations, investment grants, soft loans, mandatory energy audits, energy efficiency obligations (for example, for utilities) and energy labelling and certification schemes.

Rather than applying standardized policies, the industrial sector uses a wide variety of country- and subsector-specific approaches to improve its energy efficiency.

There is substantial potential for reducing energy use in the industrial sector. But due to its diverse nature, it has proven impractical to implement standardized policies and measures. Most policy packages are very country-, subsector- and size-specific.

A typical approach is for governments to assist companies in identifying cost-effective investments, often through energy audits or in-depth energy reviews. Governments also provide incentives for making these investments by reducing the payback time of these investments, through subsidies and loans; by mandating, through energy-saving targets and emissions trading; or by encouraging implementation through voluntary agreements and differentiated electricity pricing.

Three particularly promising policies and measures are worth highlighting:

i: *Corporate energy saving programmes* lay down comprehensive requirements to reduce energy use in the industrial sector. China has one of the most extensive of these programmes, the Top-10,000 Energy-Consuming Enterprises.

ii: *Energy consumption targets* are company-specific targets for energy-intensive sectors, such as aluminium or cement. India's Perform, Achieve and Trade, with its 478 target companies, is a major example.

iii: *Energy performance standards* are common for three-phase electric motors – standards are now mandatory in 44 countries, including Brazil, China, the Republic of Korea and the USA. Another example is that China has applied specific energy efficiency standards to the production of 39 industrial commodities.

Improving energy efficiency in the transport sector can slow down growing fuel consumption. Effective policies are available to make that happen.

Worldwide, more than half of oil consumption is for transport; three-quarters of transport energy is consumed on roads. Without strong new policies, fuel use for road transport is projected to double between 2010 and 2050. Nevertheless, a huge amount of energy can be saved in the transport sector now and in the future through efficiency improvements.

The principal means for improving energy efficiency in the transport sector is through mandatory fuel economy standards for road vehicles. Governments often supplement standards with other measures such as labelling, taxes and incentives, which aim to boost vehicle efficiency and accelerate the market penetration of new efficient vehicle technologies. Vehicle fuel efficiency can also be increased by making the air conditioning, lighting and other non-engine components of vehicles more efficient or by modifying driving habits, which can reduce average fuel use by 10 per cent or more.

An important approach to improving energy efficiency in the transport sector is to promote the use of more efficient transportation modes, especially by shifting from private vehicles to public transportation or bicycling. This shift in mode of transportation is being encouraged in many cities, especially in Europe, through local zoning policies that limit the use of private vehicles in certain areas. More broadly, land-use planning and management can play a critical role in reducing energy use related to mobility by reducing the need for motorized transport and enabling full capacity public transport.

The overall efficiency by which electricity is produced, transmitted and distributed can be greatly increased.

Great potential exists for saving energy in the power sector. A key factor for improving energy efficiency is maintaining competition through appropriate legislation, regulations and policies with respect to open access, restructuring and deregulation. Another important approach is to support the retirement of inefficient and emissions-intensive production facilities as well as improving operating practices to make the production facilities, especially coal-based facilities, operate near their design heat-rate values.

Improving energy efficiency in this sector also involves reducing transmission and distribution losses which amount to an annual global economic loss of more than US$ 61 billion and generate annual greenhouse gas emissions of more than 700 million tonnes. One-third of network losses occur in transformers and as a response Australia, Canada, China and the USA have adopted energy performance standards to reduce these losses.

Actions to improve energy efficiency sometimes have a rebound effect, in that they might stimulate further growth in energy demand and thus lower the greenhouse emissions reductions that are aimed for.

The rebound effect, as applied to energy consumption, refers to the situation in which an efficiency improvement is counteracted by additional energy consumption. This could arise for various reasons, ranging from human behaviour to stimulated economic activity. The question arises whether some of the rebound effect can be viewed as an acceptable price for society to pay in order to get the multiple benefits described above. Considering the potential impact of this effect on the expectations of energy efficiency policies and measures, it is important to better understand its effects, and to take it into account when charting strategies for mitigating climate change.