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Lessons from a decade of emissions gap assessments

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Lessons from a decade of emissions gap assessments

UN environment

United Nations Environment Programme

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Lessons from a decade of emissions gap assessments

This publication has been prepared by the scientific editors of the UN Environment Emissions Gap Reports: John Christensen (UNEP DTU Partnership) and Anne Olhoff (UNEP DTU Partnership).

UN Environment warmly thanks all the authors, the members of the steering committee and the reviewers of the emissions gap assessments over the past 10 years for their invaluable contributions.

This year, UN Environment will publish the tenth edition of the annual Emissions Gap Report. To mark the 10-year anniversary and as a contribution to the United Nations Secretary-General's Climate Action Summit, this publication revisits the gap rationale and how it has evolved, comparing the expectations following the Copenhagen Accord with the reality 10 years later. The findings are sobering. Despite a decade of increasing political and societal focus on climate change and the milestone Paris Agreement, global greenhouse gas (GHG) emissions have not been curbed, and the emissions gap is larger than ever. The challenges for the United Nations Secretary-General's Climate Action Summit and for international climate change negotiations in 2019 are clear. Unless mitigation ambition and action increase substantially and immediately in the form of new or updated nationally determined contributions (NDCs) by 2020 and are reflected in ambitious long-term GHG development strategies, exceeding the 1.5°C goal can no longer be avoided, and achieving the well-below 2°C temperature goal becomes increasingly challenging. These and other key lessons emerging from a decade of Emissions Gap Reports are summarized under the 10 headings of this publication.

1 The Emissions Gap Report – the annual gauge of the disconnect between where we are and where we need to be

The Copenhagen Accord of 2009 and the Cancun Pledges of 2010 – the origin of the 2020 emissions gap assessments

The Copenhagen Accord declared that "deep cuts" in global emissions were required "so as to hold the increase in global temperature below 2 degrees Celsius" and called for an assessment that would consider strengthening the long-term goal, including in relation to "temperature rises of 1.5 degrees Celsius". Since December 2009, 140 countries have endorsed the Copenhagen Accord. Of these, 85 countries have pledged to reduce their emissions or constrain their growth up to 2020.

The pledges and the temperature targets referred to in the Copenhagen Accord were formalized by the 2010 Cancun Agreements and gave rise to a central question: will there be a gap in 2020 between emissions expected under full implementation of pledges and the level consistent with the 2°C target? This was the central question addressed in the Emissions Gap Reports from 2010 to 2014 (UNEP 2010; UNEP 2011; UNEP 2012; UNEP 2013; UNEP 2014).

Some of the Cancun Pledges for 2020 were unconditional, while others were conditional on action by others or support received, and their GHG emission implications furthermore depended on whether a strict or lenient interpretation of accounting rules was applied. Consequently, the Emissions Gap Reports operated with four pledge cases for 2020 (Figure 1).

To estimate the 2020 emissions gap, the emissions under the pledge cases were compared with a median estimate of global emissions in 2020 consistent with a pathway to 2°C in 2100 (with at least 66 per cent chance). This approach has been applied consistently over all the years, with a shift to 2030 as the focal year as it became the target for the Paris Agreement.

Over the 2010–2014 period, the gap estimates for 2020 ranged from a low of 5 $GtCO_2e$ according to the most ambitious pledges and measured under strict accounting rules (UNEP 2010) to a high of 13 $GtCO_2e$ in 2020 according to the least ambitious pledges and more lenient accounting rules (UNEP 2012). As pledges and accounting approaches became clearer, the gap estimate converged towards between 8 and 10 $GtCO_2e$ (UNEP 2014).

The Paris Agreement – strengthened temperature goals and a shift to the 2030 emissions gap

The Paris Agreement, adopted by 195 countries at Conference of the Parties (COP) 21 in December 2015, represents a major step forward on global climate governance. It sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C, the two formal temperature goals of the agreement.

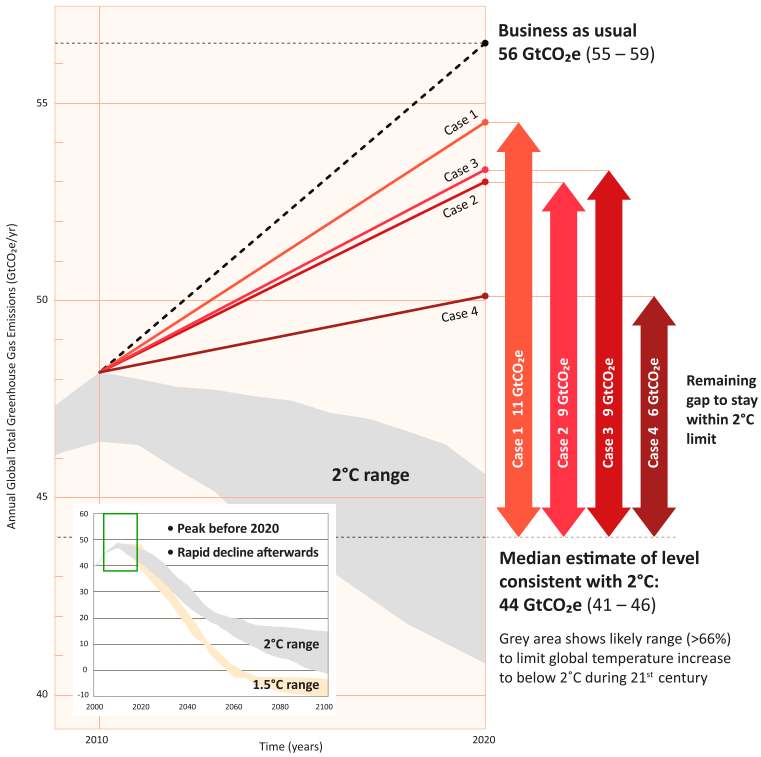
Nationally determined contributions (NDCs) are at the heart of the Paris Agreement and the approach adopted in favour of its long-term goals. NDCs represent national climate plans that embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. At the time of writing, 184 Parties have communicated their first NDCs.

Acknowledging that a voluntary bottom-up political process is unlikely to be very ambitious from the outset, the Paris Agreement is designed with a five-year review and new submission cycle, making it possible to collectively ramp up ambitions over time.

With the Paris Agreement, the focus of the gap assessment shifted from 2020 to 2030 as the new target year, and started to include the 1.5°C limit of the agreement, as shown in Figure 2.

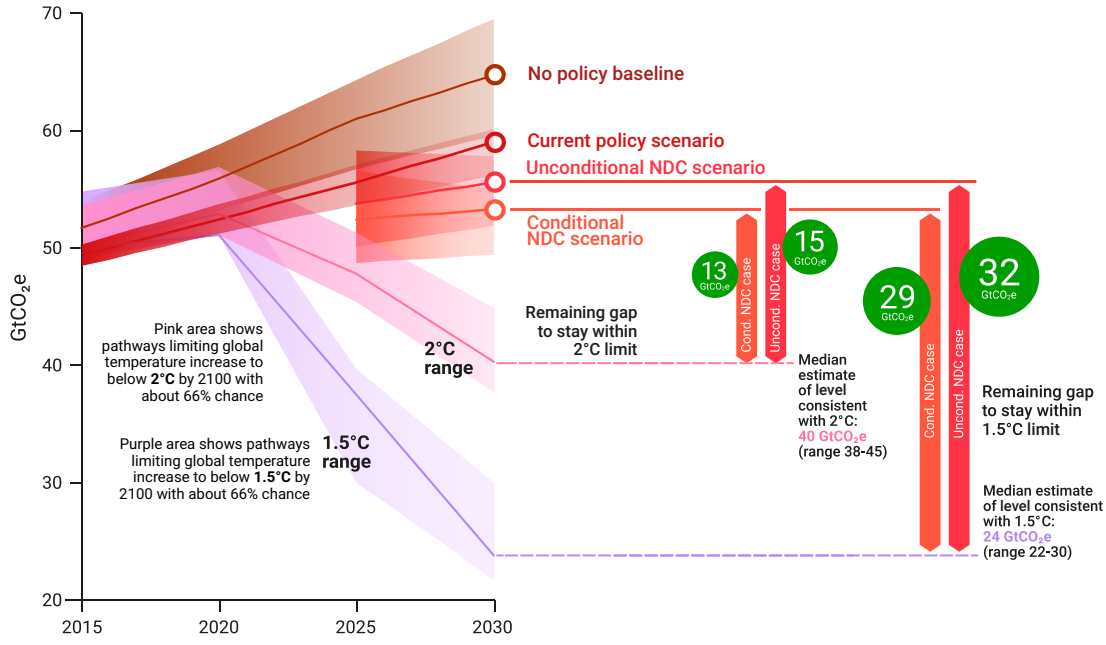
In line with the 2020 emissions gap, the 2030 emissions gap is estimated as the difference between projected global emissions in 2030 under full implementation of conditional and unconditional NDCs respectively and the emissions levels that scientific projections indicate are consistent with limiting global temperature increase in 2100 to below 2°C and 1.5°C respectively.

Figure 1 — The emissions gap in 2020



Source: UNEP (2011)

Figure 2 — The emissions gap in 2030



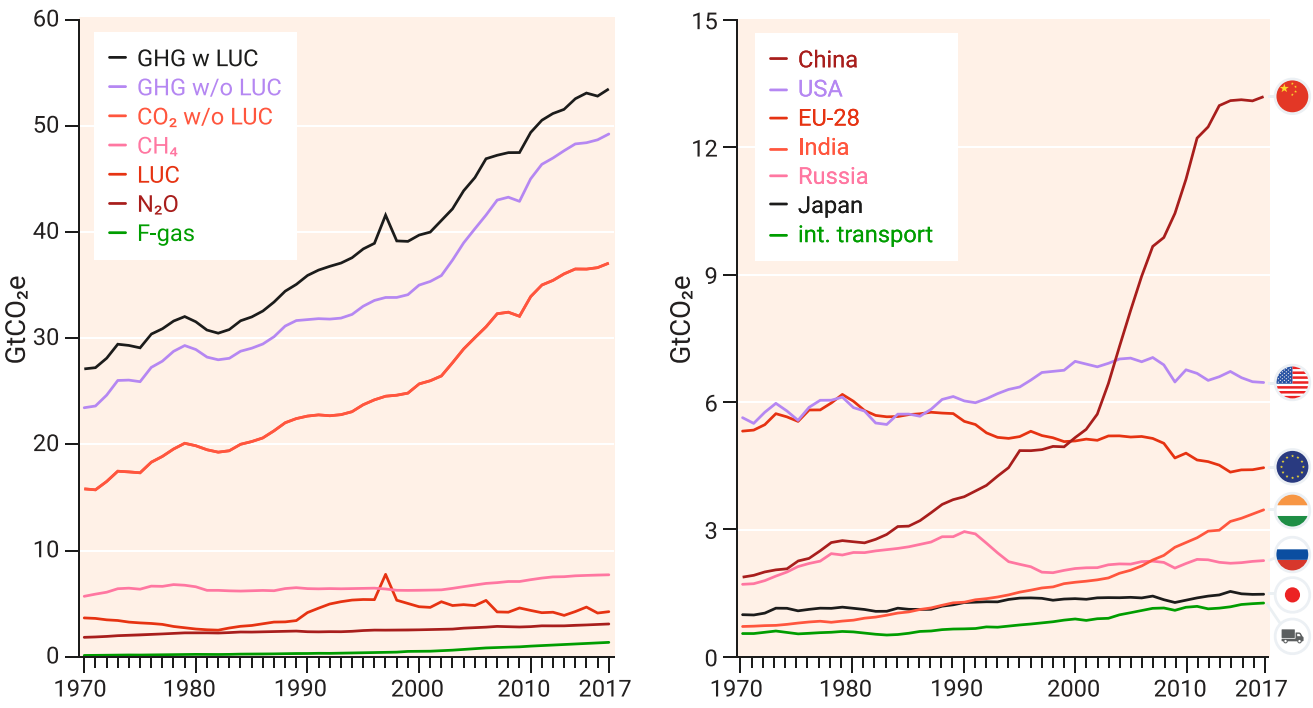
Source: UNEP (2018), Figure 3.1.

2 A decade lost – essentially no change in global emissions trend

Despite progress on climate policy in many countries, global GHG emissions continue to grow and show no signs of peaking (Figure 3). Global GHG emissions grew at an average of 1.6 per cent per year during the period from 2008 to 2017, reaching a record 53.5 $GtCO_2e$ in 2017, including emissions from land-use change. Preliminary findings from the Emissions Gap Report 2019 indicate that global GHG emissions continued to grow in 2018, breaking the 2017 record. Countries with declining emissions have so far been unable to offset the growth in emissions in other countries and in sectors not covered by national accounting, such as aviation and shipping.

The current level of global GHG emissions is by now almost exactly at the level of emissions projected for 2020 under the business-as-usual, or no-policy, scenarios used in the Emissions Gap Reports (see Figures 1 and 2), which are based on the assumption that no new climate policies are put into place from 2005 onwards. In other words, essentially there has been no real change in the global emissions pathway in the last decade. The effects of climate policies have been too small to offset the impact of key drivers of emissions such as economic growth and population growth.

Figure 3 — Global greenhouse gas emissions per type of gas (left) and Top greenhouse gas emitters, excluding land-use change emissions due to lack of reliable data (right)



Source: UNEP (2018), Figure 2.3.

This rather bleak fact hides many nuances in terms of, for example, policy progress in individual countries and declines in energy and carbon intensities. The Emissions Gap Reports assess that collectively G20 members are on track to achieve the mid-level of the Cancun Pledges, although some G20 members are projected to miss their pledges, or there is uncertainty as to whether they will achieve them.

Acknowledging the importance of achieving of the Cancun Pledges, the fact remains that at the global scale we have failed to bridge or even narrow the 2020 emissions gap, as assessed in the Emissions Gap Reports from 2010 to 2014.

The Emissions Gap Reports have consistently emphasized the importance of enhanced pre-2020 action and pledges and warned that unless urgent action is taken, there will be a number of consequences, including (UNEP 2016):

- Significantly higher rates of global emission reductions are required in the medium- and long-term to meet the well-below 2°C target. The order of magnitude of these rates has no historic precedent.
- The 'solution space' and options available to society to achieve stringent emission reductions is reduced.
- Greater lock-in of carbon- and energy-intensive infrastructure in the energy system and society, as a whole, which will simultaneously be a disincentive for the short-term learning and technology development that is essential in the long-term.
- Greater dependence on negative emissions technologies in the medium term – technologies that so far are unproven on a larger scale.
- Increased costs of mitigation and adaptation in the medium- and long-term, and greater risks of economic disruption.

Importantly, delaying action is associated with greater risks of failing to meet the well-below 2°C target and is incompatible with meeting a 1.5°C target. The implication is clear: if the Paris goals are to be kept viable, the world cannot afford to lose another decade.

3 The emissions gap is larger than ever

Concerns about the current level of both ambition and action are amplified in the 2018 report and the forthcoming 2019 report. As shown in Figure 2, the 2018 report estimates the emissions gap in 2030 between emission levels with full implementation of conditional NDCs and levels consistent with least-cost pathways to the 2°C target to be 13 $GtCO_2e$. If only the unconditional NDCs are implemented, the gap increases to 15 $GtCO_2e$.

The gap in the case of the 1.5°C target is 29 $GtCO_2e$ and 32 $GtCO_2e$ respectively. The gap numbers have increased compared with 2017, mainly as a result of the more detailed and diverse literature on 1.5°C and 2°C pathways prepared for the Intergovernmental Panel on Climate Change (IPCC) Special Report on global warming of 1.5°C . This literature made it possible to assess the gap compared to pathways associated with a "likely chance" (at least 66 per cent) of meeting the 1.5°C target, the same probability used for the 2°C gap assessment. Due to the lack of available studies that could achieve 1.5°C with a likely chance, earlier reports only considered the gap associated with a "medium chance" (50 to 66 per cent) of limiting temperature increase to 1.5°C in 2100.

Updated analysis for the forthcoming 2019 Emissions Gap Report reiterates that progress on national commitments under the Paris Agreement is limited and that the current pace of national action is hugely insufficient for achieving the Paris Agreement long-term temperature goal, and even for achieving the emissions reductions implied by the current NDCs. Increased emissions and lagging action means that the gap numbers in the 2019 report will be larger than ever.

Considering the entire decade of Emissions Gap Reports, three main factors contribute to the growing emissions gap. First, the failure to bridge the original 2020 emissions gap has led to a larger 2030 gap. Whereas the 2020 gap for 2°C was 8 to 10 $GtCO_2e$ in the 2014 report, the 2030 gap is in the order of 13 to 15 $GtCO_2e$. In other words, the 2030 gap is about 50 per cent larger than the 2020 gap. Second, the strengthened temperature targets of the Paris Agreement of well below 2°C and 1.5°C imply an increase in the emissions reductions needed by 2030. Third, over time and as scientific knowledge has improved, the pathways for especially the 1.5°C target have become more stringent. Altogether, ambition and action over the past decade have simply been inadequate, so action now needs to be faster and more transformational.

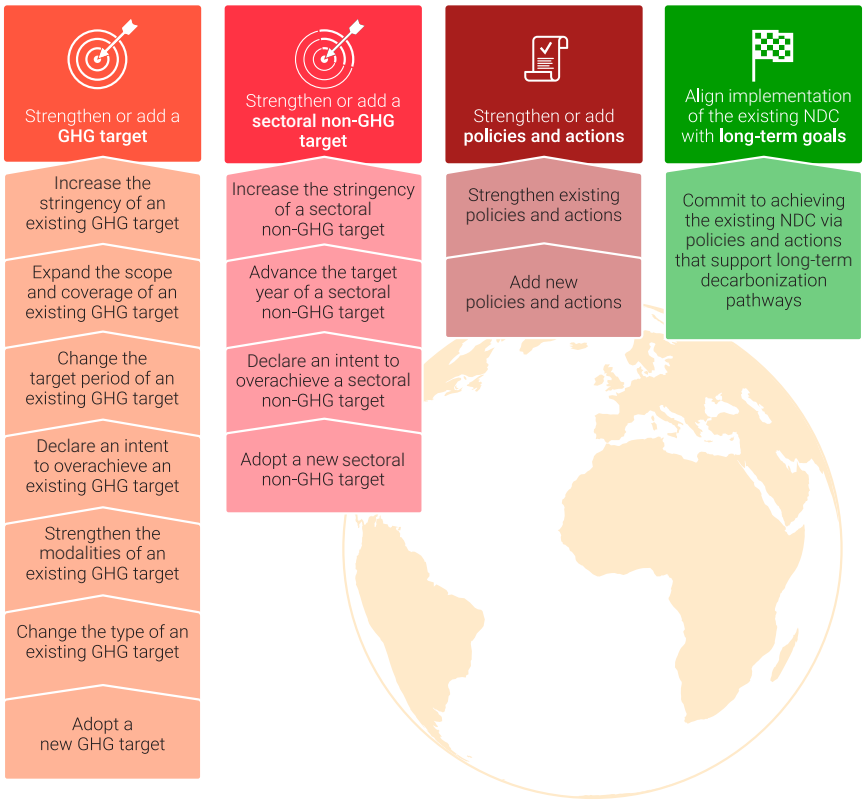
4 The global challenge – the ambition level of current NDCs needs to be tripled to get on track to 2°C and increased fivefold to align with 1.5°C

The Emissions Gap Reports show that nations must triple the level of ambition reflected in their current NDCs to get on track towards limiting warming to below 2°C, while at least a fivefold increase is needed to align global climate action and emissions with limiting warming to 1.5°C by the end of this century (see also Figure 2). For this to be realistic, new and enhanced NDCs need to be agreed by 2020 and the implementation of existing actions accelerated.

The defining challenge for the United Nations Secretary-General's Climate Action Summit in 2019 and for the United Nations Framework Convention on Climate Change (UNFCCC) negotiations over the coming year is to bring about this giant leap in ambition and to accelerate action. As Figure 4 shows, enhanced mitigation ambition can take many forms and options must be pursued in all categories and by all countries to meet the challenge. The year 2020 will be defining. Given the time lag between developing policies and achieving emission reductions, enhanced ambition of NDCs cannot wait until the global stocktake planned for 2023.

The Emissions Gap Reports conclude that a continuation of current policies would lead to a global mean temperature rise of between 3.4°C and 3.7°C by 2100 relative to pre-industrial levels, and continuing thereafter (UNEP 2016). Implementing the current unconditional NDCs, and assuming that climate action continues consistently throughout the twenty-first century, would lead to a global mean temperature rise of between 2.9°C and 3.4°C by 2100 relative to pre-industrial levels, and continuing thereafter. Implementation of the conditional NDCs would reduce these estimates by 0.2°C in 2100 (UNEP 2016; UNEP 2017; UNEP 2018). These numbers are currently being updated for the forthcoming Emissions Gap Report, and will likely become even more dramatic.

Figure 4 — Options for enhancing ambition of the NDCs



Source: UNEP (2018), Figure 4.1.

5 The gap can still be bridged, but unprecedented and immediate action is required

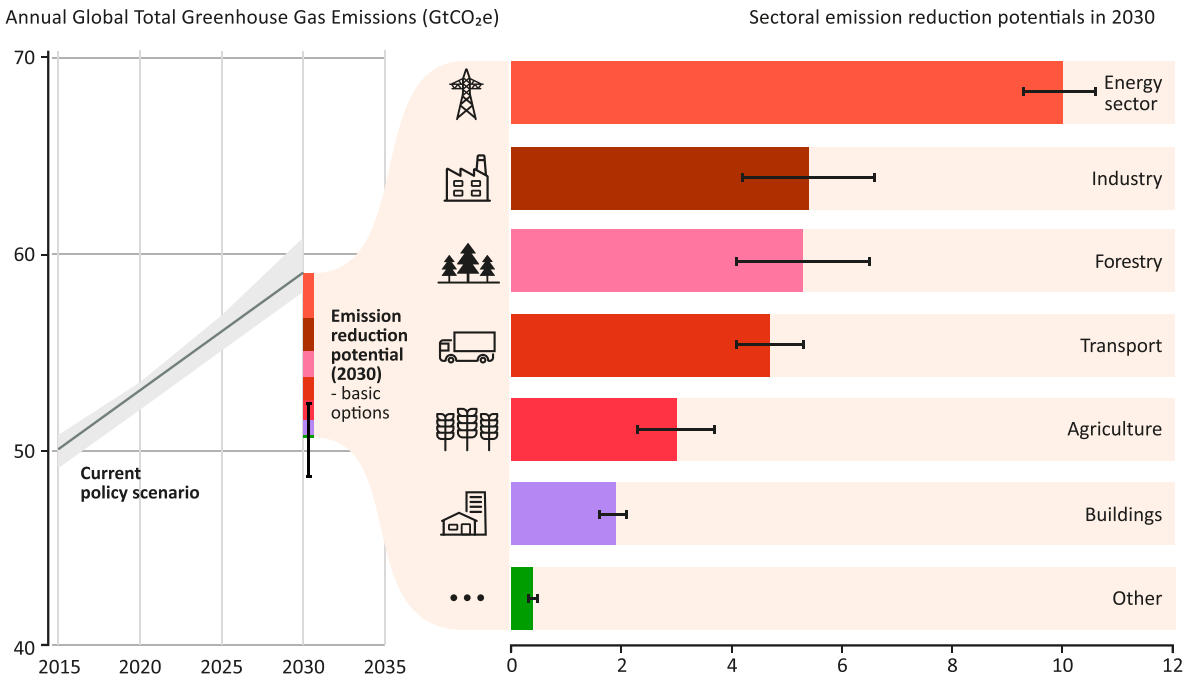
To assess whether the emissions gap can be bridged, the Emissions Gap Reports have regularly assessed sectoral emission reduction potentials. The 2017 report provided a detailed updated systematic assessment of sectoral mitigation options in 2030, which shows that the emissions gap can be bridged before 2030 if countries quickly adopt proven and cost-effective technologies and management practices. A substantial part of the economic and technical potential can be realized through scaling up and replicating existing, well-proven policies that simultaneously contribute to key Sustainable Development Goals (SDGs).

The 2017 assessment showed that by considering only proven technologies and adopting relatively precautionary assumptions, emissions could be reduced by 33 $GtCO_2e$ per year by 2030 (uncertainty range of 30–36 $GtCO_2e$), which is sufficient to get on track to well below 2°C and 1.5°C. This 'basic' potential is illustrated in Figure 5. Remarkably, a large part of this potential is available in just six areas: solar energy, wind energy, efficient appliances, efficient passenger cars, afforestation and stopping deforestation. These six areas present a combined potential of up to 21 $GtCO_2e$ per year by 2030, which is more than sufficient to get on a pathway to well below 2°C.

If areas where estimates of potentials are relatively new, and the feasibility of realizing these in 2030 is more uncertain, are also considered, the total emission reduction potential is 38 $GtCO_2e$ per year (uncertainty range of 35–41 $GtCO_2e$).

The underlying assumption is that all countries will act quickly and implement the most cost-effective measures in their national contexts. This is evidently a very idealistic assumption, but it underlines the fact that the policies and technologies needed to bridge the gap are readily available and at limited costs. While new innovation will be needed for full decarbonization, there is no excuse for inaction now.

Figure 5 — Total emission reduction basic potentials compared to the current policy scenario for 2030



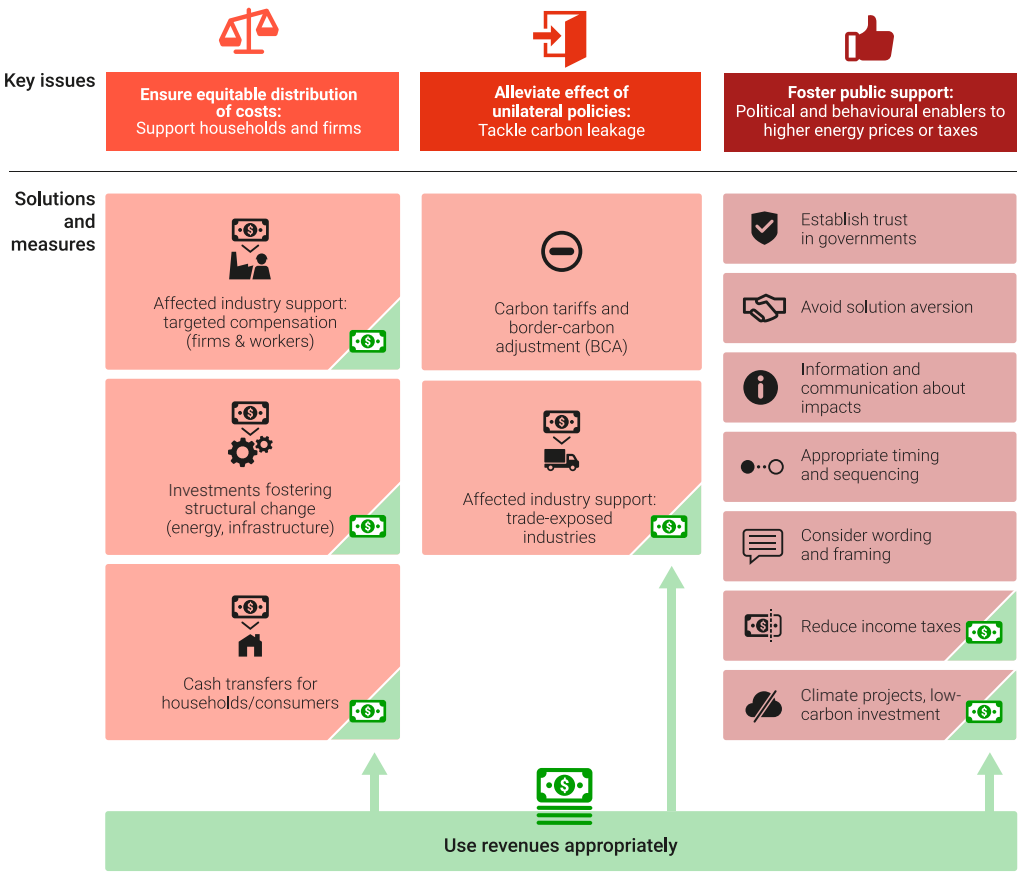
Source: UNEP (2017), Figure 4.1.

Only a fraction of this potential is captured in the current NDCs, so the potential for enhanced ambition and action is huge. As stated above, this potential is sufficient to close the 2030 gap, even for the ambitious 1.5°C goal.

The 2018 Emissions Gap Report showed that major gaps in coverage and stringency of domestic policies remain, including among key G20 members. These findings are reinforced in the pre-release chapter of the forthcoming Emissions Gap Report on opportunities for enhancing mitigation ambition and action among G20 members in particular. For example, in the areas of fossil-fuel subsidy reduction, material efficiency measures in industry, oil and gas methane, support schemes for renewables, heating and cooling systems, emission standards for heavy-duty vehicles, and e-mobility programmes, and even in areas where policy coverage is high, stringency can be improved.

Despite the huge potential of carbon pricing to reduce GHG emissions, it is still only just emerging in many countries and is generally not applied at a sufficient level to facilitate a real shift towards low-carbon societies. Even when considering energy-specific taxes together with explicit carbon pricing policies, half of the emissions from fossil fuels are not priced at all, and only 10 per cent of global emissions from fossil fuels are estimated to be priced at a level consistent with limiting global warming to 2°C. If all fossil-fuel subsidies were phased out, it would lead to a reduction of global carbon emissions of up to about 10 per cent by 2030. In this and other areas, ensuring political viability and handling distributional impacts of the transition to development paths in line with the Paris Agreement is often key, as illustrated by Figure 6.

Figure 6 — Key issues for making fiscal reforms politically viable (upper part) and solutions and measures to address them (lower part)



Source: UNEP (2018), Figure 6.3.

Reducing short-lived climate pollutants (SLCPs) is another area that is attracting attention. These agents have a relatively short lifetime in the atmosphere – from a few days to a few decades – but are potent GHGs with a significant short-term warming influence on the climate. The main SLCPs are black carbon, methane, tropospheric ozone and some hydrofluorocarbons (HFCs). Reducing these pollutants will limit the rate of short-term warming and, when sustained and combined with carbon dioxide (CO_2) reductions, will help limit long-term warming, which is the ultimate aim of closing the emissions gap (UNEP 2017).

One significant development is the phasedown of HFC use and associated emissions as a result of the Kigali Amendment to the Montreal Protocol, which could reduce global hydrofluorocarbon emissions by 0.7 $GtCO_2e$ per year by 2030, and by up to 2.7 $GtCO_2e$ per year by 2050. Additional indirect CO_2 mitigation is likely through parallel improvements in the energy efficiency of refrigeration and air-conditioning appliances and equipment. Previous phase-outs under the Montreal Protocol have catalysed significant improvements in the energy efficiency of appliances – by up to 30 per cent in some subsectors. UN Environment is currently undertaking a separate scientific assessment of these effects.

It is worth noting that in its 2018 assessment, the Scientific Assessment Panel for the Montreal Protocol concluded that "The Kigali Amendment is projected to reduce future global average warming in 2100 due to hydrofluorocarbons (HFCs) from a baseline of 0.3–0.5°C to less than 0.1°C. The magnitude of the avoided temperature increase due to the provisions of the Kigali Amendment (0.2 to 0.4°C) is substantial in the context of the 2015 Paris Agreement" (World Meteorological Organization 2018).

Some of the other key action areas covered in recent Emissions Gap Reports are highlighted under the subsequent headlines.

6 Decarbonizing energy supply and transport is key for transformational change

CO_2 emissions from fossil-fuel use in the energy and industry sectors dominate total GHG emissions. Following a period of stabilization from 2014 to 2016, emissions started to rise again in 2017 and 2018. At the same time, energy needs are projected to grow by approximately 30 per cent by 2040. This increasing demand is stimulated by economic growth and the accompanying trends of urbanization, industrialization, infrastructure growth, and a growing global middle class. As the challenge for the energy sector is therefore immense, transforming the way in which energy is produced and consumed will be key to reaching the Paris Agreement goals.

The forthcoming Emissions Gap Report examines key elements of the required energy transformation, which combined with findings from previous reports stress the urgency of accelerating energy efficiency across the board and of rapidly expanding renewable energy supply and use.

Enhanced energy efficiency is required across the board with a strong focus on heating and cooling, appliances and lighting, industrial processes and motors, and transport.

Many policy options exist in key sectors and have been documented in previous Emissions Gap Reports. For example, the 2016 Emissions Gap Report highlighted a small number of successful policies that have already been implemented or are under implementation in many countries that can be rapidly replicated and scaled up (Figure 7).

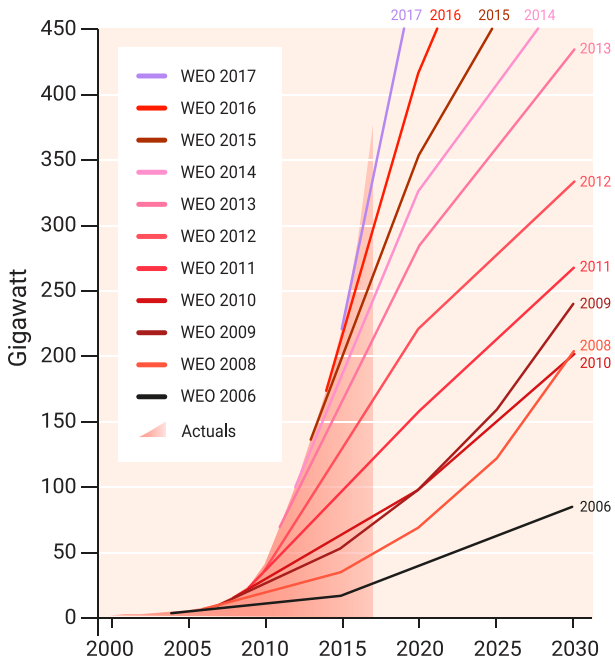
The transport sector can be treated either as a subset of energy consumption or separately as an important individual sector for mitigation interventions. There is an increasing focus on electrification as a major mitigation option in transport. Such a transition would bring significant local air pollution benefits, and in the transport sector in particular there is a need for an integrated approach.

Almost all NDCs include mitigation in the energy sector as a key area and around 75 per cent include actions on transport focusing on three concepts: (1) To avoid and reduce the need for motorized transportation, (2) To shift to more environmentally friendly modes of transportation, and (3) To improve the energy efficiency of transport modes.

The transition requires rapid expansion of renewable electricity supply, establishment of smarter and more flexible electricity grids, and huge increases in the numbers of products and processes that run on electricity in buildings, transport and industry.

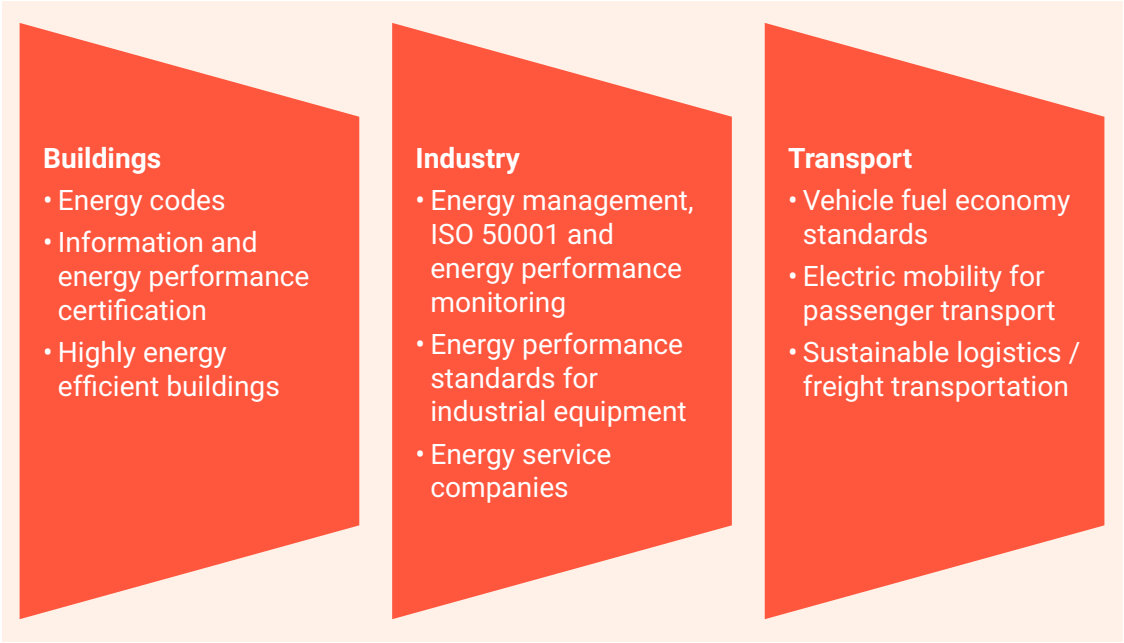
The renewables expansion has already become increasingly market driven. Stable and conducive policies and regulatory frameworks are, however, important preconditions along with access to the necessary private sector finance. Overall capacity additions in 2018 were around 50 gigawatts for wind power and more than 100 gigawatts for solar photovoltaic (PV) power. For the seventh successive year, the net additional power generation capacity of renewable sources exceeded that of non-renewable sources. Growth rates in renewable power have averaged 8–9 per cent per year since 2010. Renewable energy investment continues to increase, although it is slightly down from 2017 (UNEP forthcoming). This trend over the last decade is encouraging, but it will need to be accelerated even further, as described above and illustrated in Figure 8.

Figure 8 — Cumulative solar PV installations compared to forecasts from various International Energy Agency (IEA) World Energy Outlooks



Source: UNEP (2018), Figure 7.2.a.

Figure 7 — Examples of proven sectoral energy efficiency policies



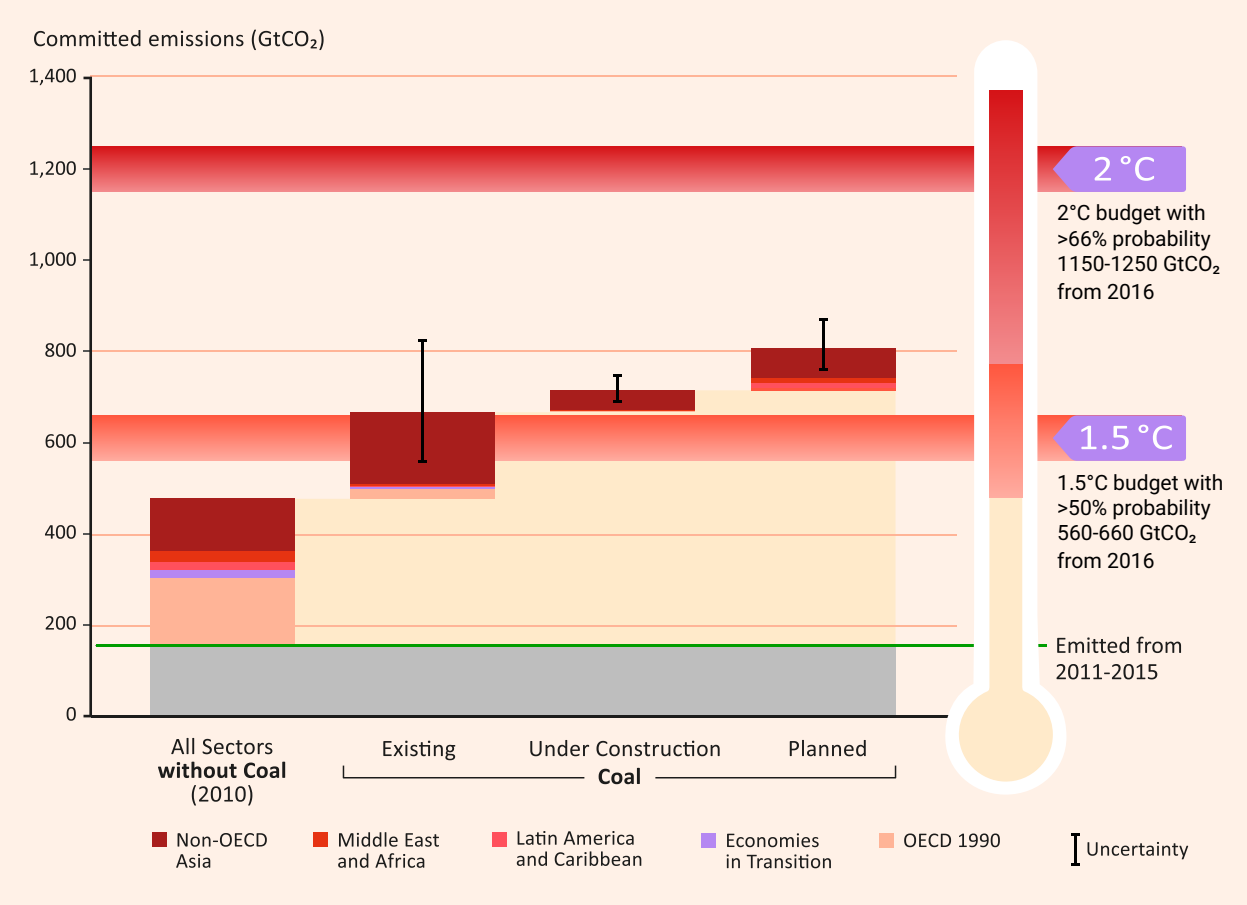
Source: UNEP (2016), Figure ES.7.

7 Phasing out coal is indispensable, but requires a balanced transition

At the global scale, the stock of coal-fired power plants is still increasing, as are emissions from coal. The existing stocks, in combination with what is currently planned and being built (assuming standard lifetimes and usage rates) alone account for a significant share of the available carbon budget for a 2°C target, and would plausibly make a 1.5°C target infeasible, as illustrated in Figure 9. Facilitating a transition away from coal for power production will therefore be essential to successful global mitigation efforts. Avoiding further lock-in through new coal-fired power plants is therefore a major and urgent requirement, followed by a gradual phasing out of existing coal plants.

While coal is widely used, only around 10 or 11 large countries have very significant coal emissions. For all these countries, a transition away from coal presents a major political and economic challenge that will take time. Removing domestic subsidies and including pricing of externalities will be important, with the latter helping generate revenue to address the societal challenges a transition will encounter. This will include addressing impacts on affected workers and communities, as well as the coal owners and industry, balancing energy prices for different social groups and energy-intensive industries, to mention a few (see also Figure 6).

Figure 9 — Emissions committed to the atmosphere from coal-fired power plants (existing, under construction and planned) and other economic sectors, by region



Source: Based on UNEP (2017), Figure 5.1.

8 Nature-based solutions can make a large contribution and are currently the main option for CO_2 removal

The Climate Action Summit uses the term 'nature-based solutions' as the convening theme for a broad set of issues related to the enhanced used of natural systems for improving mitigation and adaptation to climate change. The main categories include:

- Forests and other terrestrial ecosystems
- Agriculture and food systems
- Marine and coastal ecosystems

Not all aspects of nature-based solutions have been covered in the Emissions Gap Reports. However, mitigation potentials and options in forestry, including REDD+, were assessed in the 2012, 2015 and 2017 reports, agriculture options in the 2013 and 2017 reports, and nature-based CO_2 removal options in the 2017 report. The Emission Gap Report findings are aligned with the information in the recently released IPCC Special Report on Climate Change and Land and the fifth assessment report of the IPCC.

Most mitigation options are quite well known, but often difficult to implement in practice due to challenges related to limited access to financing, poverty issues, institutions, ecological issues, and barriers concerning technological development, diffusion and transfer.

Best practice policies to curb deforestation were reviewed in the Emission Gap Reports in both 2012 and 2015 and highlighted four distinct policy categories that have economic potential to mitigate around 5 $GtCO_2e$ annually by 2030 according to the 2017 Emissions Gap Report:

- Establishing new protected areas.
- Using command-and-control measures (enacting, enforcing and monitoring of regulations on forest conversion, may include investment in existing protected areas to prevent incursion).
- Using economic instruments (taxes, subsidies, payments for ecosystem services).
- Creating policies affecting drivers and contexts that currently promote deforestation (sectoral policies, institutional frameworks, governance structures and agricultural subsidy reform).

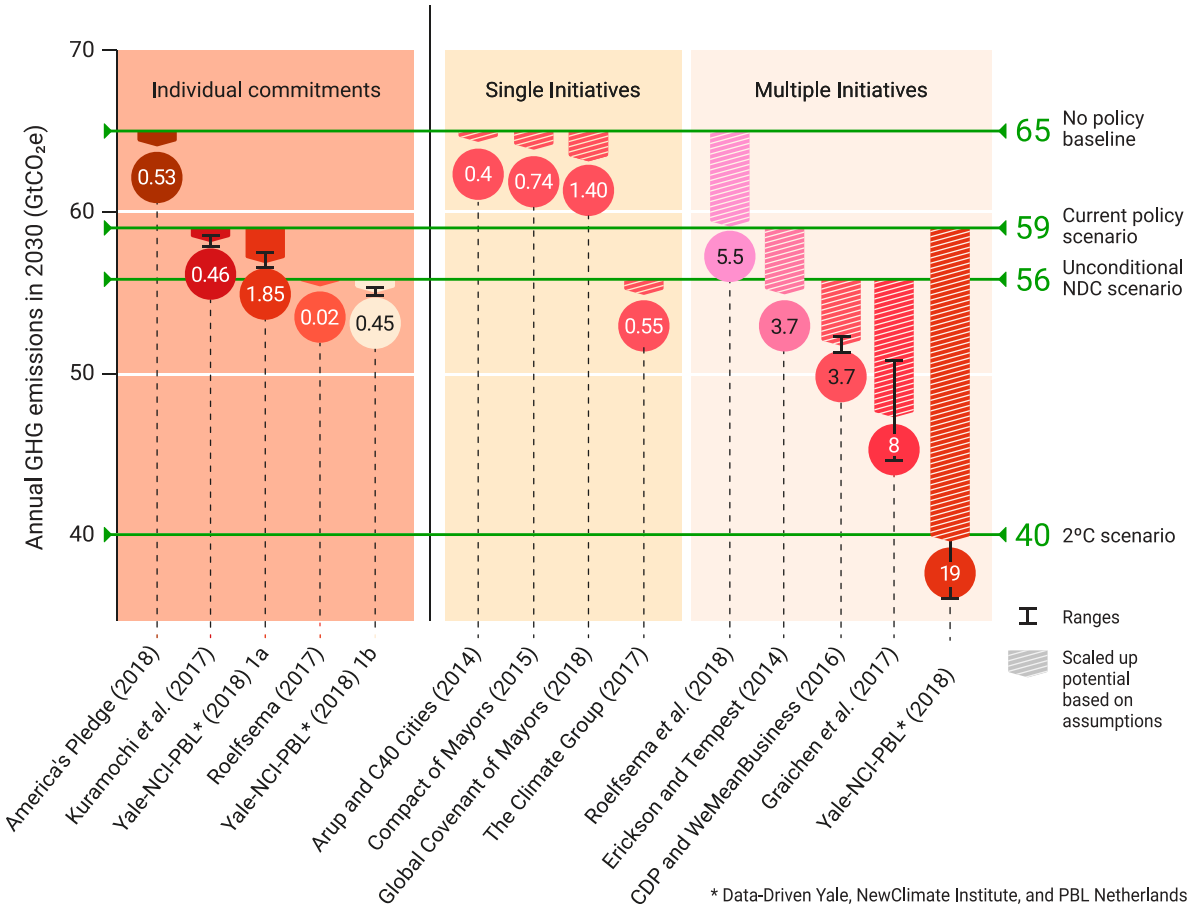
9 Non-State and subnational actors are essential, but the current mitigation impacts are still limited and poorly documented

Non-State and subnational action plays an important role in delivering NDCs. Since 2015, the Emissions Gap Reports have included assessments of the role of such action and the 2018 report included a special focus on non-State and subnational actors. The 2018 report documents the rapid increase in the number of actors participating in climate action: more than 7,000 cities from 133 countries and 245 regions from 42 countries, along with more than 6,000 companies with at least US$36 trillion in revenue, have pledged mitigation action.

Commitments cover large parts of the economy and are gradually expanding in terms of regional coverage. Many of the actors are engaging in 'international cooperative initiatives', which are characterized by multi-country and multi-actor engagement. The numbers are impressive, but there is still huge potential for expansion. Based on available data, less than 20 per cent of the world population is represented in current national and international initiatives, and many more of the over 500,000 publicly traded companies worldwide still can, and must, act.

Assessing the emission reduction potential from non-State and subnational action is challenging and must take into account overlaps with national action. The Emissions Gap Reports find that the potential could ultimately be significant, allowing countries to raise their ambition, but the current impacts are limited and poorly documented (Figure 10).

Figure 10 — The range of estimated potential emission reductions in various non-State and subnational action studies



Source: UNEP (2018), Figure 5.4.

10 Innovation and new solutions are needed for long-term carbon neutrality

Combining innovation in the use of existing technologies and in behaviour with the promotion of investment in new technologies and market creation has the potential to radically transform societies and reduce their GHG emissions. However, it will not happen by itself. Five principles are likely to be key in the design of policies and programmes to accelerate low-carbon innovation (UNEP 2018):

1. Public organizations must be willing to take on the high, early-stage risk that private organizations shy away from.

2. At the mid-stage of the innovation chain, public organizations must be able to nurture feedback effects among different parts of the innovation landscape and help de-risk private investment in commercial-scale projects.

3. Green policies must set a direction for the whole economy, not for each sector separately.

4. Mission-oriented innovation is useful for stimulating investment and innovation across different parts of the economy to reach concrete, target-specific goals by a specific date.

5. Policy instruments need to be structured to mobilize actors through bottom-up exploration and participation. All these policies benefit from a long-term design horizon that creates certainty for private finance to be crowded in.

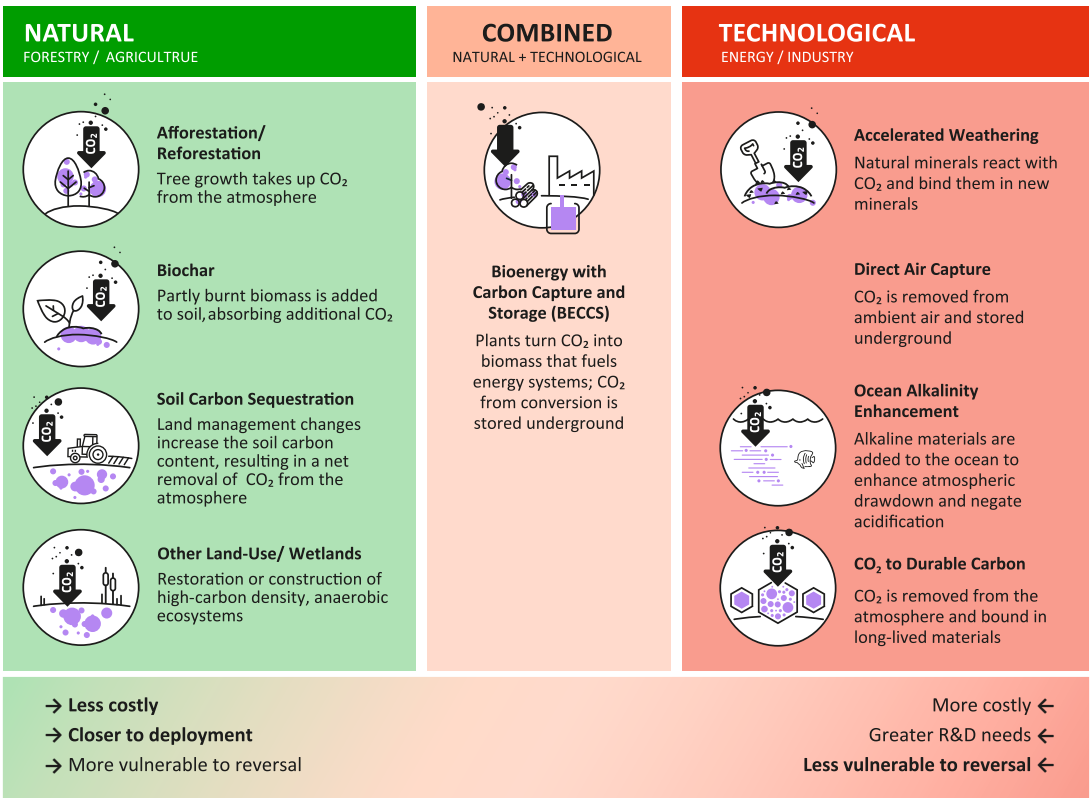
CO_2 removal is one of many areas where innovation and new solutions are needed. Most of the global modelling scenarios that analyse different pathways to achieving the Paris Agreement goals of 1.5°C or well below 2°C include elements of 'negative emissions solutions', that is, options that actively reduce CO_2 in the atmosphere. In the 2017 Emissions Gap Report, the various options for CO_2 removal were therefore assessed. CO_2 removal and the deployment of negative emissions approaches must be employed in addition to other mitigation options. In other words, CO_2 removal is concerned with the management of overshoot, in the event that all relevant mitigation options have been pursued.

Figure 11 provides an overview of the various CO_2 removal options and strategies. Natural removal options have already been mentioned as part of the nature-based solutions and currently constitute the main and most cost-effective options for CO_2 removal. The combined options focus on increased use of bioenergy, especially for power production, combined with Carbon Capture and Storage (CCS). Studies indicate a significant mitigation potential but there are many unresolved issues around the land and water resources required for large-scale biomass for energy production and currently CCS is too costly for large-scale deployment.

Human-made technologies to remove CO_2 from the air have been in use for many years, mostly in submarine, aerospace and medical applications. Only recently have these technologies been considered as global-scale carbon removal agents. They offer specific benefits in that they use very little land or water, they do not emit non-CO_2 GHGs and they have very high levels of certainty regarding the flux and long-term fate of the CO_2 removed. Some approaches also produce materials that can be used commercially, for example, cements and aggregates.

However, many approaches are very expensive and may have numerous, as yet unknown, side effects that may have repercussions for societies. Most have not been deployed at scale and have a low level of technical readiness. Nonetheless, increased investment in developing these options could, over time, change the situation. Precaution is recommended, and pros and cons need to be assessed, before any full-scale deployment could happen. The United Nations may have a role to play in ensuring an overarching intergovernmental policy approach that can help ensure no one is left behind, if such technologies are to be deployed widely.

Figure 11 — Major strategies for negative emission technologies



Source: UNEP (2017), Figure 7.1.

Looking ahead – the next decade will be defining

While the past decade has been a lost opportunity in terms of bending the global emissions curve, a large number of positive policy and technology developments have taken place, creating a solid foundation for enhancing mitigation ambition and accelerating action. The scientific understanding of both the consequences of inadequate action and the available options for rapid and cost-effective emission reductions has also improved significantly.

Bending the emissions curve and bridging the emissions gap, while presenting an unprecedented challenge, is still possible. It will require the full utilization of all emission reduction options and policies to support these, replication and scale-up of current best practices, a shift in investments to bring about the transformations and innovations needed in the longer term, and careful management of the interests of the economic and societal sectors that might be affected during the transition to a zero-carbon and climate-resilient future. It will require concerted climate action of all stakeholders, at all levels and in all sectors.

The next decade will be defining – postponing ambition and action is no longer an option, if we want the goals of the Paris Agreement to remain within reach.

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