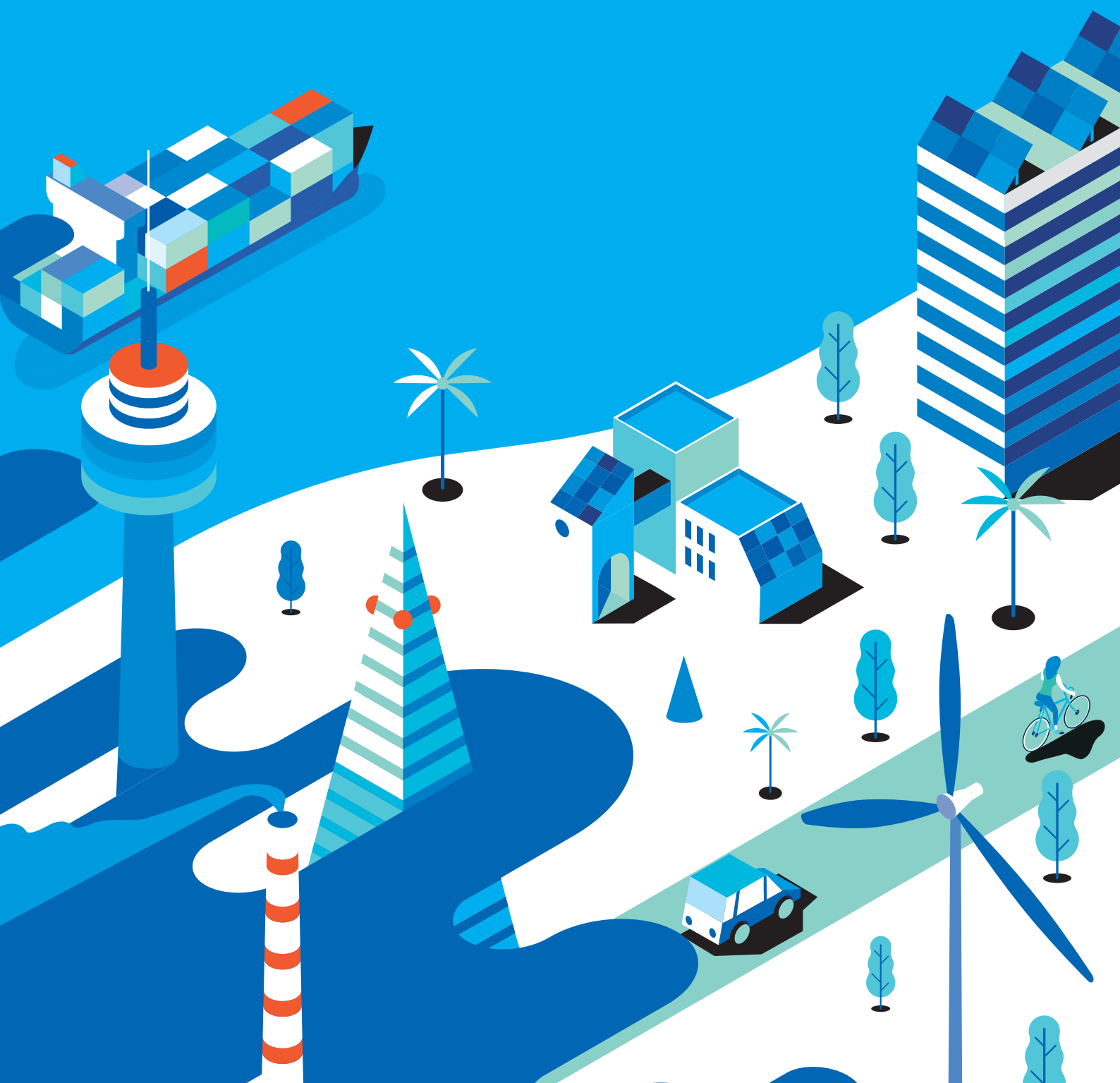


Bridging the Gap – Enhancing Mitigation Ambition and Action at G20 Level and Globally

Pre-release version of a chapter in the forthcoming
UNEP Emissions Gap Report 2019



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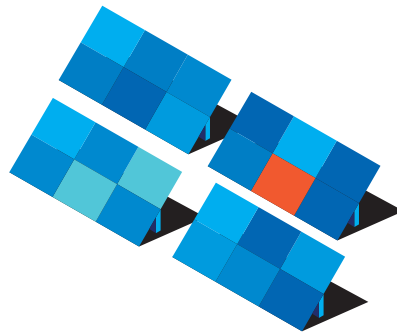
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Executive Summary

This publication is a pre-release version of a chapter in the forthcoming UNEP Emissions Gap Report 2019. It provides a comprehensive overview of recent ambitious climate actions by national and subnational governments as well as non-state actors, and a detailed overview of policy progress and opportunities for enhanced mitigation ambition for selected G20 members. The objective is to inform the preparation of new and updated nationally determined contributions (NDCs) that countries are requested to submit by 2020.

The science and the global challenge are clear: unless NDC ambitions are increased immediately and supported by action, exceeding the 1.5°C goal can no longer be avoided and the well below 2°C goal will slip increasingly out of reach. The Emissions Gap Report (United Nations Environment Programme [UNEP] 2018) showed that nations must triple the level of ambition in their current NDCs to get on track towards limiting global warming to below 2°C, while 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. For this to be realistic new and enhanced NDCs must be agreed by 2020 and the implementation of existing actions must be 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.

There are more opportunities and incentives for ambitious climate action than ever before, which provides a strong basis for enhancing NDC ambitions by 2020. Renewables are now the cheapest source of new power generation in most of the world and falling battery costs are leading to predictions that electric vehicles will achieve price parity with internal combustion engine vehicles by the mid-2020s. There is increased understanding of the potential multiple benefits of climate action and ample examples of ambitious actors from national and subnational governments, businesses and investors.

Collectively, the G20 members have not yet taken on transformative climate commitments at the breadth and scale necessary. There is an urgent need for the G20 members to step up their commitments on ambitious climate action and to reflect this in new or updated NDCs by 2020. Policymakers in G20 member nations can work together with national and subnational actors that are already committing to ambitious climate action to accelerate their target-setting and implementation across economic sectors.

The number of countries and states that are committing to zero greenhouse gas (GHG) or carbon dioxide (CO₂) emission targets is increasing, though it is still far from the scale and pace required. To date, 20 countries accounting for about 9 per cent of global GHG emissions, and 8 states have communicated long-term objectives to achieve zero emissions, differing in scope, timing and in the degree to which they are legally binding. Five G20 members have committed to long-term zero emissions targets, of which three (the European Union and Germany and Italy as part of the European Union) are currently in the process of passing legislation, with two G20 members (France and the United Kingdom) having recently passed legislation. The remaining 15 G20 members have not yet committed to zero emission targets.

Economy-wide climate action remains extremely limited in other areas, such as a complete phase-out of fossil-fuel subsidies, comprehensive and ambitious carbon pricing and making all finance flows consistent with the Paris Agreement. In 2009, the G20 members adopted a decision to gradually phase out fossil-fuel subsidies, though no country has yet committed to fully phasing these out by a specific year. Similarly, while carbon pricing is expanding, no country has established a comprehensive and ambitious system for this. At present, carbon tax and emissions trading system initiatives at the national and regional level represent about 20 per cent of global GHG emissions. However, 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. Furthermore, no country has explicitly committed to making their finance flows consistent with the Paris Agreement, though several multilateral development banks are currently working towards aligning their financing activities with the Paris Agreement goals.

Some countries and states have communicated 100 per cent renewable electricity targets to fully decarbonize their electricity supply sector. Globally, 10 countries have explicitly committed or are in the process of committing to 100 per cent renewable energy targets. However, these countries accounted for less than 1 per cent of global CO₂ emissions from electricity generation in 2016. Five G20 members have also committed to long-term zero emissions targets, and, in turn, to fully decarbonizing their electricity sectors, and 21 states and regions, including California (by 2045), as well as an increasing number of cities and companies, have committed to 100 per cent renewable energy targets.

The countries that are committing to phasing out coal-fired power plants are primarily those that already have low shares of coal. The 13 countries that have currently committed or are in the process of committing to a full phase-out of coal accounted for around 5 per cent of global CO₂ emissions from coal-based electricity generation in 2016. Five G20 members are among these 13 countries: Canada, France and Italy have already passed legislation, while Germany and the United Kingdom are in the process of passing legislation. A few non-state actors show high ambition, including 22 banks that have stopped direct financing to new coal mine projects and 23 banks that have stopped direct financing to new coal plant projects worldwide.

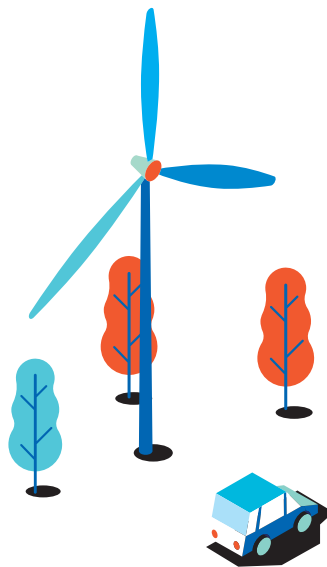
An increasing number of countries, states and cities are pledging to phase out combustion engines for vehicles and initiate substantial modal shifts towards public transport, though to date, no such commitments have been made for aviation, shipping and freight transport. Only a few actors have currently committed to ambitious targets for these transport modes. For example, Norway is aiming to make domestic flights 100 per cent carbon-free by 2040 and several companies are working on zero-emission tanker and port infrastructure.

At present, countries and states are largely refraining from ambitious target-setting in the industry sector, both in terms of carbon pricing and phase-in of zero-carbon technologies. Some major steel and cement producers have recently pledged to zero emissions by 2050 for their operations. Such commitments and technology road maps could serve as a starting point to define targets for the entire industry sector, following the frontrunners.

The buildings sector shows only scattered policy action at high levels of mitigation ambition, mainly centred on policymaking in the European Union. In addition, six states and more than 23 cities have recently committed to zero targets for the buildings sector as part of the World Green Building Council's Net Zero Carbon Buildings Commitment by 2050. In general, there is a lack of targets for phasing out fossil fuels in heating, zero emissions in the sector and deep retrofits of existing buildings.

Many countries, including most G20 members, have committed to zero net deforestation targets in the last decades, though these commitments are often not supported by action on the ground. Countries, states, businesses and investors urgently need to ensure that they implement their various commitments, including those under the New York Declaration on Forests, the World Wide Fund for Nature's (WWF) call for zero net deforestation by 2020 and the Soft Commodities Compact.

While all countries need to accelerate the pace and scale of transformation across economic sectors, there is no single approach to climate action and policies must therefore be adapted to national contexts. National and subnational governments and non-state actors all have context-specific approaches to ambitious climate action, with broader development goals an overarching priority for many. The examples in the country sections of this report illustrate how distinct types of targets and policies can achieve common goals in different countries. For example, ambitious renewable energy targets can be achieved with a variety of support policies to handle distributional impacts linked to transitions.



Bridging the Gap – Enhancing Mitigation Ambition and Action at G20 Level and Globally

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1 Introduction

In the lead-up to the 2019 Climate Action Summit, United Nations Secretary-General António Guterres has called on leaders to “announce the plans that they will set next year to reduce greenhouse gas emissions for 2030 and to achieve net zero emissions by 2050” (Farand 2019). The Secretary-General’s message has echoed the growing popular movement for transformative, ambitious climate action.

The focus on ambition and action is well founded. The Emissions Gap Report for 2018 estimated that the gap by 2030 between emissions levels under full implementation of conditional nationally determined contributions (NDCs) and those consistent with least-cost emissions pathways to the 2°C target to be 13 GtCO_{2e}. If only the unconditional NDCs are implemented, the gap is estimated to increase to 15 GtCO_{2e}. The gap estimate in the case of the 1.5°C target is 29 GtCO_{2e} and 32 GtCO_{2e} respectively. These estimates will be updated in the forthcoming Emissions Gap Report 2019.

The decision text of the Paris Agreement (United Nations Framework Convention on Climate Change [UNFCCC] 2015a) requests that by 2020, Parties whose NDCs extend up to 2025 communicate new NDCs and Parties whose NDCs extend up to 2030 communicate or update their NDCs. Unless these new and updated NDCs reflect much greater mitigation ambition that is backed up by immediate action, it will no longer be possible to avoid exceeding the 1.5°C goal. If the 2030 emissions gap is not bridged, it is highly likely that the goal of a temperature increase well below 2°C will also slip out of reach (UNEP 2018). 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 (Christensen and Olhoff 2019).

This report aims to inform the 2020 NDC cycle by summarizing the key opportunities to enhance ambition, addressing the following questions:

- ▶ How has the global situation changed since the Paris Agreement was adopted and how does this affect opportunities to increase ambition?
- ▶ How many and what type of ambitious climate commitments have been adopted by national governments, as well as by cities, states, regions, companies and investors to date?
- ▶ Among selected G20 members, what progress has been made recently towards ambitious climate action and what are the key opportunities for additional action?

The primary focus of this report is on ambitious climate targets and actions, which are defined as those that unambiguously contribute towards the transformations required to align global greenhouse gas (GHG) emissions pathways with the Paris Agreement goals. Section 2 summarizes the global opportunity to enhance ambition and action and provides an overview of the status of ambitious climate mitigation commitments made by G20 members as well as countries and non-state actors globally.

As G20 members account for almost 80 per cent of global GHG emissions, they largely determine global

emission trends and the extent to which the 2030 emissions gap will be closed. This report therefore also pays particular attention to G20 members, with Section 3 focusing on progress and opportunities for enhancing mitigation ambition of seven selected G20 members: Argentina, Brazil, China, the European Union, India, Japan and the United States of America, which represented around 56 per cent of global GHG emissions in 2017.ⁱ Section 3 considers ambitious climate actions, as well as actions that are incremental. The selection of the G20 members was based entirely on the availability of expertise in the author team. In the final version of this report, which will be included in the Emissions Gap Report 2019 (to be released in advance of the twenty-fifth session of the Conference of the Parties (COP 25) in December 2019), country analyses for Mexico and South Africa will be added.ⁱⁱ

2 The global opportunity to enhance ambition and action

2.1 The scale and type of transformation needed to enhance climate ambition and action are clear

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C (Intergovernmental Panel on Climate Change [IPCC] 2018) concluded that limiting the temperature increase to 1.5°C with no or limited overshoot would mean reducing global CO₂ emissions by about 45 per cent from 2010 levels by 2030 and reaching net zero around 2050. To align with the 2°C limit, global CO₂ emissions would need to decline by about 25 per cent from 2010 levels by 2030 and reach net zero around 2070.

Under the Paris Agreement, countries are invited to submit long-term low GHG emission development strategies by 2020 and are requested to submit updated or new NDCs also by 2020. Considering the update of NDCs in the context of the development of long-term mitigation strategies is an important means to ensure consistency between short-term mitigation policies and targets and long-term goals. The IPCC Special Report on Global Warming of 1.5°C provides clear guidance on the economy-wide and sector transformations that are needed to limit the temperature increase to 1.5°C by the end of the century.

Although the time frame for global emission reductions consistent with the 2°C limit is slightly longer, the major long-term sectoral transformations needed to reach net zero GHG emissions globally are essentially the same and can be summarized under the following headings:

- ▶ full decarbonization of the energy sector, based on renewable energy and electrification across sectors – this includes phasing out coal-fired power plants
- ▶ decarbonization of the transport sector in parallel with modal shifts to public transportation, cycling and walking
- ▶ shifts in industry processes towards electricity and zero carbon and substitution of carbon-intensive products
- ▶ decarbonization of the building sector, including electrification and greater efficiency
- ▶ enhanced agricultural management as well as demand-side measures such as dietary shifts to more sustainable, plant-based diets and measures to reduce food waste
- ▶ zero net deforestation and the adoption of policies to conserve and restore land carbon stocks and protect natural ecosystems, aiming for significant net CO₂ uptake in this sector

(IPCC 2018; UNEP 2017).

Transformations in these areas will require major shifts in investment patterns and financial flows, as well as several sectoral and economy-wide policy targets. The ambitious climate targets considered in section 2.3 are based on these overall areas of transformation and important sub-targets. A full overview is provided in Annex I, Table A-1.

2.2 Drivers of ambition have evolved since the Paris Agreement

Compared with the run-up to the Paris Agreement in 2015, when countries prepared their intended NDCs, many drivers of climate action have changed, with several options for ambitious climate action becoming less costly, more numerous and better understood. Changes within three main categories in particular could facilitate greater NDC ambition today (UNEP 2018). First, technological and economic developments present opportunities to decarbonize the economy, especially the energy sector, at a cost that is lower than ever. Second, the synergies between climate action and economic growth and development objectives, including options for addressing distributional impacts, are better understood. Finally, policy momentum across various levels of government, as well as a surge in climate action commitments by non-state actors, is creating opportunities for countries to enhance the ambition of their NDCs.

ⁱ Using the latest inventory data for all G20 members in the Electronic Data Gathering, Analysis, and Retrieval (EDGAR) (Olivier and Peters 2018) and latest reported national inventory data for each country for LULUCF emissions.

ⁱⁱ Since the European Union Member States present a single NDC, the European Union is represented collectively rather than as the four Member States that are also individual G20 members.

The cost of renewable energy is declining more rapidly than was predicted just a few years ago. Renewables are currently the cheapest source of new power generation in most of the world, with the global weighted average purchase or auction price for new utility-scale solar power photovoltaic (PV) systems and utility-scale onshore wind turbines projected to compete with the marginal operating cost of existing coal plants by next year (International Renewable Energy Agency [IRENA] 2019). These trends are increasingly manifesting in a decline in coal plant construction, including the cancellation of planned plants, as well as the early retirement of existing plants (Jewell et al. 2019; Smouse et al. 2018). Moreover, real-life cost declines are outpacing projections. The 2019 costs of onshore wind and solar PV power are 8 and 13 per cent lower respectively than IRENA predictions from just one year ago in 2018 (IRENA 2019). These cost declines, along with those of battery storage, are opening possibilities for utility-scale solar power.

Although technological progress has been uneven across sectors, with the industry and buildings sectors in particular lagging behind (International Energy Agency [IEA] 2019), the benefits extend beyond power generation. For example, as a result of falling battery costs, predictions forecast that electric vehicles will achieve price parity with internal combustion engine vehicles by the mid-2020s and lead global sales between 2035 and 2040 (Bloomberg 2018).

Aside from advancements in technology, a growing body of research has documented that ambitious climate action, economic growth and sustainable development can go hand-in-hand when well managed. Analysis by the Global Commission on the Economy and Climate estimates that ambitious climate action could generate US\$ 26 trillion in economic benefits between now and 2030 and create 65 million jobs by 2030, while avoiding 700,000 premature deaths from air pollution (The New Climate Economy 2018). Similarly, the IPCC (2018) found that, if managed responsibly, most mitigation options consistent with limiting warming to 1.5°C could have strong synergies with the Sustainable Development Goals (SDGs), especially those related to health, clean energy, cities and communities, responsible consumption and production, and oceans (IPCC 2018).

Momentum at all levels of government and parts of the business sector increases the potential to reflect greater ambition in the NDCs. At the subnational level, for example, over 70 large cities housing 425 million people have committed to go carbon-neutral by 2050 or sooner (see Table A-1). At the national level, 12 countries have communicated long-term, low GHG emissions development strategies to the UNFCCC (UNFCCC 2019), with many more under development or developed at the national level but not communicated internationally (WRI 2019). At the international level, the Kigali Amendment to the Montreal Protocol outlines phase-down schedules for production and consumption of hydrofluorocarbons (HFCs). Businesses are increasingly moving towards zero emissions, 100 per cent

renewables and 100 per cent emission-free transport (see Table A-1).

Taken together, cost-competitive technologies, potential synergies with development and economic growth, and strong action from the subnational to international levels provide a strong basis for more ambitious NDCs by 2020.

2.3 An increasing number of countries and regions are adopting ambitious goals in line with the transformation needed, but the scale and pace are far from sufficient

Several national and subnational governments and non-state actors have embarked on ambitious climate action in different policy areas that can help initiate the transformational change required to meet the long-term goals of the Paris Agreement. Although recent developments send promising signals, the adoption of ambitious climate targets is far from the scale and rate urgently required

This section presents an overview of the extent to which G20 members, as well as countries and regions worldwide, have committed or are in the process of committing to ambitious climate targets and actions. These targets and actions are defined as unambiguously supporting a move towards the major long-term sectoral transformations required to meet the well-below 2°C and 1.5°C temperature limits of the Paris Agreement, as outlined in Section 2.1. Expanding on the key types of policy targets and actions that would support such major transformations, this section provides an overview of the status of commitments to the following ambitious climate targets organized in six main categories:

- 1) Overarching economy-wide targets and actions: Zero GHG or CO₂ targets by a certain year; ambitious comprehensive CO₂ pricing in all sectors, which is at least of the order considered consistent with limiting the global temperature increase to 2°C; a complete phase-out of fossil-fuel subsidies by a certain year; and making financial flows consistent with the Paris Agreement goal by a certain year
- 2) Electricity production: 100 per cent renewable or carbon-free electricity by a certain year; a phase-out of coal-fired power plants by a certain year and supported with a fair transition plan; and stopping the financing and insuring of coal-fired power plants by a certain year
- 3) Transport: A certain percentage shift to public transport by a specific year; a 100 per cent share of new zero-emission motorbikes, cars and/or buses by a specific year; 100 per cent carbon-free heavy transport and ships by a certain year; and 100 per cent carbon-free aviation by a specific year
- 4) Heavy and extractive industry: Ending new fossil-fuel explorations and production by a certain year; setting

a zero fugitive emissions target for a certain year; enforcing that all new installations are low-carbon or zero emissions and maximize material efficiency by a certain year; and ambitious carbon pricing for industry by a specific year

- 5) Buildings: Pursuing 100 per cent zero-energy buildings as new buildings by a certain year; full decarbonization of the building sector by a certain year; phase-out of fossil fuels (for example, gas) for residential heating by a specific year; and increase in the rate of zero-energy renovations to a certain percentage within a certain time frame
- 6) Forestry: Zero net deforestation by a specific year

A detailed overview of commitments made as of August 2019 for the above targets by individual countries, regions, businesses and investors is provided in Annex I, Table A-1.

It should be noted that the overview of targets and commitments provided in this section and in the Annex is not exhaustive. Rather, it builds on a broad range of literature to identify ambitious climate action in the different categories (Kuramochi et al. 2018), but given the scope of existing policies and rapid changes in policymaking, the overview may not be completely up-to-date. The list of targets is also incomplete. Notably, it is beyond the scope of this report to provide an overview of ambitious climate targets and commitments for agriculture. Finally, no attempt has been made to assess whether individual commitments are aligned with global least cost-effective emissions pathways to the 1.5°C or 2°C targets. Commitments differ in various respects, including the extent to which they are legally binding, the percentages and target years adopted, whether they refer to GHG or CO₂ emissions and whether they are net targets.ⁱⁱⁱ These specifications are important for a detailed picture of the individual commitments and are provided in Table A-1.

Ambitious climate targets and actions adopted by countries and regions to date are prime examples of climate action that others can follow. Dynamics to adopt legally binding targets differ between target categories and sectors. Most of the recent increase in national and subnational commitments is related to the adoption of economy-wide zero emission targets by 2050 or sooner (see Figure 1), 100 per cent renewable energy or electricity targets (see Figure 2) and a 100 per cent share of new zero-emission motorbikes, cars and/or buses (see Figure 3)^{iv}. To date, countries, regions and subnational actors have mostly refrained from adopting

legally binding ambitious targets in other sectors, such as industry, buildings or heavy transport, except for a few first movers.

Overall, the number of countries and states that are committing to zero emission targets is increasing, though it is still far from the scale and pace required, as illustrated in Figure 1. To date, 20 countries account for about 9 per cent of global GHG emissions^v, and eight states have long-term objectives to achieve net-zero emissions, differing in scope, timing and the degree to which they are legally binding. Five G20 members have committed to long-term net-zero emissions targets, of which three (the European Union and Germany and Italy as part of the European Union) are currently in the process of passing legislation, with two G20 members (France and the United Kingdom) having recently passed legislation. The remaining 15 G20 members have not yet committed to net-zero emission targets.

Economy-wide climate action remains extremely limited in other areas, such as a complete phase-out of fossil-fuel subsidies, comprehensive and ambitious carbon pricing and making finance flows consistent with the Paris Agreement. In 2009, the G20 members adopted a decision to gradually phase out fossil-fuel subsidies, though no country has yet committed to fully phasing these out by a specific year. Similarly, while carbon pricing is expanding, no country has established a comprehensive and ambitious system for this. At present, carbon tax and emissions trading system initiatives at the national and regional levels represent about 20 per cent of global GHG emissions (World Bank 2019). However, 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 (UNEP 2018). Furthermore, no country has explicitly committed to making their finance flows consistent with the Paris Agreement, though several multilateral development banks are currently working towards aligning their financing activities with the Paris Agreement goals (World Bank 2018).

In terms of electricity production (Figure 2), 10 countries have committed or are in the process of committing to a 100 per cent renewables target. However, these countries accounted for less than 1 per cent of global CO₂ emissions from electricity generation in 2016.^{vi} Five G20 members have also committed to long-term net-zero emissions targets and, in turn, to fully decarbonizing their electricity sectors. In addition, 21 states and regions, including California (by 2045), as well as an increasing number of cities and companies, have committed to 100 per cent renewable electricity targets.

ⁱⁱⁱ For this reason, reference is made to 'zero emissions targets and the reader is referred to Table A-1 for further detail.

^{iv} The targets considered cover legally binding, legally binding but under consideration, and non-legally binding pledges.

^v The share of these countries has been calculated on latest available EDGAR data and FAO data for LULUCF emissions (FAOSTAT, 2018; Olivier and Peters, 2018).



^{vi} The share of these countries has been calculated on emissions data for CO₂ emission from electricity generation provided by IEA's CO₂ emission form fuel combustion dataset (IEA, 2018).

Figure 1– Overview of ambitious overarching economy-wide climate actions and targets by G20 members, countries and regions (for full details, see Annex I, Table A-1)

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An increasing number of countries and regions are committing to zero carbon dioxide or greenhouse gas emission targets, but not at the scale and pace required. Other economy-wide climate action such as completely phasing out fossil fuel subsidies, introducing comprehensive and ambitious carbon pricing and making all finance flows consistent with the Paris Agreement remains inadequate.

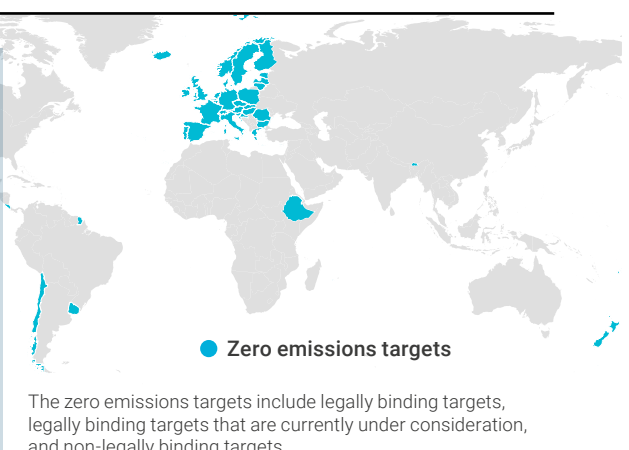
Target categories	G20 countries	Country level	Regional level
Zero emissions by year x	<p>2 G20 members (France, UK) have passed legislation</p> <p>3 G20 members (EU and Germany and Italy as part of EU¹) currently in process of passing legislation</p> <p>15 G20 members have no binding (net-) zero-emission targets</p>	<p>20 countries</p>  <p>Bhutan, Chile, Costa Rica, Denmark, Ethiopia, EU, Fiji, Finland, France, Iceland, Ireland, Marshall Islands, Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, UK, Uruguay</p>	<p>8 regions</p>  <p>California, New South Wales, New York, Queensland, Scotland, South Australia, Tasmania, Victoria</p>
Ambitious comprehensive CO ₂ pricing in all sectors by year x ²	<p>No G20 member has implemented ambitious comprehensive CO₂ pricing in all sectors, but 9 G20 members have implemented carbon pricing as ETS or carbon tax with partial coverage and/or lower CO₂ prices (as at August 2019)</p>	<p>No country</p> <p>✗</p>	<p>No regions</p> <p>✗</p>
Phase out all fossil fuel subsidies by year x	<p>No G20 member has existing reform plans to fully phase out all fossil fuel subsidies, but the G20 took a decision in 2009 to gradually phase out fossil fuel subsidies with an annual peer-review among G20 members</p>	<p>No country</p> <p>✗</p>	<p>No regions</p> <p>✗</p>
Make all finance flows consistent with the Paris Agreement goals by year x *	<p>No G20 member has made all finance flows fully aligned with the Paris Agreement goals, but the UK has published a Green Finance Strategy in 2019 as an example of intermediate action</p>	<p>No country</p> <p>✗</p>	<p>No regions</p> <p>✗</p>



*** Non-state actor example**

10 Multilateral Development Banks (MDBs) are currently working towards aligning their financing activities with the Paris Agreement goals. The MDBs will develop relevant methods and tools with the objective of presenting a joint Paris alignment approach and individual MDB progress towards alignment at COP 25 in 2019.

More information:
<http://pubdocs.worldbank.org/en/784141543806348331/Joint-Declaration-MDBs-Alignment-Approach-to-Paris-Agreement-COP24-Final.pdf>



Notes:¹Italy is not currently pursuing a process to pass national legislation on a zero-emissions target, but will be covered under the European Union target, if adopted.
²The Report of the High-Level Commission on Carbon Prices of 2018 recommends an average economy-wide price of at least US\$ 40–80/tCO₂ by 2020 and US\$ 50–100/tCO₂ by 2030 to close the emissions gap in order to meet the 2°C target (High-Level Commission on Carbon Prices 2017; UNEP, 2018). For this reason, economy-wide carbon prices would need to be higher in the respective years to close the emissions gap in order to meet the Paris Agreement’s temperature goal of “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels”.

The 13 countries that have currently committed or are in the process of committing to a full phase-out of coal accounted for around 5 per cent of global CO₂ emissions from coal-based electricity generation in 2016.^{vii} Five G20 members are among these 13 countries: Canada, France and Italy have already passed legislation, while Germany and the United Kingdom are in the process of passing legislation. A few non-state actors show high ambition, including 22 banks that have stopped direct financing to new coal mine projects and 23 banks that have stopped direct financing to new coal plant projects worldwide.

An increasing number of countries, states and cities are pledging to phase out combustion engines for vehicles and initiate substantial modal shifts towards public transport, though to date, no such commitments have been made for aviation, shipping and freight transport (Figure 3). However, there are several interesting examples of non-state actors committing to ambitious climate action for these transport modes, as the figure shows. For example, Norway is aiming to make domestic flights carbon-free by 2040 and several companies are working on zero-emission tanker and port infrastructure.

At present, countries and states are largely refraining from ambitious target-setting in the heavy and extractive industry sector (see Annex I, Table A-1). Six countries, including one G20 member (France), are currently committed to stopping new fossil-fuel explorations and production. In addition, a few European (re-)insurance companies have recently implemented policies to stop investments, insurance cover and underwriting for new and ongoing fossil-fuel projects. No countries have committed to zero fugitive emissions targets or to ensuring that all new installations are low-carbon or zero emissions and maximize material efficiency. Only Sweden has set a target for ambitious carbon pricing in the industry sector. Some major steel and cement producers have recently pledged to zero emissions by 2050 for their operations. Such commitments and technology road maps could serve as a starting point to define targets in the entire industry sector, following the frontrunners.

The buildings sector shows only scattered policy action at high levels of mitigation ambition, mainly centred on policymaking in the European Union (see Annex I, Table A-1). In addition, six states and more than 23 cities have recently committed to zero targets for the buildings sector as part of the World Green Building Council's Net Zero Carbon Buildings Commitment by 2050. In general, there is a lack of targets for phasing out fossil fuels in heating, zero emissions in the sector and deep retrofits of existing buildings.

Many countries, including most G20 members, have committed to zero net deforestation targets in the last

decades (see Annex I, Table A-1), though these commitments are often not supported by action on the ground. Countries, states, business and investors urgently need to ensure that they implement their various commitments, including those under the New York Declaration on Forests, the World Wide Fund for Nature's (WWF) call for zero net deforestation by 2020 and the Soft Commodities Compact.

To summarize, G20 members urgently need to step up their commitments on ambitious climate action. As this section shows, there are many opportunities to adopt economy-wide and sector-specific climate action targets as called for in advance of the United Nations Climate Summit in September 2019, and to reflect such targets in the upcoming ambition-raising cycle and submission of long-term strategies under the Paris Agreement by 2020. Section 3 elaborates on the types of actions and targets that G20 members could commit to in the short-term across the different sectors, focusing on seven selected G20 members.










The G20 members could follow other national and subnational frontrunners driving ambitious climate action in several areas. Only a few G20 members, including France and the United Kingdom, have recently adopted legally binding legislation in multiple sectors, such as energy, transport and buildings, in addition to an economy-wide net-zero emissions target by 2050. The national and subnational actors already committed to ambitious climate action should inform policymakers in G20 member nations to accelerate their target-setting in different sectors of the economy. This is particularly true for sectors that are difficult to decarbonize, where subnational actors are showing promising frontrunner action aimed at long-term decarbonization in line with the Paris Agreement.

^{vii} The share of these countries has been calculated on emissions data for CO₂ emission from coal-based electricity generation provided by IEA's CO₂ emission from fuel combustion dataset (IEA, 2018).

Figure 2 – Overview of climate actions and targets in the electricity generation sector by G20 members, countries and regions (for full details, see Annex I, Table A-1)



Figure 3 – Overview of ambitious overarching economy-wide climate actions and targets by G20 members, countries and regions (for full details, see Annex I, Table A-1)

TRANSPORT			
 <p>While an increasing number of countries, regions, and cities pledge to phase out combustion engines and initiate substantial modal shifts towards public transport, no such commitments have been made for aviation, shipping, and freight transport to date.</p>			
Target categories	G20 countries	Country level	Regional level
100% share of new zero-emission motorbikes, cars and/or buses as of year x	<p>5 G20 members (Canada, France, Japan, Mexico, UK) have announced target</p> <p>2 G20 members (India, Indonesia) have announced target but confirmation is pending</p> <p>13 G20 members have not announced target for 100% new zero-emission motorbikes, cars and/or buses</p>	<p>21 countries</p>  <p>Canada, Costa Rica, Denmark, France, Iceland, India, Indonesia, Ireland, Israel, Japan, Mexico, Nepal, Netherlands, Norway, Portugal, Scotland, Slovenia, Spain, Sweden, UK</p>	<p>5 regions</p>  <p>Australian Capital Territory, British Columbia, California, Hainan, Hawaii</p>
Shift to x% public transport by year x *	<p>3 G20 members (China, India, Indonesia) with distinct modal shift targets</p> <p>No conclusion possible for all other G20 members</p>	<p>4 countries</p>  <p>China, India, Indonesia, Singapore have distinct modal shift targets No comprehensive data available for all other countries</p>	<p>No regions</p> 
100% carbon-free heavy transport and ships as of year x **	<p>No G20 member with legally binding target for 100% carbon-free heavy transport and ships</p>	<p>No country</p> 	<p>No regions</p> 
100% carbon-free aviation as of year x ***	<p>No G20 member with legally binding target for 100% carbon free aviation</p>	<p>No country</p> 	<p>No regions</p> 
<p>* Non-state actor example</p> <p>52 cities have targets for 100% electric cars and/or busses, e.g. Shenzhen has already electrified all busses and taxis, Paris aims for 100% fossil free cars and busses in the city by 2025. 49 companies have pledged to accelerate their transition to electric vehicles under the EV100 initiative.</p> <p>More information: https://www.theguardian.com/cities/2018/dec/12/silence-shenzhen-world-first-electric-bus-fleet https://www.theclimategroup.org/ev100-members</p>			
<p>** Non-state actor example</p> <p>Several companies have recently announced their plans to develop zero emission container ships, for example by entirely powering tankers by hydrogen produced from renewable energy sources. For example, Maersk, the world's largest container shipping company, has committed to making carbon-neutral vessels commercially viable by 2030 by using energy sources such as biofuels and will cut its net carbon emissions to zero by 2050.</p> <p>More information: https://www.maersk.com/news/articles/2019/06/26/towards-a-zero-carbon-future</p>			
<p>*** Non-state actor example</p> <p>Norway and Scotland both aim to decarbonize their domestic aviation sector by 2040. Avinor, Norway's airport operator, has announced a switch to electric air transport for all domestic flights as well as those to neighbouring Scandinavian capitals. Scotland plans to becoming the world's first net-zero aviation region by 2040, with trials of low or zero emission flights to begin in 2021.</p> <p>More information: http://www.airport-business.com/2019/06/avinor-domestic-air-transport-norway-electrified-2040/ https://www.bbc.com/news/uk-scotland-scotland-politics-49556793?utm_source=CP+Daily&utm_campaign=66d62ab006-CPdaily03092019&utm_medium=email&utm_term=0_a9d8834f72-66d62ab006-110247033</p>			

3 Opportunities to enhance ambition in example countries

The following sections provide an overview of the main policies affecting GHG emissions that selected G20 members have recently implemented. As mentioned previously, the selection of the G20 members is based entirely on the availability of data and expertise of the author team.

To the extent possible, changes in policies since the adoption of the Paris Agreement that are expected to be associated with the highest emissions impacts are highlighted, supported by quantitative estimates from the literature reviewed to give a sense of the magnitude of the actions. No attempt has been made to provide mitigation potential per G20 member, as it is difficult to provide values that are comparable across members. Recent changes are identified as :

- ▲ positive
- neutral
- ▼ negative

The section also provides a summary of country-specific opportunities for enhanced climate ambition and action in the selected countries. These opportunities represent possible next steps in the policymaking process based on

the current situation. The list of actions is not exhaustive and other actions, including those identified in the previous section and in Table A-1, would also need to be implemented to achieve global emission reductions at the scale required to maintain progress towards achieving the targets set out in the Paris Agreement.

Several steps were followed to identify the opportunities. Using the current policy situation in each country as a starting point, political areas that would be obvious to pursue for development of the next steps were identified. For example, consideration was given to whether policy proposals had already been put forward by relevant actors. Subsequently, the opportunities were checked against the major actions that must be taken to put the world on a path that is compatible with the Paris Agreement long-term temperature goal as summarized in Section 2.3 and listed in Table A-1. Finally, the opportunities were cross-checked with several country experts.

Table 1 provides an overview of selected opportunities for enhancing mitigation ambition identified for the seven G20 members considered in this publication. The selection is based on expert judgements regarding the extent to which these opportunities are in line with ambitious climate actions and targets as defined and outlined in Section 2.3. The country sections provide additional examples of country-specific opportunities.



Table 1 – Selected current opportunities to enhance ambition in seven G20 members in line with ambitious climate actions and targets as identified in Table A-1

Argentina
<ul style="list-style-type: none"> ● Refrain from extracting new, alternative fossil-fuel resources ● Reallocate fossil-fuel subsidies to support distributed renewable electricity generation ● Shift towards widespread use of public transport in large metropolitan areas ● Redirect subsidies granted to companies for the extraction of alternative fossil fuels to building-sector measures
Brazil
<ul style="list-style-type: none"> ● Commit to the full decarbonization of the energy supply by 2050 ● Develop a national strategy for ambitious electric vehicle (EV) uptake aimed at complementing biofuels and at 100 per cent CO₂-free new vehicles ● Promote the ‘urban agenda’ by increasing the use of public transport and other low-carbon alternatives
China
<ul style="list-style-type: none"> ● Ban all new coal-fired power plants ● Continue governmental support for renewables, taking into account cost reductions and accelerate development towards a 100 per cent carbon-free electricity system ● Further support the shift towards public modes of transport ● Support the uptake of electric mobility, aiming at 100 per cent CO₂-free new vehicles ● Promote near-zero emission building development and integrate it into Government planning
European Union^x
<ul style="list-style-type: none"> ● Adopt an EU regulation to refrain from investment in fossil-fuel infrastructure, including new natural gas pipelines ● Define a clear endpoint for the EU emissions trading system (ETS) in the form of a cap that must lead to zero emissions ● Adjust the framework and policies to enable 100 per cent carbon-free electricity supply by between 2040 and 2050 ● Step up efforts to phase out coal-fired plants ● Define a strategy for zero-emission industrial processes ● Reform the EU ETS to more effectively reduce emissions in industrial applications ● Ban the sale of Internal Combustion Engine (ICE) cars and buses and/or set targets to move towards 100 per cent of new car and bus sales being zero-carbon vehicles in the coming decades ● Shift towards increased use of public transport in line with the most ambitious Member States ● Increase the renovation rate for intensive retrofits of existing buildings
India
<ul style="list-style-type: none"> ● Plan the transition from coal-fired power plants ● Develop an economy-wide green industrialization strategy towards zero-emission technologies ● Expand mass public transit systems ● Develop domestic electric vehicle targets working towards 100 per cent new sales of zero-emission cars
Japan
<ul style="list-style-type: none"> ● Develop a strategic energy plan that includes halting the construction of new freely emitting coal-fired power plants, as well as a phase-out schedule of existing plants and a 100 per cent carbon-free electricity supply ● Increase the current level of carbon pricing with high priority given to the energy and building sector ● Develop a plan to phase out the use of fossil fuels through promoting passenger cars that use electricity from renewable energy ● Implement a road map as part of efforts towards net-zero energy buildings and net-zero energy houses
USA
<ul style="list-style-type: none"> ● Introduce regulations on power plants, clean energy standards and carbon pricing to achieve an electricity supply that is 100 per cent carbon-free ● Implement carbon pricing on industrial emissions ● Strengthen vehicle and fuel economy standards to be in line with zero emissions for new cars in 2030 ● Implement clean building standards so that all new buildings are 100 per cent electrified by 2030

^x As policies in the European Union are already quite advanced, many of the opportunities to enhance ambition are evidently ambitious.

3.1 Argentina

Argentina submitted its first Nationally determined contribution (NDC) in November 2015 and a revised version in 2016 in which the country unconditionally pledged to emit no more than 483 MtCO_{2e} by 2030. Since then, the country has established a Climate Change National Cabinet with representation from most ministries to design a low-carbon strategy and to ensure coherence of policies and measures across the Federal Government. Under this institutional framework, the ministries have prepared a set of Sectoral National Action Plans describing the mitigation policies and measures to be implemented to reach the NDC goal and thus fulfil the country's commitment under the Paris Accord (National Climate Change Cabinet 2019).

Current GHG emission projections made by institutions and experts show that the NDC goal will be achieved in various scenarios, including those that are less optimistic. The reasons for this achievement vary quite significantly. On the one hand, the economic downturn witnessed in the country over the past few years is constraining domestic production of goods and services, hampering the rate at which GHG emissions increase (INDEC 2019). On the other hand, the initial implementation of several of the policies and measures in the Sectoral National Action Plans – particularly in the energy sector – are already driving down emission

levels, and to some extent compensate for other policies and measures that are pushing up emission levels, such as the subsidies for the extraction of alternative fossil fuels or the allocation of financial resources that do not fulfil the obligation under the federal law to protect native forests (FARN 2019b).

Argentina's NDC goal was compared with the following scenarios:

- 1) Mitigation policies and measures fully implemented as described in Sectoral Plans
- 2) The same as scenario 1, but including emissions from the production of alternative fossil fuels and offshore oil and gas
- 3) Mitigation policies and measures partially implemented due to potential barriers identified

In all cases, GHG emissions would be below the level of emissions committed to as the unconditional NDC goal, indicating that it should be possible to increase ambition further – even more so if co-benefits from most of the mitigation policies and measures are taken into consideration.

Table 2 – Selected current opportunities to enhance ambition in seven G20 members in line with ambitious climate actions and targets as identified in Table A-1

Argentina	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> • Refrain from extracting new, alternative fossil-fuel resources* • Reallocate fossil-fuel subsidies to support distributed renewable electricity -generation*
Industry	<ul style="list-style-type: none"> • Improve the efficiency of equipment and processes, for example, management and treatment of effluents with large organic matter content
Transport	<ul style="list-style-type: none"> • Shift towards widespread use of public transport in large metropolitan areas* • Promote hybrid and electric vehicles (EVs) • Eliminate subsidies for fossil-fuel powered cars
Buildings	<ul style="list-style-type: none"> • Redirect subsidies granted to companies for the extraction of alternative fossil fuels to building-sector measures, and to residential distributed generation systems based on renewable energy in particular*
Agriculture and forestry	<ul style="list-style-type: none"> • Review agricultural production practices and technologies • Fully fund and ensure compliance with the law to protect native forests

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

3.1.1 Energy supply

Recent changes

▲ The energy Sectoral National Action Plan adopted over the last two years includes policies and measures addressing both the supply of and the demand for energy. On the supply side, policies and measures include the construction of several large-scale hydropower plants, three new nuclear power plants, and various types of large-scale renewable energy power plants such as wind, photovoltaic (PV) solar and biomass, as well as renewable energy systems for distributed generation and other residential applications. According to the Sectoral National Action Plan for the energy sector, the expected GHG emission reductions are approximately 77 MtCO_{2e} in 2030 in accordance with the emissions baseline for this sector.

The extent of the implementation of these policies and measures varies, but most of them are behind the original schedule (CAMESA 2019). In all cases, access to financial resources is the main cause of the delay, mainly due to the instability of the economy and the recurrent economic crisis that make this task difficult, if not impossible (Gubinelli 2018). For grid-connected power plants, the weak infrastructure for electricity transmission appears to be a bottleneck (Mercado Eléctrico 2019; Singh 2019).

▼ The US\$ 598 million of subsidies allocated in 2018 alone to oil companies for both the extraction of alternative fossil fuels and the distribution of natural gas from the Vaca Muerta formation for domestic use as well as for export, is contributing new domestic fugitive GHG emissions at a magnitude similar to the estimated emissions reductions of the entire renewable energy plan (Iguacel 2018). The initial exploration and future extraction of offshore oil and natural gas will add to the burden (Baruj and Drucaroff 2018; Boletín Oficial de la República Argentina 2019).

Areas of possible additional actions

Possible action: The extraction of new, alternative fossil-fuel resources would need to be reconsidered, as it is inconsistent not only with Argentina's NDC goal but also with global goals, according to most carbon budget studies, including the latest Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C. The extraction of these fuel resources will potentially create stranded assets and lock the country into technologies and infrastructure that will prevent the energy sector transformation into a renewable and more sustainable sector. See Table A-1 for examples of countries and other actors that have adopted this target.

Possible action: The energy Sectoral National Action Plan includes distributed generation using renewable energy, a policy that has the potential to change not only the GHG emissions trend of the sector but also the way energy is produced and consumed in the country. In 2018, the Argentine National Congress passed a law to promote distributed generation, creating – among other

mechanisms – the Fund for the Distributed Generation of Renewable Energy (FODIS) to support individuals and small and medium-sized enterprises to buy and install energy systems connected to the grid and to produce their own energy. With a budget of US\$ 12 million (Energía Estratégica 2019), this fund could be largely beneficial, if even part of the US\$ 598 million allocated in 2018 to subsidies for oil and gas companies for the extraction and distribution of alternative fossil fuels is reallocated into FODIS (FARN 2019a).

3.1.2 Industry

Recent changes

▲ The industry sector has developed its Sectoral National Action Plan that includes numerous mitigation policies and measures for energy efficiency, recycling and reusing waste (the circular economy), renewable energy generation for use within the sector, and the catalytic decomposition of nitrous oxide (N₂O). The plan estimates a reduction of 6.4 MtCO_{2e} in 2030 compared to with the emissions baseline for the industry sector. There is currently little awareness of the degree of implementation of these measures, although some actions in the cement industry have been identified, in particular the use of alternative fuels such as those derived from urban and agroindustrial waste (Agencia Nacional de Promoción Científica y Tecnológica 2015).

Areas of possible additional actions

Possible action: The industry sector has the potential to reduce emissions by improving the efficiency of its equipment and processes. An example is the management and treatment of industrial effluents with large organic matter content from the food and agro-industry, a project that does not require large investment and – more importantly – can bring a number of co-benefits to the environment beyond GHG emission reductions, such as the reduction of disease carriers, improved air quality, the prevention of water pollution and odours, among others. The Industrial Reconversion Programme (PRI) that used to provide incentives for effluents management improvements, among other measures, should be reviewed and put back in place (SAyDS 2019).

3.1.3 Transport

Recent changes

▲ The transport sector in Argentina accounts for 15 per cent of the emissions in the country and the trend has continued to rise over the last few decades. The transport Sectoral National Action Plan includes policies and measures ranging from the promotion of low-emission urban mobility and public transport, as well as the restoration of the intercity railway, to efficiency improvements in road and rail freight transportation. Biofuels mixed with fossil fuels have been used for several years and the percentage of biofuels in these mixtures is expected to increase over the coming years, although car manufacturers are currently hesitant about implementing the measure (Biodiesel Argentina 2017; Molina 2019). Initial

implementation of hybrid and electric buses is currently taking place in large cities (Ministerio de Transporte 2018). Emission reductions of approximately 5.9 MtCO_{2e} are expected from these measures by 2030 compared to with the emissions baseline for the sector.

▼ However, these measures contradict the subsidies recently allocated for boosting the sale of fossil-fuel powered passenger vehicles (ADEFA 2019; Ministerio de Producción y Trabajo 2019). Other measures in the transport Sectoral Plan seem to be behind schedule, particularly the restoration of passenger and freight intercity railway.

Areas of possible additional actions

Possible action: In Argentina, the use of individual passenger vehicles rather than public transportation has increased over the last few decades. Therefore, the shift towards widespread use of public transport in large metropolitan areas is key not only to reducing GHG emissions but also to reducing air pollutants and noise pollution, as well as avoiding traffic congestion and accidents. Measures implemented in Buenos Aires to increase the use of public transport – although somewhat insufficient – are worth replicating in other metropolitan areas of the country.

Possible action: Technological changes such as hybrid or electric vehicles will help to reinforce the benefits that would be achieved by the modal shift described in the previous paragraph. However, particular attention must be paid to the social and environmental impacts of extracting the minerals used in the batteries. These measures would have to be accompanied by the redistribution of the subsidies to fossil-fuel powered cars. See Table A-1 for examples of countries and other actors that have adopted such targets.

3.1.4 Buildings

Recent changes

▲ The policies and measures for buildings are included in the energy Sectoral National Action Plan. These measures are related to promoting energy-efficient home appliances, thermal insulation, water heaters, lighting and heat pumps (Diputados Argentina 2018; Banco de la Nación Argentina 2019) and are in accordance with the recently approved Building Code for Buenos Aires (Government of Argentina 2018). Residential energy production is also promoted through the use of solar water heaters and renewable energy systems for thermal-energy and electricity. The recently passed distributed generation law will contribute towards promoting some, but not all, of these measures. Other methods will therefore be necessary, mainly to enhance the adoption of energy-efficiency measures in households (Government of Argentina 2017).

Areas of possible additional actions

Possible action: The measures planned for the building sector could also be boosted if current subsidies granted to oil and gas companies for the extraction of alternative

fossil fuels were redirected for this purpose. A robust, multidimensional analysis should be conducted to determine the benefits of supporting these measures compared to supporting the production and continued use of fossil fuels.

3.1.5 Agriculture and forestry

Recent changes

The agriculture and forestry sector is highly significant in the country due to its contribution to the domestic gross domestic product (GDP) and GHG emissions (39 per cent). However, for a long time, agricultural practices and technologies in the country have been negatively impacting the environment both at local level through the extensive use of agrochemicals and at global level through GHG emissions.

The forestry Sectoral National Action Plan includes measures such as conservation and restoration of native forests, sustainable forest management and fire prevention. According to estimates provided in the plan, these measures would reduce emissions by approximately 27 MtCO_{2e} by 2030 compared to the emissions baseline for the sector.

The agriculture Sectoral National Action Plan only includes conditional measures to increase the forested area and promote bioenergy made from different biomasses, expecting emission reductions of 26 MtCO_{2e} by 2030 compared to the emissions baseline for the sector.

The current status of the implementation of measures in these two sectors is not clear. Few bioenergy projects using agricultural residues have been implemented over the past two years, reaching an installed capacity of 36 MW – 0.09 per cent of the total power capacity in the country. Forestry emissions have decreased since the passing of the law to protect native forests in 2007, but the increased rate of deforestation recorded in 2017 raises questions about the future trends of GHG emissions in the sector (Ministerio de Ambiente y Desarrollo Sustentable 2018).

Areas of possible additional actions

Possible action: Argentina urgently needs to review the practices and technologies it has been using for decades in agricultural production. Reports show that the soil has lost more than 40 per cent of its nutrients over this period, in addition to the impacts that the use of agrochemicals have on the health of rural and suburban populations (INTA no date; Panigatti 2010)

In the forestry sector, there is also a pressing need to protect native forests and avoid deforestation for agricultural purposes. The law to protect native forests should be fully funded and enforced across the country, in particular in the northern provinces, where deforestation rates are high.

3.2 Brazil

Brazil submitted its intended Nationally determined contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in September 2015 and on 12 September 2016, Brazil ratified the Paris Agreement. Its NDC under the Paris Agreement is to reduce greenhouse gas emissions by 37 per cent below 2005 levels by 2025 and 43 per cent below 2005 levels by 2030.

After enduring a major recession in 2015 and 2016, when GDP dropped by 7.1 per cent, and with the slow recovery of the economy from 2017 to the present day (an average GDP growth of 1.1 per cent per year), Brazilian energy-related emissions are much lower than the levels expected when Brazil presented its contributions at the 2015 United Nations Climate Change Conference (COP21) and the price of renewable energy in the country are decreasing each day (Government of Brazil 2018b). On the other hand, deforestation has shown a dangerous upward trend since 2012 (an increase of 72 per cent). As the zero illegal^{xi} deforestation by 2030 target is considered by many the most important component of emission reductions proposed by the Brazilian NDC, the country must urgently review its land-use related policies in order to get back on track to achieve the goals established in the Paris Agreement. Despite the recent crisis involving the fires in the Amazon region, President Bolsonaro guaranteed that Brazil will meet the NDC target.

In recent years, two main studies were undertaken in Brazil using robust modelling capabilities and integrated models

(sectoral and macroeconomic models). La Rovere et al (2015, 2018) and the Ministry of Science, Technology, Innovation and Communication (MCTIC 2017) produced scenarios that presented different pathways for the country to meet its NDCs. Those studies have a lot in common – the strong need to reduce and eliminate illegal deforestation in the country by 2030, the use of agricultural best practices, and the continued proliferation of the use of renewable energy in the energy mix. All these measures could be achieved at very low costs (lower than US\$ 10/tCO₂e).

Despite a few studies undertaken by country experts on how to promote low-carbon development in the country, Brazil is yet to present an official long-term strategy to UNFCCC. One of these studies, Brazil: Zero Carbon in 2060 (La Rovere et al. 2018), was conducted in collaboration with civil society, with the Brazilian Forum on Climate Change facilitating the discussions. Among important mitigation measures applied in this scenario are the widespread adoption of renewable energy (wind, solar, biofuels), large-scale electrification of passenger and freight transport after 2030 alongside a significant expansion in the consumption of biofuels, including biokerosene for aviation and biooil for bunker fuels, the dissemination of best practices in the agricultural sector, the recovery of degraded pastures, and a large carbon sink in the land-use sector (recovery of degraded lands home to commercial and native forests). This study was submitted to former President Michel Temer in December 2018, but it is not yet clear whether President Bolsonaro will follow up on it.

Table 3 – Selected current opportunities to enhance ambition in seven G20 members in line with ambitious climate actions and targets as identified in Table A-1

Brazil	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> • Commit to the full decarbonization of the energy supply by 2050* • Exclusively focus on renewable technologies and related infrastructure investments in upcoming auctioning rounds
Industry	<ul style="list-style-type: none"> • Provide an updated energy efficiency plan for the industry sector • Implement minimum energy performance standards for industrial machines and equipment
Transport	<ul style="list-style-type: none"> • Develop a national strategy for ambitious electric vehicle (EV) uptake aimed at complementing biofuels and at 100 per cent CO₂-free new vehicles* • Promote the 'urban agenda' by increasing the use of public transport and other low-carbon alternatives*
Buildings	<ul style="list-style-type: none"> • Extend the energy-efficiency labelling system to private buildings, both commercial and residential • Regularly update the energy performance labels for appliances
Agriculture and forestry	<ul style="list-style-type: none"> • Maintain and strengthen the regulation and enforcement mechanisms that resulted in a reduction in deforestation between 2005 and 2014 • Strengthen rapid-response capacities for deforestation alerts • Ensure the monitoring and strengthening of protected areas

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

^{xi} The National Institute for Space Research (INPE) does not have the capacity to determine the total amount of illegal deforestation. The MapBiomass Alerta platform (<http://alerta.mapbiomas.org/>) – developed by a group of NGOs and universities – was recently launched to answer this question, among others.

3.2.1 Energy supply

Recent changes

▲ Market developments seem to favour renewable energy over fossil fuels. Although fossil fuel technologies were eligible for new capacity in the latest national energy auction in September 2018, no coal and only 363 MW of natural gas capacity were contracted in comparison to 1,251 MW of wind-, 458 MW of hydro- and 29 MW of biomass capacities.

▼ The latest Ten-Year Energy Expansion Plan 2018 envisions an increase in the share of the total primary energy supply that fossil energy sources represents in comparison to the previous version in 2017.^{xii}

▼ The National Congress of Brazil approved a further tax exemption for oil and gas explorations in December 2017, valid until December 2040.

Areas of possible additional actions

Possible action: Government long-term planning should aim to phase out fossil-fuel subsidies and fully decarbonize the Brazilian energy supply by 2050 (see Table A-1 for examples), thus deviating from recently published discussion papers by the Brazilian Energy Research Office (EPE) estimating the remaining shares of fossil fuels. Given the lack of competitiveness of coal in past auctions and the need to fully decarbonize the electricity supply by 2050, the Government should exclusively focus on other (renewable) technologies and related energy infrastructure improvements required to connect them to the grid. Consistency within variable energy policy is necessary to de-risk renewable energy investments (for example, the Government cancelled the only reserve energy auction for wind and solar energy in December 2016, citing an expected power surplus in the country).

3.2.2 Industry

Recent changes

(No changes were made).

Areas of possible additional actions

Possible action: Energy efficiency in the Brazilian industry sector could be significantly improved. Since the major recession that began at the end of 2014, the sector has invested very little in new capacity and operates with a high idle capacity. When investments in the industrial sector return to the country in the next few years, an updated and realistic energy-efficiency plan must be in place, establishing minimum energy-efficiency standards for industrial machines and equipment.

3.2.3 Transport

Recent changes

▲ RenovaBio was established in February 2018 and is a national policy on biofuels published in 2017 (Presidência da República Brasil 2018). The regulations include a description

of the responsible agencies (including the RenovaBio Committee), their tasks and a description of the carbon reduction scheme, as well as how the mandatory emission reduction targets will be set and when they will enter into force. It aims to reduce the current carbon intensity of Brazil's transport fuel mix (73.55 gCO₂e/MJ) by 10.1 per cent between 2019 and 2028 (Ministério de Minas e Energia, no date).

▲ On 30 July 2019, President Bolsonaro signed a concession agreement between the Federal Government and Rumo Logística regarding the exploration of the 1,537-km section of the North-South Railway. It was the first concession in the sector in 10 years. The project is the backbone of Brazilian rail transportation, allowing cargo to be transported from the Midwest and flow through both the Port of Itaquí (in the north) and the Port of Santos (in the southeast) (Government of Brazil 2019). The Federal Government plans to significantly increase the share that railway transport represents in the transport sector in the next eight years (from 15 per cent to 29 per cent).

Areas of possible additional actions

Possible action: Brazil could develop an ambitious strategy for EV uptake, aimed at complementing biofuels and at 100 per cent CO₂-free new vehicles. This strategy should take into account its synergies with biofuel policies and technologies (hybrid flexible-fuel vehicles and ethanol fuel cells), since a relatively high share of electricity in Brazil is generated using renewable energy. An urban agenda (including air quality) should also be developed, with care taken to ensure that it is in accordance with the Ministry of Environment's current focus on improving traffic congestion in big cities (more public transport and other low-carbon alternatives).

3.2.4 Buildings

Recent changes

▲ An energy-efficiency labelling system was created in 2014 to assess the energy-efficiency performance of a building. New or refurbished public buildings are legally obligated to adopt energy-efficiency labelling.

Areas of possible additional actions

Possible action: Building performance standards, together with energy-efficiency labelling, should be introduced for all new and refurbished buildings.

Possible action: The energy-performance labels for appliances should be regularly updated. They could also be extended to vehicles, particularly to new cars.

3.2.5 Agriculture and forestry

Recent changes

▲ Agricultural production levels in Brazil grew to almost five times higher from 1975 to 2017, and more than 80 per cent of this growth is due to productivity gains that continue

^{xii} Due to hydropower generation limitations as a result of droughts over recent years, the already high share of renewable energy in the power mix (82 per cent), and the projected high-penetration of intermittent renewable energy such as solar and wind in the Ten-Year Energy Expansion Plan 2018 (Government of Brazil, 2018a), a higher share of natural gas power plants was projected to back-up the power system.

to increase every year – land productivity increased by 8.0 per cent and total factor productivity (TFP) increased by 7.4 per cent from 2016 to 2017 (Ministério da Agricultura Pecuária e Abastecimento 2019). These significant productivity gains are in large part due to the Brazilian Agricultural Research Corporation (Embrapa), the federal research institution created in 1972 that focused on improving productivity through the development of appropriate agricultural techniques and new and more tailored solutions as well as on the correct use of chemical inputs and the mechanization of production in the country since that growth period.

▼ In 2017, the previous Administration signed legislation that had been approved by Congress to legalize more illegal land-grabbing practices and sent a bill to Congress that would remove protections from 349,000 hectares (862,000 acres) of the Jamanxim National Forest in the Amazon state of Pará.

▼ In 2019, the National Institute for Space Research (INPE) identified the highest number of fires in the Amazon region from 1 January to 31 August since 2010.

▼ In 2017, former President Temer allowed the conversion of environmental fines into alternative compensations. The former Minister of Environment stated that this is not an amnesty, but rather a requirement of real compensations to the environment, such as reforestation and recovery of degraded areas.

▼ The new Administration tried to change the Forest Code to extend the deadlines for these enforcement measures. The proposition was passed in the Chamber of Deputies but was rejected by the Senate.

Areas of possible additional actions

Possible action: Reducing and eliminating illegal deforestation in the country must be a priority. This can be achieved by ensuring monitoring and strengthening of protected areas, maintaining and strengthening systems of regulation and enforcement that resulted in decreased deforestation between 2005 and 2012, enabling rapid responses to deforestation alerts, implementing effective and long-term environmental public policies, supporting sustainable forest use and best farming practices, and introducing drastic market restrictions on products associated with new deforestation, as well as low-carbon agriculture and afforestation/reforestation.

3.3 China

China's NDC targets include peaking CO₂ emissions around 2030 and making an effort to peak them earlier and a 20 per cent share of non-fossil fuels of total primary energy demand (based on the conversion factor of the Chinese National Bureau of Statistics for renewable energy and nuclear power generation). Further targets include reducing the carbon intensity of its GDP by 60 to 65 per cent below 2005 by 2030 and increasing forestry stock by 4.5 billion m³ by 2030 compared to the 2005 level.

With the strong air quality improvement policies implemented from 2013 and the energy revolution announced by President Xi Jinping in 2014, the rapidly rising upward trend in CO₂ emissions flatlined from 2013, although there was an increase in 2017 and 2018 after a decrease from 2013 to 2016.

The top performing policies in the around 50 air-pollution prevention policy measures announced by the State Council in 2013 are energy-related policies, including targets for reducing coal use in selected provinces (Hebei, Tianjin, Shaanxi, Shanxi, Shandong, Henan), the strong promotion of renewable energy, energy-efficiency policies promoting the use of natural gases, replacing coal use in rural areas and small enterprises with electricity and natural gases, among others. All these policies are consistent with CO₂ emissions reduction. In order to achieve air quality targets, these policies are strictly implemented.

The energy revolution strategy proposed by President Xi Jinping in 2014 on energy consumption, energy supply, energy technology innovation, the energy management programme, among others, became the leading example for energy development in China. In order to implement these energy revolution strategies, low-carbon and green development of energy systems in China are becoming key indicators for the energy transition in China.

The following results were observed:

- 1) By 2018, carbon intensity in China reduced by 45.8 per cent compared to 2005, exceeding the target set for Copenhagen Accord.
- 2) The installed capacity of solar power in China increased to 175.6GW in 2018, while it was 42.6GW in 2015, accounting for 34.6 per cent of the global installed capacity of solar PV. The installed capacity of wind power increased from 96.6GW in 2014 to 184.3GW in 2018, accounting for 32.2 per cent of the global installed capacity, which shows that China is dominating the global development of modern renewable energy. The capacity of solar PV and wind power accounts for 15 per cent of total installed power-generation capacity. If large-scale hydro and nuclear power generation is included, China's newly installed capacity of non-fossil fuel energy was more than half that of the rest of the world in 2017.
- 3) In 2018, there were 1.25 million electric vehicles sold in China, accounting for 62 per cent of electric cars sold in the world.
- 4) By 2018, 4,354 km of rapid transit lines were operational and 6,374km were under construction, accounting for more than 65 per cent of rapid transit lines under construction in the world.

- 5) The rapidly increasing upward trend of coal use changed course in 2013. Coal use in China decreased from 2013 to 2016. Although there was an increase in coal use in 2017 and 2018, the trend changed from rapidly increasing to remaining stable.
- 6) In 2018, 29,000 km of high-speed train railways were operational, accounting for 64 per cent of the high-speed railways in the world. More than 6,000 km were under construction.

In 2014, when the latest Government data became available, non-CO₂ GHGs, including methane, nitrous oxide and fluorinated gases (F-gases) accounted for 16 per cent of the country's total GHG emissions, or around 2 billion tons (Gt) of CO₂e (Government of China 2018). The emissions alone were equivalent to the seventh largest GHG-emitting country in the world (WRI 2018).

While non-CO₂ GHGs were not among the quantitative top-line targets in China's NDC, China has made significant progress. Since 2015, China has implemented or announced a series of new policies, including committing to ratify the Kigali Amendment, reach zero growth of nitrous oxide emissions from industrial processes by 2020, and meet enhanced targets on coal-mine methane utilization, rural biogas development and municipal solid waste treatment during the thirteenth Five-Year Plan period (2016–2020). A recent study estimates that China's current policies will eliminate around 383 MtCO₂e emissions from non-CO₂ GHGs per annum by 2030 compared to policies in 2015 (including the NDC). With additional efforts, China could further mitigate 280–549 Mt CO₂e emissions per annum by 2030 (Song 2019). China has also put in place measures to strengthen the enforcement of a ban on the production of chlorofluorocarbons (CFCs) after reports on increased release of CFC-11 in the country (Ministry of Ecology and Environment 2019).

Table 4 – Possible actions to increase mitigation ambition in China

China	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> • Affirm targets to cap emissions before 2025 and reach 25 per cent of non-fossil fuels in primary energy use by 2030 • Ban all new coal-fired plants* • Continue governmental support for renewable energy, taking in to account cost reductions and accelerate development towards a 100 per cent carbon-free electricity system* • Use or flare coal mining methane with concentrations higher than 9 per cent
Industry	<ul style="list-style-type: none"> • Support the deployment of Carbon Capture and Storage (CCS) technologies in the steel and cement sector • Support industry processes with low/zero-carbon technologies • Extend the emissions trading system (ETS) from the power sector to other sectors with a strict cap on CO₂ emissions • Mandate N₂O emissions mitigation for all adipic acid and major nitric acid manufacturers by 2030
Transport	<ul style="list-style-type: none"> • Further support the shift towards public modes of transport* • Support the uptake of electric mobility, aiming at 100 per cent CO₂-free new vehicles* • Promote non-vehicle transport such as bicycles, electric bikes and walking
Buildings	<ul style="list-style-type: none"> • Promote near-zero emission building development and integrate it into Government planning*
Agriculture and forestry	<ul style="list-style-type: none"> • Take additional actions to reduce agriculture emissions such as a nitrogen fertilizer application reduction target • Increase the use of probiotics and tea saponins in animal feed as well as in irrigation improvement for rice cultivation to reduce CH₄ and N₂O emissions • Commit to increasing forestry stock by 6 billion m³ compared to 2005 levels

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

3.3.1 Energy supply

Recent changes

▲ China's existing policies to promote renewable energy throughout the country already appear at the top of the global rankings. Subsidies to support wind and solar power generation in China are some of the highest in the world. The subsidy for distributed solar PV power in Beijing was up to 0.72 yuan/kWh in 2017, with 0.42 yuan/kWh granted by the national Government, and 0.3 yuan by the Government of Beijing (Jiang 2017). Provincial Government subsidies vary. These renewable energy policies led to a boom in the development of solar PV and wind power over the last few years. With the cost of renewable energy decreasing in China, a new regulation was introduced on 31 May 2018 to control the development of solar PV power generation and reduce the subsidies granted for this purpose. A new pricing policy for wind power generation was introduced in May 2019, and the subsidy for onshore and offshore wind power was also reduced. Feed-in tariff (FIT) rates for offshore wind power in 2019 will be 0.8 yuan/kWh (US\$ 0.123/kWh) and 0.75 yuan/kWh (US\$ 0.11/kWh), respectively. Upon hearing about the new policy, offshore wind power developers rushed to implement their projects. Nearly 50GW of offshore wind power is awaiting approval from the Chinese National Development and Reform Commission (NDRC). In 2018, there was 1.85GW of newly installed capacity for and investment in offshore wind power in China was US\$ 11.4 billion, while global investment in offshore wind power is US\$ 25.7 billion.

● However, reducing subsidies granted for solar and wind power is not necessarily having negative effects. By April 2019, there were 20.3GW of unsubsidized solar PV projects awaiting approval from the National Environment Agency (NEA). This could be a new era for solar PV development in China. In Inner Mongolia, the price of electricity generated using newly built solar PV systems is 0.26 to 0.28 yuan/kWh (US \$0.038 to US \$0.041/kWh) in August 2019, which is lower than the price of electricity generated in local coal-fired plants.

From 2015 to 2016, China had a serious problem with wind and solar PV energy curtailment. Thanks to the intervention of the NEA, which encouraged the grid and local government to improve the situation, the curtailment rate was significantly reduced to under 5 per cent in 2018.

▲ With the successful commissioning and commercial operation of its Generation III pilot units, China also launched several new nuclear projects from the end of 2018. Six advanced reactor units were approved for construction by May 2019, all of which are up to Generation III safety standards.

● It should be noted that the capacity of coal-fired plants has continued to increase until the present day. Since 2013, the increasing electricity demand has mainly been supplied by renewable energy, nuclear and natural gas-fired plants. The output from coal-fired plants remained stable nationwide, but electricity demand varies throughout the regions of China.

This situation affords coal-fired plants some space to be developed.

▲ China launched a nationwide emissions trading system (ETS) in December 2017, including the power-generation sector. Emissions caps for each power plant are established using the benchmarking or baseline method with each province able to decide which method to use. Free allowances are available within the cap. The Chinese ETS pilot will be ready by 2020 and will be in place until the formal launch of the system that same year.

Areas of possible additional actions

Possible action: Devise a plan to peak CO₂ emissions before 2025 and revise the "20 per cent proportion of thermoplastic elastomer (TPE) non-fossil fuels by 2030" target to 25 per cent.

Possible action: The construction of new coal-fired plants must be blocked. Coal-fired plants already have a serious amount of surplus capacity and there is a significant amount of risk attached to building them. Weak climate change policies or targets are major reasons for investors not understanding the risk, especially investors within provincial governments and in the industry sector.

Possible action: Renewable energy, particularly large-scale hydropower, could be further developed. Despite the growth in newly installed solar, wind and hydropower capacity in China already being unprecedentedly large over the last three or four years and occupying nearly half of newly installed capacity in the world, there is still room for China to do more, particularly as the cost of these renewable energy is continuing to significantly reduce. Nuclear power is also a large potential area for China's power-generation transition. Nuclear power may be instrumental in replacing a very large amount of coal-fired plants to follow the emission pathway for the Paris Agreement. A clear decision for the future of nuclear power is therefore crucial. All things considered, China could start planning for a 100 per cent carbon-free electricity system.

Possible action: China could require all coal-mine methane emissions beyond a 9 per cent concentration to be utilized or flared, as this measure would cost very little to implement. This action will reduce annual methane emissions that are equivalent to 47 MtCO₂ per annum by 2030 (Song 2019). With more ambition, the country could also adopt the recommendations made by the China Coal Consumption Cap Plan and Policy Research project (2016) to reduce coal consumption to less than 2,000 MtCO₂e by 2030.

3.3.2 Industry

Recent changes

▲ Reducing scattered coal use in small businesses and increasing the share of electricity use in industry are major policies developed in recent years. By 2018, around 61 million tons of scattered coal was reduced, and a further 45

million ton reduction is also expected. These measures are also mainly the result of air pollution control targets, in light of which small coal use facilities such as small coal-fired boilers and small coal-fired kilns were replaced with natural-gas fired facilities or electric heaters.

▲ Distributed solar PV systems are being adopted in industries. Many sectors have roof space for solar PV panels. Some sectors have benefited from using rooftop solar PV systems to reduce workspace cooling needs.

▲ While China has yet to ratify the Kigali Amendment to the Montreal Protocol, the country nevertheless supported the Amendment during its negotiation. China reaffirmed its commitment to ratify and implement the Kigali Amendment in a joint statement released on the margins of the G20 Summit in Osaka (United Nations 2019). Per the Kigali Amendment, HFC-23 GHG emissions should be zero by 2020 and other HFC emissions should be phased down. It is estimated that the Kigali Amendment will reduce China's HFC emissions by 213 MtCO₂e per annum by 2030 compared to policies in 2015 (Song 2019).

▲ In China's First Biennial Update Report, the country stated its intention to try to reach zero growth of nitrous oxide emissions from industrial processes by 2020. Song (2019) estimates that this target would reduce nitrous oxide emissions to around 105 MtCO₂e per annum by 2030 compared to policies in 2015.

Areas of possible additional actions

Possible action: There is more than 600GW of potential for solar PV in industry in China, and profits from solar PV remain stable. This could be more widely promoted now and in the near future. In the meantime, the steelmaking and cement sectors could begin to use Carbon Capture and Storage (CCS) technologies. Some steel companies are already working with CCS technologies today. New industry processes in the steelmaking, non-ferrous and chemical industries that involve using low/zero-carbon technologies such as hydro-reduction processes should be promoted in the future. China's ETS could be extended to several industrial sectors such as the cement, steelmaking, non-ferrous and chemical sectors, among others, as originally planned.

Possible action: China can require nitrous oxide emissions mitigation for all adipic acid and major nitric acid manufacturers by 2030. The mitigation measures have relatively low technical costs: US\$ 0.12–US \$1.35/t CO₂e for adipic acid and US\$ 0.2–\$10/t CO₂e for nitric acid (secondary treatment). Song (2019) estimates that such regulatory requirements could lead to a reduction of 112–116 MtCO₂e per year by 2030 compared with current policies.

3.3.3 Transport

Recent changes

▲ Electric vehicles have been promoted in China in recent years. The subsidy for doing so was reduced in 2019, due to reductions in the cost of electric vehicles, especially electric cars. There were 984,000 electric vehicles sold in 2018, an 88.9 per cent increase compared with the previous year, accounting for 4.4 per cent of the total vehicles sold that year, and by June 2019, electric vehicle sales were 617,000, an 80 per cent increase compared with the same period in 2018, accounting for 6.2 per cent of total vehicle sales. More than 30 cities in China have announced that they will electrify their bus and taxi fleet by 2022. Beijing is considering stopping the sale of gasoline-powered cars before 2025.

▲ Public transport is rapidly developing, including rapid transit lines and buses. By 2018, the total length of the public bus network was around 840,000 km, increasing from 488,800 km in 2010, with an annual growth rate of 7 per cent. The length of the metro network is 5,767 km, a significant increase compared with its 2,286 km length in 2012, with an annual growth rate of 16.7 per cent. The number of people using the metro was 21 billion in 2018, with an annual growth rate of 15.8 per cent from 2012.

Areas of possible additional actions

Possible action: Besides further development of electric vehicles and public transport, there is still considerable potential to promote non-vehicular modes of transportation by building a better environment for bicycles, electric bikes and pedestrians. Car-free zones, bicycle and electric bike lanes and pedestrian-friendly sidewalks should be much more intensely developed in all Chinese cities.

3.3.4 Buildings

Recent changes

▲ By 2018, more provinces upgraded their building energy-efficiency standards from 65 per cent to 75 per cent^{xiii}. More than 2.5 billion m² of building floor space is green-building certified and 50 per cent of new buildings in 2020 will have this certification. The first Near Zero-emission Building Standard was released in April 2019 and implementation will begin in September 2019.

Areas of possible additional actions

Possible action: Promote near-zero emission building development in the short term, formulating related standards as soon as possible, and factoring them into Government planning.

3.3.5 Agriculture and forestry

Recent changes

The National Forest Management Plan (2016–2050) has set

^{xiii} China's building efficiency standard is based on an efficiency improvement that exceeds efficiency levels in 1986, the reference year selected for the energy efficiency of buildings. The 65 per cent emission standard means 65 per cent higher efficiency compared to 1986 levels, in terms of energy use per m² for space heating and cooling. The European Union's near-zero emission building efficiency standard is 92 per cent efficiency according to the Chinese standard.

targets for forest stock to reach 16.5 billion m³ by 2020 and 23 billion m³ by 2050 (NFA 2016). These targets put the country on track to achieve 5.2 billion m³ of forest stock increases in 2030 compared to the 2005 level and to exceed the NDC forestry target to increase stocks by 4.5 billion m³ by 2030.

Areas of possible additional actions

Several mitigation measures in the agriculture sector have negative costs, which includes best practices in fertilizer management, reduced application of nitrogen-based fertilizers for rice, wheat, maize, and cash crops, animal breeding improvement and the use of probiotics and tea saponins in animal feed.

Possible Action: China could promote lifestyle changes that would lead to less meat consumption. As enteric fermentation and animal manure management are projected to emit around 429 MtCO_{2e} in accordance with 2030 current policies (Song 2019), a 25 per cent reduction of meat consumption would result in a reduction of 107 MtCO_{2e} per annum by 2030.

Possible action: Probiotics and tea saponins in animal feed and irrigation improvement for rice cultivation will mitigate around 74 MtCO_{2e} of methane and nitrous oxide emissions per annum by 2030 compared to current policies (Song 2019).

Possible action: Additional efforts, such as a more ambitious nitrogen fertilizer application reduction target, use of nitrification inhibitors, slow-release fertilizer and biochar in rice cultivation, among other methods to increase meat and dairy production efficiency, can further reduce agriculture emissions (Song 2019).

Possible action: For forestry, China could commit to increasing forestry stock by 6 billion m³ compared to the 2005 level. This target is more ambitious than the National Forest Management Plan (2016–2050). However, it is consistent with China's unofficial target to reach 21 billion m³ of forest stock increases by 2035 and would exceed the current NDC target by 1.5 billion m³ of forest stock (The State Council of the People's Republic of China 2018).

3.4 The European Union

The European Union (EU) is likely to meet its NDC of GHG emission reductions of at least 40 per cent below 1990 levels by 2030 with its currently implemented policies. The EU revised its renewable energy target for 2030 from 27 per cent to 32 per cent and its efficiency target from 27 per cent to 32.5 per cent, which would lead to a reduction of GHG emissions by 45 per cent by 2030 (European Commission 2018b), 48 per cent (Climate Action Tracker 2018a) or even 50 per cent if planned and implemented Member States policies on a coal phase-out are taken into account (Sandbag 2019). Based on planned measures and stated ambitions for national GHG reductions included in the recently developed draft National Energy and Climate plans, the overall GHG reduction for the EU is predicted to meet

the 40 per cent GHG emission reduction target for 2030 compared to 1990. Member States are still reviewing these plans, including plans detailing measures to increase their renewable-energy and energy-efficiency ambitions. These plans need to be finalized by the end of 2019 (European Commission 2019a).

At the end of 2018, the European Parliament called for the EU's 2030 NDC emissions reduction goal to be increased to 55 per cent below 1990 levels. Other studies suggest that a reduction of 60 per cent would be possible (Cornet et al. 2018). Reduction opportunities particularly include energy efficiency in electricity use on the demand side, accelerating the coal exit, sustained support for renewable energy, stricter emissions standards for vehicles and support for the faster penetration of electric vehicles, both faster and more intensive renovation of existing buildings, resource efficiency and the circular economy. While a comprehensive framework that addresses many of these reduction opportunities already exists at EU level, it could be improved to make it more compatible with the Paris Agreement. The European Commission's proposal for an 'EU 2050' vision that includes a goal of greenhouse gas neutrality, covers all sectors and is the basis for ongoing high-level debate to establish an EU long-term strategy under the Paris Agreement could serve as a good starting point for the discussions in these areas.

3.4.1 Energy supply

Recent changes

▲ The reform of the EU Emissions Trading System adopted in April 2018 has already resulted in higher emissions allowance prices. It currently stands at €28/tCO₂ after several years of prices of around €5/tCO₂.

▲ Austria, Denmark, France, Finland, Ireland, Italy, Portugal, Sweden, the Netherlands and the United Kingdom – accounting for 26 per cent of EU coal capacity – have set phase-out goals for coal-fired plants. In Germany, the multi-stakeholder Commission on Growth, Structural Change and Employment has developed a proposal to gradually phase out coal in the country, combined with recommendations for sustainable, forward looking structural development in the regions most heavily affected by the coal phase out. The proposal has not yet been incorporated into national law.

On the other hand, Poland – the second largest emitter of carbon dioxide from coal-based power generation – is planning to construct new coal-fired plants.

● In 2018, the EU implemented the latest Renewable Energy Directive (RED II) which – while setting economy-wide renewable targets for 2030 of 32 per cent of gross inland energy consumption – requires the share of renewable energy in the energy sector to increase to around 55 per cent in 2030 in order to achieve this target (Climate Action Tracker 2018b). Unlike its predecessor, RED II does not adopt a top-down approach or include targets broken down by Member States. Instead, it requires Member States to set their own targets, from the

Table 5 – Possible actions to increase mitigation ambition in the EU

European Union	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> • Adopt an EU regulation to refrain from investment in fossil-fuel infrastructure, including new natural gas pipelines* • Define a clear endpoint for the EU emissions trading system (ETS) in the form of a cap that must lead to zero emissions* • Adjust the framework and policies to enable 100 per cent carbon-free electricity supply by between 2040 and 2050* • Step up efforts to phase out coal-fired plants*
Industry	<ul style="list-style-type: none"> • Define a strategy for zero-emission industrial processes* • Reform the EU ETS to more effectively reduce emissions in industrial applications* • Turn the Circular Economy Action Plan into concrete, binding action/targets for Member States to follow
Transport	<ul style="list-style-type: none"> • Ban the sale of Internal Combustion Engine (ICE) cars and buses and/or set targets to move towards 100 per cent of new car and bus sales being zero-carbon vehicles in the coming decades* • Shift towards increased use of public transport in line with the most ambitious Member States*
Buildings	<ul style="list-style-type: none"> • Increase the renovation rate for intensive retrofits of existing buildings * • Harmonize the definition of near-zero energy building across methodological frameworks
Agriculture and forestry	<ul style="list-style-type: none"> • Advance the European regulatory framework for land-use to maintain/increase current net sinks accompanied by mitigation targets • Increase activity to change diets and realize emission reduction potentials

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

bottom up. While the comprehensive Energy Union governance approach passed in 2018 aims to ensure that Member States meet their targets, it remains to be seen whether it can also avoid 'freeriding' by individual Member States.

▼ While under the first Renewable Energy Directive (RED I), only three Member States had growth rates for renewable energy that were below the indicative growth rates in 2015/2016, this number increased to eight Member States for the 2017/2018 time frame. Nevertheless, 11 countries have already managed to achieve their 2020 targets as set under the RED I.

▲ The EU is taking initial steps to address the challenges associated with integrating larger shares of variable renewable energy (VREs) into the system. As part of its Clean Energy for All Europeans package, it passed a set of measures aimed at improving the electricity market design to enable larger shares of VREs. Among others, the package sets out general rules for a common electricity market in the EU, sets a limit on the emission intensity of power plants that are allowed to receive capacity payments, and also urges Member States to facilitate consumer participation or to consider demand-side options.

Areas of possible additional actions

Possible action: The EU is currently increasing its investments

in new gas infrastructure which could lead to increasing emissions in the mid- to long-term and emission lock-ins. At the same time, natural gas consumption is decreasing and will make it very difficult for the new investments to provide the expected return on investment. This is especially the case for the Nord Stream 2 pipeline, which is built on a premise of continuing gas imports for decades (DIW 2018). Ireland has recently committed to refrain from investment in fossil fuels, including investments in natural gas pipelines (Reuters 2018). See Table 1 for further examples. This could serve as a model for other EU Member States and could be implemented in EU legislation.

Possible action: Further reform of the EU ETS is necessary to ensure it will contribute to the achievement of the long-term goals of the Paris Agreement. An important option for this reform is the definition of a clear endpoint for the ETS in the form of a cap that must go to zero. In addition, to achieve this, only a limited amount of the allowances that enter the market stability reserve should be re-entered into the market.

Possible action: Frameworks and policies could be put in place to facilitate 100 per cent carbon-free electricity by between 2040 and 2050 (see Table A-1 for other country examples). Studies suggest that the share of wind and solar VREs could reach up to 80 per cent by 2050 (European Commission 2018a; Pestiaux et al. 2018). Two

main areas of intervention are important. Firstly, a level playing field for renewable energy needs to be created and secondly, zero-carbon flexibility solutions need to be developed. For instance, the EU could mandate all Member States to implement frameworks that enable similar growth of VRE shares to the Member States that have achieved the fastest growth in the past (Cornet et al. 2018). In addition, comprehensive packages of zero-carbon flexibility options such as demand-side management, dispatchable renewable energy power plants, such as hydro or biomass, improved synergies between countries and storage solutions need to be developed at Member State and/or EU level.

Possible action: Coal phase-out ambitions must be increased (see Table 1 for examples). All Member States should be encouraged to define phase-out targets and a coal phase-out strategy should be defined at the EU level. In 2030, studies suggested that coal consumption needs to be reduced by at least two-thirds (Agora Energiewende 2019), with some studies suggesting it needs to be reduced to zero (Climate Action Tracker 2018b). Since each Member State will be affected very differently, this could include a mechanism to support and/or compensate those that are most affected by a coal phase-out. To implement this phase-out, linkages to the EU ETS should be considered. The cancellation of allowances is one viable option to achieve the coal phase-out target.

3.4.2 Industry

Recent changes

- The reform of the EU ETS agreed in November 2017 has already resulted in higher emissions allowance prices, that after several years at lower price levels, currently stand at € 28/tCO₂. While this is a significant step in the right direction, a significant share of industrial installations still receive free allowances with the intention of shielding internationally competing industry from carbon leakage. While this number is reduced from year to year, the plan of the European Commission is to continue to facilitate 30 per cent of the installation with free allocations in 2020 and even beyond, thus limiting the impact of the price increase on the industry sector. The EU is trying to partially counteract this with benchmark-based criteria for the allocation.

- ▲ In 2015, the EU introduced the Circular Economy Action Plan. In 2019 – three years after its introduction – the plan has been completed and its 54 actions have either already been delivered or are currently being implemented. The diverse set of actions range from measures such as adopting circular economy processes in the Industrial Emissions Directive and implementing a revised legislative framework on waste to defining a European strategy for plastics in a circular economy. For instance, the revised legislative framework on waste covers recycling targets for various products until 2030–2035 but also includes a binding target to reduce landfill to a maximum of 10 per cent of municipal waste by 2035.

- ▲ An innovation fund has been set up that focuses on innovative low-carbon technologies and processes in energy-intensive industries, including less carbon-intensive products to replace those currently in use. The fund succeeds the NER 300 programme as a funding stream drawing on ETS revenues. These revenues were, to date, mainly flowing to renewables, as, for instance, only one out of 38 projects funded by these resources addresses carbon capture and storage (Climate Action Tracker 2018c). The innovation fund is aimed at compensating for this lack of funding for the industry sector by providing revenues from the ETS auctioning scheme in the order of 450 million allowances from 2020 to 2030 as well as unspent funds from the NER 300 programme.

Areas of possible additional actions

Possible action: Define a strategy for zero-emission industrial processes. This could either be achieved by the EU encouraging Member States to develop carbon-neutrality road maps for the industrial sectors or by setting a framework at EU level that requires Member States to implement nationally binding carbon-neutrality strategies. Either way, the strategy requires the strengthening of the innovation policy at the EU level and could build on and bring together the elements that already exist in the EU framework in a scattered form in one place.

Possible action: Reform the ETS further to make it more effective at reducing emissions in industrial applications. This would require directly or indirectly reducing the impact of installations receiving free allocation. Directly, this could be achieved by including more installation in the auctions instead of providing them with free allocation. Indirectly, it could be achieved through other policy instruments with similar effects on the industry. The former could be accompanied by the introduction of Border Adjustment Tax that would protect industries against competition and resulting carbon leakage. The latter might be desired by Member States that still fear that inclusion in the auction scheme will affect the competitiveness of their industries. While the EU is currently trying to achieve this through the introduction of benchmarks for the allocation, innovative approaches in this direction are also starting to emerge at Member State level. For instance, the Netherlands is looking to implement a carbon tax on industrial installations.

Possible action: Turn the successful Circular Economy Action Plan into concrete binding actions or targets for Member States. The actions included in the Circular Economy Action Plan include very few actions that lead to changes in the Member States. Making targets and actions under the Circular Economy Action Plan binding for Member States and complementing these with new targets and actions could be a good step forward here. This could include, but not be limited to, converting indicative targets on recycling rates by sector into binding ones or providing binding provisions on the circular economy within the Industrial Emissions Directive or the Ecodesign Directive. This should be accompanied by the development of a concrete policy framework to implement the wide set of measures included.

3.4.3 Transport

Recent changes

▲ The European Parliament has approved the CO₂ emission standards for new heavy-duty vehicles for the period up to 2030, which are 30 per cent lower compared with 2019 levels (European Commission 2019a) and together with the Council of Ministers has adopted the CO₂ emission standards for new cars and vans for the same period (European Commission 2019b). By 2030, emissions must be 37.5 per cent lower for new cars and 31 per cent lower for new vans compared with 2021 levels (European Council 2019). This decision also included the use of a new standard for measuring CO₂ emissions from vehicles, effectively reducing the gap between test and actual road emission measurements. While this is an important step towards reducing emissions from light-duty vehicles and heavy-duty vehicles, the standards are not compatible with the required EU-wide ban on sales of fossil fuel vehicles by 2035, which studies show is necessary to develop the sector in line with the Paris Agreement (Sterl et al. 2016).

▲ The EU's Effort Sharing Regulation adopted in May 2018 sets binding national GHG reduction targets for the 2021–2030 period for the sectors not covered by the EU ETS. As the targets are binding, Member States must buy credits if they are unable to reach their national targets, which include the land-based transport sector.

▲ Denmark, France, Ireland, the Netherlands and the United Kingdom announced plans to move towards 100 per cent zero emission cars in the coming decades, as well as bans on sales of cars with internal combustion engines (ICEs) (see Table A-1).

▼ Despite policy efforts, the transport sector's emissions are still increasing, particularly aviation-related emissions.

Areas of possible additional actions

Possible action: The fast introduction of zero emission cars, delivery vehicles and buses has significant potential. Commitments to ban sales of ICE vehicles and/or targets to move towards 100 per cent new zero emission cars in the coming decades, much like those already adopted by some EU Member States (see Table 1), could drive the fast introduction of these new vehicles. Targets to achieve this would need to be supported by comprehensive policy packages and incentives, such as those for the purchase of new cars, increase in charging stations or encouragement of consumers to change their behaviour (Cornet et al. 2018). Clear, binding targets should be set to ensure growth that is compatible with the Paris Agreement, such as for no fossil fuel cars to be sold past 2035 (Climate Action Tracker 2016).

Possible action: Several Member States have good practices in terms of environmentally-friendly modal splits, which could be replicated throughout the EU (see Table 1). Such practices include significant shares in rail transport, but also walking and cycling in urban contexts. With respect to rail transport, it is important that a shift takes place in both passenger and freight transport. Switzerland is setting an

example in this regard, with trains transporting 19.8 per cent of passengers and 27.4 per cent of freight in 2016. Austria, which has a population density similar to the EU average, is also setting a good example, with trains transporting 12 per cent of passengers and 32.8 per cent of freight, with 72 per cent of the transport electrified (Eurostat 2019). At the European level, studies suggest that railways could transport up to 23 per cent of freight and 19 per cent of passengers by 2050 (Pestiaux et al. 2018). A shift away from intra-European aviation to rail transport has the potential for a significant reduction in emissions. The potential for environmentally-friendly modal shifts towards walking, cycling and public transport is even higher at the urban level. Cities such as Copenhagen, for example, have set themselves targets and implemented comprehensive plans for transport to account for 75 per cent of these three modes (The City of Copenhagen Technical and Environmental Administration 2012).

3.4.4 Buildings

Recent changes

▲ The amendment to the Energy Performance of Buildings Directive (European Parliament and the Council of the European Union 2018) stipulates that building stock should be fully decarbonized by 2050 and that new buildings should be near zero energy as of 2020. The full decarbonization of building stock is therefore the most important contribution of the revised directive, which also included requirements for charging stations for electric vehicles and smart buildings.

▼ The amended Energy Performance of Buildings Directive did not address the varying definitions of near-zero energy standards across the EU, which ranges from values as low as 20 kWh/m²/year for Denmark to 93–217 kWh/m²/year of primary energy use for new buildings in Romania (BPIE 2015).

▲ The EU's Effort Sharing Regulation adopted in May 2018 sets binding national GHG reduction targets for the 2021–2030 period for the sectors not covered by the EU ETS. As the targets are binding, Member States must buy credits if they are unable to reach their national targets, which include the building sector. Under the revised Energy Efficiency Directive adopted in December 2018, Member States must set up an energy efficiency obligation scheme or implement alternative measures, which include the building sector.

Areas of possible additional actions

Possible action: An important step to address the large quantities of existing building stock is to increase the renovation rate of buildings becoming zero energy, for example, by setting a binding renovation rate target. Although the Energy Efficiency Directive and Energy Performance of Buildings Directive try to encourage Member States to undertake ambitious renovation measures, there is no regulation binding countries to such measures beyond public buildings. As a result of these directives, existing renovation rates are approximately 0.5–2.5 per cent, though further efforts are needed for these rates to reach the necessary 5 per cent per year (Climate Action Tracker 2018b).

Possible action: Harmonizing the definition of the near zero energy buildings across Member States could significantly reduce the sector's emissions further. Although Member States' energy levels differ due to climate conditions and other factors, a standardized methodological framework in defining near zero energy buildings could ensure that countries aim to achieve similar target levels. These targets should be at a level compatible with the Paris Agreement, such as all new buildings being free of fossil fuels near zero energy by 2020 (Climate Action Tracker 2018b).

3.4.5 Agriculture and forestry

Recent changes

▲ The EU's Effort Sharing Regulation adopted in May 2018 sets binding national GHG reduction targets for the 2021–2030 period for the sectors not covered by the EU ETS. These targets include agricultural emissions, except those related to land-use. In May 2018, the EU adapted a regulatory framework that enshrines the "no-debit rule", which requires Member States to balance their land-use emissions with a land-use sink or the same size or greater. The new framework extends an existing rule from the Kyoto Protocol period to cover all land uses and not only forests, which is leading to improved land-use management and safeguards for climate integrity (Böttcher et al. 2019).

▲ The European Commission's proposal for a long-term strategy sets out an overview of what needs to happen and the trade-offs to make the agriculture and forestry sector compatible with the Paris Agreement. Analysis accompanying the strategy shows that carbon sinks can be kept at current levels in 2050 or even increased, which will effectively contribute to achieving carbon neutrality in the EU. This presents a common vision that will give clearer signals to actors in these sectors.

Areas of possible additional actions

Possible action: The European regulatory framework for land-use needs to become stricter than the "no-debit rule" if the sector is to become compatible with the Paris Agreement. To achieve compatibility, current net carbon sinks need to be maintained and even increased in the future. However, under the current rule, it is possible that carbon sinks will shrink. To ensure the framework is developed in line with the Paris Agreement, established accounting rules need to be accompanied by mitigation targets. Agriculture provisions under the EU long-term strategy represent a first important step in this direction (Böttcher et al. 2019). Supporting policies to implement this framework also need to be compatible with the agreement. The upcoming reform of the Common Agricultural Policy should be informed by the IPCC Special Report on Climate Change and Land (IPCC 2019) and adopt an integrated approach to addressing mitigation, adaptation, biodiversity and resilience issues.

Possible action: Although the EU long-term strategy analyses behavioural measures and technical measures to reduce agricultural emissions, policy recommendations from the strategy focus on the implementation of technical measures.

However, behavioural measures, such as changing diets in particular, have significant potential to reduce emissions, with the technical analysis showing that by 2015, different dietary choices may have contributed to emission reductions between 8 and 25 per cent (European Commission 2018a). Emissions could be further reduced through minimizing food and agricultural waste.

3.5 India

India's NDC has three numeric targets for 2030: reduce emissions intensity by 33–35 per cent from 2005 levels, achieve an installed power capacity of 40 per cent from non-fossil fuel sources and create an additional carbon sink of 2.5–3.0 GtCO₂e from forest and tree cover. Scenarios based on current policies project that India is on track, and could even overachieve, its energy-related targets (Buckley, Garg and Shah 2018; Chaturvedi, Koti and Ramakrishan Chordia 2018; CSTEP 2018; Mangan, Mitra and Rissmann 2018; Dubash et al. 2018; TERI 2018a). In terms of its forestry target, although Government estimates indicate that the net sequestration is positive and that current rates are on track (Government of India 2018), the state of the country's forests and the target itself are ambiguous (Lahiri 2015; Pull 2015), with studies that have used different definitions of forest cover estimating that national net sequestration is in fact negative (Reddy et al. 2016; Dubash et al. 2018; TERI 2018b).

As India is on track to achieve its energy-related targets, recent scenarios have outlined pathways for the country to overachieve its NDC emissions intensity and capacity targets. One particular scenario projects that India can integrate 390 GW of wind and solar capacity by 2030, which is more than 40 per cent greater than the renewable uptake trajectory as per current policies, by making electricity supply and demand more flexible (Udetanshu et al. 2018). A second scenario projects that if grid integration costs are managed, the share of fossil fuel-free capacity could exceed 65 per cent in 2030 (Chaturvedi, Koti and Ramakrishan Chordia 2018). The most ambitious scenario that internalizes global decarbonization targets, projects that India's CO₂ emissions from energy will only need to increase by 9 per cent from 2012 to 2030, even when the economy grows at a rate above 7 per cent per annum (Dubash, Khosla, Rao, et al. 2018). However, such scenarios contrast with those based on current policies, which project a 91–98 per cent increase in CO₂ from energy from 2012 to 2030 (Dubash, Khosla, Rao, et al. 2018).

The wide range of pathways shows that there are uncertainties regarding India's emissions future, the biggest of which is how rapidly the country's economy will grow in the coming decades and the economy's share of energy-intensive manufacturing, even if the policy directions are still not clear (Chaturvedi, Koti and Ramakrishan Chordia 2018; Dubash, Khosla, Rao, et al. 2018). Other uncertainties include India's ability to untangle vested interests and livelihood concerns surrounding its coal, industrial, agriculture and forestry sectors, as well as its ability to take advantage of electrification and efficiency in transportation, industry and buildings.

Table 6 – Possible actions to increase mitigation ambition in India

India	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> • Enhance consistency of support for renewable electricity • Plan the transition from coal-fired power plants* • Make implementation of air quality emission norms stricter • Plan how to manage the burden of costs of the transition to renewables in electricity distribution
Industry	<ul style="list-style-type: none"> • Develop an economy-wide, green industrialization strategy towards zero emission technologies*
Transport	<ul style="list-style-type: none"> • Expand mass, public transit systems* • Develop domestic electric vehicle targets working towards 100 per cent new sales of zero emission cars*
Buildings	<ul style="list-style-type: none"> • Implement an affordable homes programme in a low-carbon manner • Implement a programme for aggregating demand for appliances • Implement building energy codes
Agriculture and forestry	<ul style="list-style-type: none"> • Consider facilitating deliberations of affected actors of forest policies • Provide clarity on assessments of biophysical changes in India's forests • Improve efficiency of water and fertilizer use

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

3.5.1 Energy supply

Recent changes

▲ The National Electricity Plan promotes demand reduction and capacity additions for various energy technologies with a slowdown in the installation of new coal-fired power plants (CEA 2018). Its assessment of energy generation requirements is based on a low-carbon growth strategy which prioritizes renewables. It is estimated that 6.4 GW of additional coal capacity will be required until 2022, though since 47.8 GW is already under construction, no additional capacity has been planned. The plan proposes that an additional 46.4 GW of coal capacity be installed between 2022 and 2027, while also retiring 48.3 GW of coal plants by 2027. This amounts to a remarkably smaller addition of coal capacity compared with the significant increases of previous plans, which has been made possible due to the uptake of renewables at a rate faster than expected and the growth of energy demand at a rate slower than expected (partly due to internalized energy efficiency). The plan does not mention the uptake or retirement of coal beyond 2027.

▲ Private investment and confidence in coal power plants is declining due to a wider infrastructure finance crisis in the country, with many coal plants deemed to be non-performing or stressed assets (Parliamentary Standing Committee on Energy 2018).

▲ India's total renewables capacity was 78.4 GW in May 2019 (CEA 2019), with renewable capacity deployment exceeding conventional fuels in 2018. An additional 40 GW of renewables is to be tendered by the Ministry of New and Renewable Energy in the 2019/2020 financial year. With respect to India's target to achieve 175 GW by 2022, the

country is on track to achieve only 141–157 GW according to independent estimates (Vembadi, Das and Gambhir 2018; Buckley and Garg 2019).

● Through the Saubhagya Scheme, a Government project to provide electricity to all households, India reported almost 100 per cent electrification of households in early 2019 (Ministry of Power 2019b), potentially increasing energy demand from newly electrified homes.

▼ India's Clean Environment Cess of 400 Indian rupees per ton of coal is still levied, though it no longer feeds the National Clean Energy and Environment Fund, which aimed to finance low-carbon energy initiatives and research. Instead, it has been reformed as the Goods and Services Tax (GST) Compensation Cess for subnational state governments with reduced tax revenue (Ministry of Coal 2017). This redirection will likely reduce State-led deployment of renewables in India.

▼ The GST regime has unclear, inconsistent taxation norms for solar and renewable technologies. This uncertainty for solar deployers is coupled with a 25 per cent import duty on foreign-made solar cells and panels from 2018 to 2020 (Vembadi, Das and Gambhir 2018; Buckley and Garg 2019).

▲ The Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) scheme (March 2019) promotes solar energy in rural areas. It aims to install up to 26 GW of solar agricultural pumps by 2022, replacing diesel-powered pumps, with 10 GW of the power due to come from solar-generated feeder lines (The Cabinet Committee on Economic Affairs 2019).

▲ The second phase of the Grid Connected Rooftop Solar programme was approved, aiming to achieve 40 GW by 2022 through central financial assistance for residential units and welfare associations. Rooftop solar has had limited deployment to date (only 3.8 GW against the 40 GW target), but it is a rapidly growing sector (Garg and Buckley 2019).

▲ The National Clean Air Programme was launched in 2019 and aims to reduce national PM_{2.5} and PM₁₀ concentrations by 20–30 per cent by 2024 from a 2017 base year. The programme includes actions to switch older coal power plants and industry to natural gas (MoEFCC 2019b). However, as this plan is developed by the Ministry of Environment, Forest and Climate Change, it alone is unlikely to influence decisions in the power and industrial sectors. The 2015 air pollution norms for coal power plants are yet to be complied with and the deadline for compliance has been extended from 2017 to 2022 (Garg and Buckley 2019).

Areas of possible additional actions

Possible action: India's mission approach to deploying renewables has yielded significant gains, but more consistency in taxation regimes, renewable purchase agreements and obligations, and financial support from the central Government could further enhance this deployment (Vembadi, Das and Gambhir 2018). Deployment models could be more experimental and include, for example, State, municipal or co-operative owned public sector undertakings, which could serve as a demand aggregator and market anchor (Roy et al. forthcoming).

Possible action: India needs a strategy to plan for the transition from fossil fuels to renewables in its energy and distribution sectors. An energy sector strategy should plan to phase out India's coal power plants through reducing their lifespans (Yang and Urpelainen 2019), while also aiming to rehabilitate livelihoods dependant on the coal sector. Such a phase-out plan could also bring about domestic environmental benefits, such as reduced air pollution.

Possible action: Strict implementation of air quality emissions norms for power plants could ensure that the cost of coal-powered electricity generation internalizes environmental costs, levelling with playing field between fossil-fuels and renewables. The high costs of retrofitting power plants and installing pollution abatement devices remains a significant barrier to compliance with emission norms, and existing regulatory measures need to be complemented with financial instruments such as incentives and penalties that ensure compliance (Garg and Buckley 2019).

Possible action: In the electricity distribution sector, plans should manage the burden of costs of the transition to renewables, especially considering the need to provide affordable power (Dubash, Kale and Bharvirkar 2018; Dubash, Swain and Bhatia 2019). Due to India's high rate of poverty, deployment strategies should emphasize and subsidize the dissemination of small-scale renewable systems to poorer households that have a higher need for affordable energy.

Efforts to enhance grid infrastructure and management to support variable renewables and electric vehicle usage are also required.

3.5.2 Industry

Recent changes

▲ A fifth cycle of the Perform, Achieve and Trade (PAT) scheme was notified in 2019 (Ministry of Power 2019a), and will continue to mainstream energy efficiency, covering almost 40 per cent of India's industrial energy demand (IEA 2018). In the first cycle of the PAT scheme (2012–2015), 8.67 Mtoe was saved and 31 MtCO₂ was avoided. The total target energy savings from cycles two, three and four is 19 Mtoe (Government of India 2018).

Areas of possible additional actions

Possible action: Sector-wide strategies to reduce the use of fossil fuels in industrial processes are required, especially considering the likely future growth of strategic, carbon-intensive industries such as steel and cement. Support for informal and micro, small, and medium-sized enterprises (MSMEs) that contribute to decarbonizing India's industry and waste sectors is also required.

Possible action: India's current efforts to decarbonize its industry involve mainstreaming renewable deployment and energy efficiency across all sectors, yielding incremental mitigation gains. However, India's industrial emissions may still rapidly increase in the near future, especially if the manufacturing sector develops. India should therefore develop an economy-wide green industrialization strategy towards zero emission technologies that encourages companies, collects and shares resources and incentivizes the growth of low-carbon sectors, such as renewables manufacturing, energy storage, electric and mass transport and green built environment, while taking into account employment generation and local environment objectives such as air quality.

3.5.3 Transport

Recent changes

▲ India continues to deliberate timelines and targets for the transition to electric vehicles. Although the previous target of 100 per cent sales of new electric vehicles by 2030 is no longer being pursued, plans are being proposed to differentiate targets by vehicle type. For example, NITI Aayog, a Government think tank, proposes a sales ban on new gasoline and diesel three-wheeler vehicles by 2030, only allowing sales of new electric two-wheelers below 150cc by 2050 and all types of new vehicles by 2030. These targets would put India at the forefront of such development globally.

▲ The Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME) scheme was extended in April 2019. Set up in 2015 under the National Electric Mobility Mission Plan, the FAME scheme aims to support the development of the hybrid and electric vehicles market and deploy 6–7 million vehicles per year by 2020. Phase 2 of the scheme provides

upfront incentives for purchasing such vehicles and fosters the development of charging infrastructure. The scheme is planned to support 1 million electric two-wheeler vehicles, 500,000 electric three-wheeler vehicles, 55,000 electric four-wheeler vehicles and 7,000 buses. Overall, the scheme is projected to save up to 7.2 MtCO_{2e} over the deployed vehicle's lifetime (Union Cabinet 2019).

▲ The National Policy on Biofuels (2018) updates a 2009 policy by expanding the scope of raw material that can be used for ethanol production, with an emphasis on food unfit for human consumption and food waste (Union Cabinet 2018).

▲ The Government of India approved to electrify all its broad-gauge railway routes by 2021–2022, which is projected to reduce Indian Railway's CO₂ emissions by 24 per cent by 2027–2028, which is approximately 1.83 MtCO₂ from 2014 railway emission levels (Cabinet Committee on Economic Affairs 2018; Government of India 2018).

▲ Vehicular and fuel emission standards will jump from Bharat Stage IV to Bharat Stage VI (the standards are based on European equivalents) as of 2020. The Government of Petroleum and Natural Gas also brought forward the adoption of Stage VI standards in the National Capital Territory of Delhi to 2018, citing air pollution concerns (Ministry of Petroleum & Natural Gas 2017). This policy is forecast to prevent 50 MtCO_{2e} emissions by 2030 (IEA 2018).

Areas of possible additional actions

Possible action: India could lock in the use of mass, public transit systems as opposed to private modes to reduce transit services' energy demand and increase fairness in mobility. While the focus on electrifying bus and intermediate public transit systems is welcome, a parallel mission approach to expand the coverage of mass bus and metro rail systems is required. Subsidies could encourage transit usage for underprivileged social groups. Non-motorized transport is also a significant mode and should therefore be incentivized through better cycle and pedestrian infrastructure design. Private vehicle usage, especially fossil fuel-powered vehicles, should be discouraged through congestion and parking charges, particularly in India's cities. The additional benefits of these actions, such as addressing domestic air quality, could help motivate their implementation.

Possible action: Consistent electric vehicle targets could provide policy signals to domestic industry actors to develop manufacturing capacity, as well as to domestic electricity utilities to develop appropriate charging infrastructure (see Table 9). However, India still needs to design a strategy to balance its need to rapidly deploy electric transportation and to develop its local manufacturing capacity, which will likely take time. A complementary framework to deploy electric vehicle charging infrastructure with technical standards is also required, along with guidelines for deployment and tariffs.

3.5.4 Buildings

Recent changes

▲ In 2018, ECO Niwas Samhita, an energy conservation building code for residential buildings was released, following the release of a similar code for commercial buildings in 2017, though there are concerns around its implementation and enforcement. The Bureau of Energy Efficiency launched an energy efficiency star rating for homes in 2019, which is expected to mitigate 320 MtCO_{2e} per year until 2030 (Ministry of Power 2018).

▲ India has released a Cooling Action Plan to reduce the global warming potential of cooling in buildings, which aims to reduce cooling demand by 20–25 per cent and refrigerant demand by 25–30 per cent by 2037–2038 (MoEFCC 2019a).

▲ The Unnat Jyoti by Affordable LEDs for All (UJALA) scheme had distributed 312 million light-emitting diode (LED) bulbs by October 2018, saving 33 MtCO_{2e} per annum. A similar but limited programme has distributed 2.06 million energy-efficient fans, reducing emissions by 0.1 MtCO_{2e} per annum (Government of India 2018). In 2019, the scheme was expanded to include the Super-Efficient Air Conditioning programme (Ministry of Power 2019c).

Areas of possible additional actions

Possible action: The Government's plans to build 22 million affordable homes by 2022 (12 million in urban areas) should be carried out in a low-carbon manner, using passive design elements (such as cool roofs, shading), low-carbon materials and encouraging the uptake of energy-efficient appliances (Khosla, Sircar and Bhardwaj 2019).

Possible action: Following the success of the UJALA scheme for LED bulbs, schemes to reduce prices by aggregating demand (Chunekar, Mulay and Kelkar, 2017) could be expanded to other appliances that are rapidly increasing in number, such as fans, fridges, air coolers and air conditioners. The successful star rating programme should be made mandatory for all such appliances. India's landmark cooking fuel scheme, Pradhan Mantri Ujjwala Yojana, which aims to transition households from biomass-based fuels to liquid petroleum gas and other clean, viable cooking technologies, such as electric induction and solar, could also be encouraged to reduce potential emissions from the cooking sector.

Possible action: Energy conservation codes are positive signals for the formal built environment sector, though this represents limited changes to India's built environment. Support is needed to ensure that informal building practices are low carbon, such as the provision of affordable, low-carbon building materials and incentives to include passive design elements to reduce cooling loads such as cool roofs and shading.

3.5.5 Agriculture and forestry

Recent changes

▲ A National Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy has been released which aims to incentivize forest conservation and sequestration efforts, while also emphasizing cooperation with tribal and other forest-dwelling people (MoEFCC 2018).

Areas of possible additional actions

Possible action: India's forests are contested sites where carbon sequestration objectives often involve trade-offs with forest dwellers' livelihoods. The REDD+ Strategy acknowledges this trade-off, which needs to be complemented with a governance arrangement that facilitates deliberations with affected actors.

Possible action: Further clarity on the definition, state and rate of change of forests and tree cover is still required to ensure accurate and accountable assessments of biophysical changes in India's forests (Dubash et al. 2018b; Lele and Krishnaswamy forthcoming; Reddy et al. 2016).

Possible action: Actions to improve efficiency in the use of resources, for example, water and fertilizer in agriculture, could reduce emissions while also achieving primary development objectives, such as increased farmer welfare, agricultural yields and food security.

3.6 Japan

Under its NDC, Japan aims to reduce its GHG emissions by 26 per cent by 2030 from 2013 levels. Although Japan's GHG emissions have started declining from its 2013 levels, it is uncertain whether the country will be able to achieve its NDC due to several factors, including, in particular, the share of nuclear power in its electricity mix. Despite having the potential to significantly affect national GHG emissions by 2030, there is a great deal of uncertainty as to when and how many nuclear reactors will be restarted (Oshiroa, Kainumab and Masuic 2017; Kuramochi et al. 2018; Wakiyamaab and Kuriyama 2018; den Elzen et al. 2019; Kuriyama, Tamura and Kuramochi 2019). It is also unclear which energy carriers will replace nuclear capacity if the reactors are not restarted in line with the numbers set out in the Government's plans. Slow progress in tackling fluorinated gas emissions could also hinder efforts to achieve the NDC. However, most of these assessments are based upon the NDC's GDP assumption of 1.7 per cent annual growth for 2013–2030, which is higher than any other projections by economic research institutes. A lower or more realistic level of GDP growth increases the country's possibility of achieving the 2030 target and even the possibility of attaining a greater emissions cut than the NDC level if all mitigation measures are taken as planned (Kuriyama, Tamura and Kuramochi 2019).

The Japanese Government formulated its long-term strategy under the Paris Agreement in June 2019 (The Government of Japan 2019). It is a significant step in stimulating policy debates on taking the next step towards

the goal of reducing emissions by 80 per cent by 2050 or achieving carbon neutrality as early as possible in the second half of this century. Under this strategy, however, Japan would reach carbon neutrality later than proposed by the EU and any other country that has proposed such a goal (see Table A-1).

3.6.1 Energy supply

Recent changes

● Although the Feed-in Tariff (FIT) scheme has boosted the deployment of solar PV, the Government has started reviewing the scope of renewable projects the scheme supports to control the increasing surcharge (METI 2019e). In addition, from April 2020, the Environmental Impact Assessment Act will apply to large-scale solar PV projects with capacities greater than 40 MW (or greater than 30 MW following a screening process based on the current status of land-use on the project site) (METI 2019b). Another action being considered is the establishment of a mechanism that secures funds for solar PV disposal facilities (METI 2019c). These new rules are likely to secure proper business disciplines for solar PV in Japan, despite curbing the speed that large-scale solar projects can be deployed after the full installation of capacity with FIT approval.

▲ In November 2018, the National Diet of Japan established the Act of Promoting Utilization of Sea Areas in Development of Power Generation Facilities Using Maritime Renewable Energy Resources, which was put into effect on 1 April 2019 (METI 2019a). This act allows offshore wind power developers to occupy a registered area up to 30 years after consultation with relevant ministries and local stakeholders. The Government is expected to set five areas where renewable energy operations will have started by 2030. This will promote the development of offshore wind farms, which is an issue on which stakeholders such as fisheries and local residents have had difficulty agreeing.

▼ As of July 2019, nuclear power plants with 9 GW capacity are in operation; the remaining plants with 33 GW capacity are not fully operational due to concerns about safety checks and a lack of consensus among local residents (JAERO 2018). On 12 June 2019, the Nuclear Regulation Authority decided to order power companies to put nuclear reactors into a state of cold shutdown if they did not complete scheduled construction of anti-terrorism facilities at their power plants sites. According to statements by Kansai Electric Power, Shikoku Electric Power and Kyushu Electric Power, 10 nuclear power plants have experienced delays in the completion of anti-terrorism facilities, which has resulted in a halt in operations at the plants (NRA 2019).

● Japan's long-term strategy states that "to realize a decarbonized society, the Government will work to reduce CO₂ emissions from thermal power generation, in line with the long-term goals set out in the Paris Agreement" (The Government of Japan 2019). To achieve this, the strategy envisages the wide deployment of carbon capture, utilization

Table 7 – Possible actions to increase mitigation ambition in Japan

Japan	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> • Develop a strategic energy plan that includes halting the construction of new freely emitting coal-fired power plants, as well as a phase-out schedule of existing plants and a 100 per cent carbon-free electricity supply* • Amend current rules and design the electricity market so that there is increased flexibility in the power system • Mobilize investments to strengthen transmission and distribution networks – a demand response and virtual power plants, battery storage system and power-to-X technologies are needed • Increase the current level of carbon pricing*
Industry	<ul style="list-style-type: none"> • Establish an institutional framework to mobilize a circular economy • Stimulate awareness of climate risks and opportunities through enhancing environmental, social and governance (ESG) activities
Transport	<ul style="list-style-type: none"> • Develop a plan to phase out the use of fossil fuels through promoting passenger cars that use electricity from renewable energy* • Facilitate coordination of hard and soft infrastructure for a shared mobility service or Mobility as a Service (MaaS)
Buildings	<ul style="list-style-type: none"> • Strengthen energy-saving standards for medium-scale (300 m² and 2,000 m²) and small-scale (less than 300 m²) buildings with energy labelling • Implement a road map as part of efforts towards net zero-energy buildings and net zero-energy houses* • Extend the practice of carbon pricing for the commercial sector at the prefectural level to the national level*
Agriculture and forestry	<ul style="list-style-type: none"> • Consider facilitating deliberations of affected actors of forest policies • Provide clarity on assessments of biophysical changes in India's forests • Improve efficiency of water and fertilizer use

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

and storage (CCUS), including carbon recycling and hydrogen technologies, though only after 2030. However, the IPCC Fifth Assessment Report indicates that the global energy sector needs to be decarbonized long before 2050 to achieve the goals of the Paris Agreement (Clarke et al. 2014). The IPCC Special Report on Global Warming of 1.5°C also concludes that “the use of coal shows a steep reduction in all [1.5°C] pathways and would be reduced to close to 0 per cent (0–2 per cent interquartile range) of electricity” in 2050 (IPCC 2018). Given Japan’s current plans to construct 17 GW of coal-fired power plants and 16 GW of gas-fired power plants, none of which are CCUS ready (METI 2018a), the long-term strategy is unclear on how the country will deploy CCUS and hydrogen technologies in rapid and large-scale manner after 2030 to decarbonize power before 2050. Consistency with the goals of the Paris Agreement needs to be further elaborated.

Areas of possible additional actions

Possible action: In its next strategic energy plan, the Government could halt the construction of new freely emitting coal-fired power plants and outline a phase-out schedule for existing plants (see Table 9).

Possible action: The development of renewable energy still requires policy support and institutional reform of the power market. For example, solar and wind power in the Kyushu area has been curtailed due to the lack of flexibility in the power grid coupled with insufficient cooperation among local balancing areas. There is also not enough automation in power plant operations and insufficient grid capacity for transport electricity (Renewable Energy Institute 2019). In this case, it is necessary to amend the current rules and design the electricity market so that there is increased flexibility in the power system (IEA 2016). Investments should be mobilized to strengthen transmission and distribution networks and a demand response and virtual power plants, battery storage system and power-to-X technologies should be further developed.

Possible action: One of the priorities for the power sector is to implement carbon pricing, since CO₂ emissions from this sector account for more than 40 per cent of total CO₂ emissions. The scheme needs to be carefully designed to consider economic impact, previous carbon leakage and the predictability of carbon prices (Ministry of the Environment

2017a). Regarding the level of carbon pricing, studies by Sugiyama et al. (2019) that summarized past studies show the wide range of carbon pricing that is required for an 80 per cent emission reduction, with the minimum, median and maximum values at € 228/tCO₂, € 2,348/tCO₂ and € 6,449/tCO₂, respectively. However, a recent study indicates that an 80 per cent emission reduction with a 50–60 per cent share of renewables in the electricity mix is achievable by putting carbon pricing at €83 if Japan moves into a digitalized economy where artificial intelligence, the Internet of things (IoT) and big data are widespread (JCER 2019). The study also shows that net zero emissions could be possible with a 75 per cent share of renewables in the electricity mix when Japan can impose carbon pricing of €166. A further point is that recycling carbon revenue has the potential to decrease the necessary level of carbon pricing (Kainuma, Matsuoka and Morita 2000; Lee et al. 2018).

3.6.2 Industry

Recent changes

▲ The list of Top Runner programmes for energy efficiency standards was renewed in March 2019. As a result, items on lighting equipment and bulbs have been updated and energy-efficient standards for server-type computers and client-type computers have been formulated (METI 2019d). However, it should be noted that energy consumption of these items is only a small part of the whole industry.

▲ In November 2018, the Japan Iron and Steel Federation (JISF) announced its long-term vision, "A challenge towards zero-carbon steel", which is the first vision to mention the possibility of carbon neutrality by 2100 (JISF 2018). Even though this vision was developed as a voluntary initiative, it was incorporated into Japan's long-term low emission development strategy and could therefore act as a signal for the relevant business sector to promote research and development of mitigation technologies, including CCUS and hydrogen reduction.

Areas of possible additional actions

Possible action: Promoting electrification using renewable energy to cover low temperature heating, through heat pumps, for example, could reduce and even replace the use of fossil fuels. In instances where the electricity demand is more difficult to replace, such as high temperature heating, clean hydrogen from renewable energy or fossil fuels with CCS technologies may be used.

Possible action: For harder-to-abate sectors such as the steel, cement, plastics and aluminium sectors, greater recycling and reuse of materials within a more circular economy has significant potential to reduce CO₂ emissions (ETC 2018a). Establishing an institutional framework to mobilize a circular economy is therefore one possible action to further reduce CO₂ emissions from the industrial sector.

Possible action: Raising awareness of climate risks and opportunities by enhancing ESG activities is another

possibility. The Government has already developed several initiatives. For example, the Financial Services Agency (FSA) revised Japan's Stewardship Code to promote the sustainable growth of companies through investment and dialogue (FSA 2017), METI released the Ito Review 2.0, which includes Guidance for Collaborative Value Creation (METI 2017) and the Ministry of the Environment established Green Bond Guidelines, with aims to develop a green bond market through interaction based on sufficient information between issuers and investors (MOEJ 2017a). Strengthening ESG activities would help contribute towards achieving a decarbonized society.

3.6.3 Transport

Recent changes

▲ On 31 August 2018, the Government announced its Long-Term Goal and Strategy of Japan's Automotive Industry for Tackling Global Climate Change (METI 2018b). This strategy aims to achieve a reduction of 80 per cent (or 90 per cent for passenger cars) in GHG emissions per vehicle by 2050 compared with 2010 levels. This is a major departure from the previous strategy, as it provides a long-term goal by 2050, including the role of electrified vehicles.

▲ On 29 March 2019, the Government announced new fuel economy standards for trucks and buses, of 7.63 km/l and 6.52 km/l, respectively by 2025 (MLIT 2019b). Compared with fuel economy levels in 2015, these regulations require trucks and buses to make improvements of 13.4 per cent and 14.3 per cent, respectively. A new fuel economy standard for passenger cars was announced on 3 June 2019, which requires them to achieve a fuel economy of 25.4 km/l by 2030. This is an improvement of 32.4 per cent compared with 2016 levels (MLIT 2019a). Electric vehicles and plug-in hybrid vehicles have been newly included in the category of passenger cars, alongside gasoline vehicles, diesel vehicles and liquid petroleum gas vehicles. This could help promote the purchase of electric and plug-in hybrid vehicles among users by providing information for comparing these vehicles fuel economy against gasoline vehicles.

Areas of possible additional actions

Possible action: In addition to fuel economy standards being strengthened, it is important to develop a plan to phase out the use of fossil fuels. At the same time, electrification of passenger cars using electricity from renewable energy has great potential to achieve a decarbonized society (Kainuma et al. 2017). For heavy-duty vehicles such as trucks and buses, hydrogen, e-fuel (e-gas and e-liquids) and biofuel needs to be deployed. To activate these new technologies, developing long-term pathways to achieve the Long-Term Goal and Strategy of Japan's Automotive Industry beyond 2030 could provide the business sector with signals to decarbonize society.

Possible action: Since Japan's population is decreasing, compact and networked residential areas are necessary to satisfy adequate service levels (MLIT 2014). In line with this

movement, coordination of hard and soft infrastructure for shared mobility service or Mobility as a Service (MaaS) that is integrated with public transport could lead to significant reductions in vehicle-kilometres, thereby lowering CO₂ emissions.

3.6.4 Buildings

Recent changes

▲ In May 2019, the Government announced that energy efficiency standards would be mandated for new and retrofit buildings with floor space greater than 2,000 m² (MLIT 2019c). New and retrofit buildings with floor space between 300 m² and 2,000 m² are required to report their energy-efficient performance to the Government.

Areas of possible additional actions

Possible action: There are no mandatory energy-efficient performance standards for medium-scale (300–2,000 m²) and small-scale (less than 300 m²) buildings. In 2015 and 2016, the compliance rate of such housing buildings was only around 60 per cent (MLIT 2018). Such standards could be particularly effective in strengthening energy-saving standards for buildings. At same time, policy support for purchasers, such as energy labelling and building inspection by experts, may have accelerated compliances. To further strengthen the energy-saving standards for buildings, a policy could be implemented that puts into practice a road map for achieving net zero-energy buildings and net zero-energy houses (see Table 1).

Possible action: The effectiveness of carbon pricing to reduce emissions, at least in the commercial sector, has been observed based on practices from the cap-and-trade programmes in Tokyo and Saitama (Hamamoto 2018; Wakabayashi and Kimura 2018; TMG 2019). An extension of these programmes to the national level could therefore help reduce energy demand.

3.6.5 Agriculture and forestry

Recent changes

▲ On 27 March 2019, the Government decided to introduce the Forest Environmental Tax from 2024 in order to promote forest management, including periodic thinning of forests, which can enhance their capacity to absorb CO₂. At the same time, the Government also approved a budget for forest management activities until 2024.

Areas of possible additional actions

Possible action: The use of wood as a building material has the potential to reduce CO₂ emissions as it can be used in place of cement (Oliver et al. 2014; Hurmekoski 2017). Technology is therefore being developed to construct high-rise wooden buildings, including skyscrapers (Asdrubalia et al. 2017; Forest Agency 2019). Policy measures to improve current architectural technologies and regulations that expand the use of wood products could increase the demand for domestic wood, which would contribute to proper forest management.

Possible action: Among GHG emissions from the agriculture sector, methane emissions from rice cultivation have the largest share (GIO 2019). Rice straw, which is a source of methane from rice fields, has been used in compost and as livestock food (MAFF 2018). Recent studies have been carried out on the use of rice straw for new materials such as cellulose nanofibers (MIESC 2015). The creation of a new scheme to stimulate the demand for rice straw could reduce GHG emissions in the agriculture sector.

3.7 United States of America

The United States of America is likely to miss its NDC target to reduce emissions by 26–28 per cent by 2025 from 2005 levels, which was originally established under the Administration of President Barack Obama (UNFCCC 2015). In order to achieve this target, President Obama developed a climate action plan, which included the Clean Power Plan to limit carbon emissions from power plants, and strengthened the Corporate Average Fuel Economy (CAFE) standards for cars and light-duty trucks, among other regulations (The White House 2015). However, President Donald Trump has announced that the country will cease implementation of its NDC and intends to withdraw from the Paris Agreement, which could occur as early as 2020 (The White House 2017). President Trump has also frozen the vehicle emissions standards for 2025 at 2020 levels and replaced the Clean Power Plan with the Affordable Clean Energy (ACE) Rule, which is projected to reduce emissions from the power sector by only 0.7–1.5 per cent by 2030 (NRDC 2018). Market forces are still expected to reduce power sector emissions by 35 per cent in this period, regardless of the rollback (Irfan 2019b). Despite inaction at the federal level, subnational actors, including states, cities and businesses, have continued to lead on climate action in the country. The America's Pledge initiative released a report in 2018 which modelled the emissions reductions expected from subnational action and found that under a current measures scenario, the United States of America could be expected to reduce its emissions by 17 per cent by 2025, which is much less than the NDC target (America's Pledge Initiative 2018). However, according to final estimates from the Rhodium Group, national emissions from fossil fuel combustion increased by 2.7 per cent in 2018, with economy-wide emissions rising by 1.5 per cent to 2.5 per cent, putting the country's emissions targets even further out of reach. Rhodium Group projects that, depending on economic trends, the United States of America will achieve a reduction of only 11–21 per cent below 2005 levels by 2025, falling short of its NDC commitment in even the most optimistic scenario (Houser, Pitt and Hess 2019).

However, the America's Pledge initiative estimates that more ambitious action at the subnational level could lead to a decrease in emissions of as much as 24 per cent under the enhanced engagement scenario, which would put the NDC target within striking distance. This scenario assumes that actions will be taken by a wider array of states, cities and businesses, as well as further actions by those already reducing their emissions (America's Pledge Initiative 2018). As a result of the election of new state governors in 2018, the bipartisan United States Climate Alliance has grown to include 24 states and territories,

representing 55 per cent of the country's population (United States Climate Alliance 2019). The United States Mid-Century Strategy for Deep Decarbonization, released in late 2016 by the Obama Administration, provided a road map for reducing national emissions economy-wide by 80 per cent by 2050 through decarbonization of the energy sector, carbon sequestration and mitigation of non-CO₂ GHGs (The White House 2016). The Federal Government may re-engage in earnest in climate action in 2021, as several candidates for the 2020 presidential election have released detailed climate plans, many of which call for net zero emissions by 2050 at the latest (Irfan 2019a). Climate action has forcefully entered the political debate in the United States of America, following the introduction of the Green New Deal (GND) resolution to Congress. The resolution, which is highly unlikely to pass under the current Administration, calls for economy-wide action to achieve net zero GHG emissions through a fair and just transition.

3.7.1 Energy supply

Recent changes

- ▼ The United States Environment Protection Agency (EPA) has replaced the Clean Power Plan with the ACE Rule (2019), which gives the states licence to regulate their own power plant emissions. Experts believe this will allow old coal power capacity to remain in use for a longer period of time. The EPA estimates that the rule will decrease emissions by roughly 1 per cent by 2030, as opposed to the Clean Power Plan's goal of achieving a 32 per cent reduction in power sector emissions in the same period (NRDC 2018).
- ▼ The United States Department of the Interior reversed a rule to prevent methane leaks from oil and gas production that was finalized under the Obama Administration (Friedman 2018).

▲ Six states and territories have passed legislation setting state-wide goals for 100 per cent clean energy by 2045 or 2050. Over 100 American cities have made 100 per cent clean energy commitments (Sierra Club 2019).

▲ Four states (Connecticut, Illinois, New Jersey and New York) have passed subsidies for nuclear power plants that were struggling economically. This will prevent them from being replaced by natural gas (Mai 2019).

Areas of possible additional actions

Possible action: The NRDC estimates that if new regulations on emissions from power plants similar to the Clean Power Plan were implemented, they could reduce pollution from power plants by as much as 60 per cent by 2030 from 2005 levels at a lower annual cost than the initial estimates for the Clean Power Plan (Krishnaswami 2019).

Possible action: The adoption of a federal clean energy standard would require a certain percentage of electricity to come from zero-carbon sources. Similar to the Renewable Portfolio Standard at the state level, a clean energy standard would ensure that renewable energy sources replace electricity generated by fossil fuel combustion.

Possible action: Several carbon pricing bills have been introduced in Congress, some of which have received bipartisan support. These bills differ on how the revenue generated from carbon pricing is used (Citizens' Climate Lobby 2019).

These actions would need to be designed to facilitate the achievement of a 100 per cent carbon-free electricity supply.

Table 7 – Possible actions to increase mitigation ambition in the United States of America

United States of America	
Sector	Possible actions to increase mitigation ambition
Energy supply	<ul style="list-style-type: none"> ● Introduce regulations on power plants, clean energy standards and carbon pricing to achieve an electricity supply that is 100 per cent carbon-free*
Industry	<ul style="list-style-type: none"> ● Ratify the Kigali Amendment of the Montreal Protocol to phase down hydrofluorocarbons (HFCs) ● Implement carbon pricing on industrial emissions*
Transport	<ul style="list-style-type: none"> ● Strengthen vehicle and fuel economy standards to be in line with zero emissions for new cars in 2030* ● Extend tax credit for electric vehicles ● Invest in low-carbon transportation options ● Shift to public transport*
Buildings	<ul style="list-style-type: none"> ● Implement clean building standards so that all new buildings are 100 per cent electrified by 2030*
Agriculture and forestry	<ul style="list-style-type: none"> ● Implement a federal subsidy for tree cover expansion

* The authors consider these possible actions as opportunities to enhance ambition in line with the actions and targets indicators identified in Table A-1 as clearly ambitious.

3.7.2 Industry

Recent changes

▲ The Furthering Carbon Capture, Utilization, Technology, Underground Storage, and Reduced Emissions (FUTURE) Act was passed with bipartisan support in 2018 and extends the 45Q tax credit for carbon sequestration, which should make carbon capture more commercially viable to new types of facilities, including direct air capture. The original credit only applied to an entity that both captured and stored CO₂. With the passing of this legislation, the owner of the carbon capture equipment is the recipient of the credit, but they can approve its extension to another entity engaging in utilization and/or storage (Christensen 2019).

▲ Two states (California and Washington) have enacted laws to reduce HFC emissions, while three other states (Maryland, Connecticut and New York) have committed to developing plans to phase out the use of HFCs (Garry 2019).

Areas of possible additional actions

Possible action: The United States has yet to ratify the Kigali Amendment to the Montreal Protocol, which would phase out the consumption and production of HFCs. American industry has already invested significantly in the development of potential safe replacements to HFCs, such as refrigerants including CO₂, hydrocarbons and hydrofluoroolefins (HFOs) (Hulac 2017).

Possible action: Process emissions from cement production can only be fully mitigated through the deployment of carbon capture technology. However, strong carbon pricing will be necessary to spur widespread adoption of the technology. Carbon pricing will also be vital for encouraging steel producers to increase recycling and pursue innovative ways of decarbonizing primary production (ETC 2018b).

3.7.3 Transport

Recent changes

▼ In 2018, the Trump Administration proposed the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule (2018), which would freeze the Obama Administration's emissions and CAFE standards for cars and light-duty trucks from 2021–2025. Rather than increasing the CAFE to 54 miles per gallon, the new rule would keep the standard at 35 miles per gallon. Rhodium Group estimates that this will increase annual American GHG emissions by 28 Mt to 83 Mt by 2030, depending on future oil prices (Larsen, Houser and Mohan 2019).

▲ A group of 24 state governors issued the Clean Car Promise, calling for a national standard for automobile emissions that will provide regulatory certainty for the auto industry, give states a seat at the negotiating table and ensure that cars remain affordable for consumers (United States Climate Alliance 2019).

▲ Four major automobile manufacturers signed a deal with the state of California to strengthen gas mileage and emission standards for cars. The deal ensures more stringent

standards regardless of the outcome of the upcoming presidential election, providing regulatory certainty for the industry (Krisher and Knickmeyer 2019).

Areas of possible additional actions

Possible action: The EPA and Department of Transportation could strengthen their vehicle emissions standards and CAFE standards to be in line with zero emissions from new cars by 2030, reflecting the global effort to phase out ICEs in favour of electric vehicles. This could also ensure that the American auto market would not face a bifurcated set of regulations, given that California is attempting to retain its more ambitious standards, which are followed by 14 other states and territories (Edelstein 2017).

Possible action: The Government provides a tax credit of US\$7,500 for electric vehicle sales, but this is currently capped at 200,000 sales per auto company (Grandoni and Mufson 2019). Eliminating the cap would ensure that more electric vehicles are sold, driving down transportation emissions.

Possible action: Senate Minority Leader Chuck Schumer has called for an infrastructure bill that would invest in low-carbon technologies (Schumer 2018). This could include electric vehicle charging stations, as well as investments in new shared mobility options, such as light rail and electric buses.

3.7.4 Buildings

Recent changes

There has been no change at the federal level.

Areas of possible additional actions

Possible action: Ambitious standards for new buildings could require that oil and gas heating be phased out to ensure that all new buildings are 100 per cent electrified by 2030. Such standards could also require that all existing private and commercial buildings are retrofitted within that period.

3.7.5 Agriculture and forestry

Recent changes

▲ The United States of America passed an updated version of the Agriculture Improvement Act (also known as the Farm Bill) in 2018 which has several provisions with climate benefits. These provisions include a crop insurance programme, which will encourage farmers to grow crops that sequester nitrogen, as well as increased funding for conservation programmes with soil health benefits (Lehner and Saylor 2019).

Areas of possible additional actions

Possible action: Enacting a federal subsidy for the expansion of tree cover would make reforestation more economically viable, leading to a significant increase in forest carbon sequestration. This could be achieved through a tax credit or a cost-sharing programme, and would involve reforestation on unproductive non-forest lands, restocking of understocked forests, agroforestry and silvopasture.

Annex I

Table A-1 – Examples of countries, subnational governments, and non-state actors that have subscribed to ambitious targets, which can serve as examples for others to sign up to (collection as of August 2019, sources added in endnotes)

Possible targets	National governments				Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
This overview table builds on a broad range of literature to identify unambiguously ambitious climate action in the different sectors as of August 2019. Given the scope of existing policies and rapid change in policymaking, the table makes no claim to be exhaustive.						
Overarching						
Achieve zero emissions by year ^{xiv}	Norway	LB	2030	GHGs	<p>Regions: California (2045 – carbon-neutral), New York (2050 – carbon-neutral)⁵, Scotland (2040 – net-zero)⁶, Queensland (2050 – net-zero)⁷, South Australia (2050 – net-zero)⁸, New South Wales (2050 – net-zero)⁹, Victoria (2050 – net-zero)¹⁰, Tasmania (2050 – net-zero)¹¹</p> <p>Cities (all carbon-neutral): 32 cities have pledged carbon neutrality by 2050 as part of the <i>Carbon Neutrality Coalition</i>¹² and >70 cities have pledged to become carbon-neutral by 2050, including Cape Town (2050), Barcelona (2050), Paris (2050), Reykjavik (2040), London (2050), The Hague (2030), Boston (2050), Indianapolis (2050), San Francisco (2050), Seattle (2050), Washington, D.C. (2050), New York City (2050), Canberra (2045), Melbourne (2020 – net-zero), Sydney (2050 – net-zero), Los Angeles (2045)¹³, Copenhagen (2025)¹⁴, Oslo (2030)¹⁵ ¹⁶, Stockholm (2040 – net-zero)¹⁷, Helsinki (2035)¹⁸, Yokohama¹⁹ (2050), Kyoto (2050)²⁰, Tokyo (2050)²¹</p> <p>Businesses: >500 airports in Europe (2050) ²², Deutsche Post DHL Group²³</p> <p>Investors: None identified</p>	<p>2 G20 members (United Kingdom, France) have passed legislation</p> <p>3 G20 members (the EU28 and Germany and Italy as part of the EU28) are currently in the process of passing legislation</p> <p>15 G20 members have no binding (net-)zero emission target</p>
<p>Overview from the Committee on Climate Change report (May 2019)¹, the Net-Zero Tracker (2019)², and Climate Home News (June 2019)³ for countries and by CDP for cities⁴</p>	Sweden	LB	2045	Unclear		
	United Kingdom	LB	2050	GHGs		
	France	LB	2050	GHGs		
	Switzerland ²⁴	LB	2050	GHGs		
	Denmark	LB con.	2050	GHGs		
	EU28	LB con.	2050 (TBC)	GHGs		
	New Zealand	LB con.	2050 (TBC)	TBC		
	Chile	LB con.	2050 (TBC)	CO ₂		
	Ireland	LB con.	2050	GHGs		
	Netherlands ²⁵	LB con.	2050	GHGs		
	Finland	Not LB	2035	GHGs		
	Ethiopia	Not LB	n/a	TBC		
	Costa Rica	Not LB	2050	TBC		
	Bhutan	Not LB	Achieved	GHGs		
	Fiji	Not LB	2050	CO ₂		
	Iceland	Not LB	2040	TBC		
Marshall Islands	Not LB	2050	GHGs			
Uruguay	Not LB	2030	TBC			
Portugal	Not LB	2050	GHGs			

^{xiv} Stakeholders use varying definitions for zero emission targets. ‘Net-zero CO₂ emissions’ or ‘carbon neutrality’ refers only to CO₂. ‘Net-zero greenhouse gas emissions’ refers to all greenhouse gases. Climate neutrality can also include other climate forcers such as black carbon.

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
Implement ambitious comprehensive CO₂ pricing in all sectors by year x^{xv}	<p><i>No country has implemented ambitious comprehensive CO₂ pricing in all sectors</i></p> <p><i>Examples of intermediate action: 25 countries have implemented or planned a carbon tax (plus 3 countries that are considering doing so) and seven countries plus EU28 have implemented or planned an Emissions Trading System (plus 8 countries that are considering doing so), according to the World Bank's Carbon Dashboard²⁶</i></p>	<p>Regions: None identified Cities: None identified Businesses: None identified Investors: None identified</p> <p><i>Examples of intermediate action: 4 Canadian States implemented a carbon tax and a tax is currently being considered by Catalonia and the Northwest Territory; 21 regions in Canada, China, Japan and the United States implemented an Emissions Trading System and 8 regions in Brazil, Canada, the United States and Taiwan are considering implementing an Emissions Trading System, according to the World Bank's Carbon Dashboard²⁷</i></p>	<p>No G20 members have ambitious comprehensive CO₂ pricing in all sectors</p> <p>7 G20 members (Argentina, Canada, France, Japan, Mexico, South Africa, United Kingdom) have implemented some form of carbon tax</p> <p>3 G20 members (Australia, Canada, EU28) have implemented some form of Emissions Trading System, with 5 G20 members (China, Indonesia, Japan, Mexico, Turkey) considering doing so</p>
Phase out all fossil-fuel subsidies by year x	<p><i>No country has reform plans to fully phase out all subsidies by a specific year</i></p> <p>Decision by G20 in 2009 to gradually phase out fossil-fuel subsidies, including an annual peer review among G20 members²⁸</p> <ul style="list-style-type: none"> • G20 members progressing on consumption-related support measures as of 2018 are Argentina, India, Indonesia and Mexico • G20 members progressing on production-related support measures as of 2018 are Argentina, Canada, China, the EU28 and the United Kingdom 	<p>Regions: None identified Cities: None identified Businesses: None identified Investors: None identified</p>	<p>No G20 members have existing reform plans to fully phase out all fossil-fuel subsidies</p>

^{xv} The Report of the High-Level Commission on Carbon Prices of 2018 recommends an average economy-wide price of at least US\$40–80/tCO₂ by 2020 and US\$50–100/tCO₂ by 2030 to close the emissions gap in order to meet the 2°C target (High-Level Commission on Carbon Prices, 2017; UNEP, 2018) technology, and equipment—needed to deliver on the temperature objective of the Paris Agreement, in a way that fosters economic growth and development, as expressed in the Sustainable Development Goals (SDGs). For this reason, economy-wide carbon prices would need to be higher in the respective years to close the emissions gap in order to meet the Paris Agreement's temperature goal of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
Make all finance flows consistent with the Paris Agreement goals by year x	<p><i>No country has made all finance flows consistent with the Paris Agreement goals</i></p> <p><i>Examples of intermediate action: United Kingdom (Green Finance Strategy of 2019)²⁹</i></p>	<p>Regions: None identified Cities: None identified Businesses: None identified Investors: French Development Agency (AFD) (since 2017)³⁰, the Netherlands Development Finance Company (FMO) (2016)^{31 32}, Multilateral Development Banks (MDBs) (approach to be developed by 12/2019)³³</p>	No G20 members have finance flows fully aligned with the Paris Agreement goals
Electricity production			
<p>Reach 100 per cent renewable electricity or 100 per cent carbon-free electricity by year x</p> <p><i>Overview by the International Renewable Energy Agency (IRENA) (2019)³⁴, REN21 (2019)³⁵, and Go100%Renewable (2019)³⁶</i></p>	<p>Austria (2030)³⁷, Sweden (2040)³⁸, Cape Verde (2025)³⁹, Costa Rica (2030)⁴⁰, Fiji (2030)⁴¹, Iceland (achieved)⁴², the Solomon Islands (2030)⁴³, Tuvalu (2020)⁴⁴, Papua New Guinea (2030)⁴⁵ Samoa (2021)⁴⁶</p> <p><i>Example(s) of other intermediate action: 53 countries have further pledged to achieve some sort of 100 per cent renewable energy target with differences/little clarity on the scope and legal durability⁴⁷, including the Climate Vulnerable Forum (CVF) comprising 48 developing countries⁴⁸</i></p>	<p>Regions: California (2045), Hawaii (2045), Rhineland-Palatinate (2030), South Australia (2025), Cook Islands (2020), El Hierro (not defined), New Mexico (2050)⁴⁹, Nevada (2050)⁵⁰, Washington State (2045)⁵¹, New York (2050)⁵², Puerto Rico (2035)⁵³, Washington, D.C. (2032)⁵⁴, Maine (2050)⁵⁵, Burgenland (2020)⁵⁶, Upper Austria (2030)⁵⁷, Lower Austria (achieved)⁵⁸, Schleswig-Holstein (achieved)⁵⁹, Mecklenburg-Vorpommern (achieved)⁶⁰, Hessen (2050)⁶¹, Fukushima (2040)⁶², Sumba (2025)⁶³, Scotland (2020)⁶⁴</p> <p>Cities: Sydney (2030)⁶⁵, Canberra (2020)⁶⁶, Vancouver (2050)⁶⁷, Victoria (2050)⁶⁸, Malmo (2020)⁶⁹, 122 United States cities have committed to 100 per cent renewable energy⁷⁰ including San Francisco (2030), Portland (2035) and Los Angeles (2045)⁷¹</p> <p>Businesses: 180 companies “to go 100 per cent renewable” as part of the RE100 initiative⁷²</p> <p>Investors: None identified</p>	No G20 members have a 100 per cent renewable electricity or a 100 per cent carbon-free electricity target

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
Phase out coal-fired power plants by year x with a just transition plan ^{xvi}	Finland (2029), Austria (2020), Chile (2040), Denmark (2030), France (2021), Ireland (2025), Italy (2025), the Netherlands (2030) ^{xvii 73} , Portugal (2030), Sweden (2022), Canada (2030) ⁷⁴ , United Kingdom (2025, under consideration) ⁷⁵ , Germany (2038, under consideration) ⁷⁶	Regions: Australian Capital Territory, Alberta, British Columbia, Balearic Islands, California, South Chungcheong Province, Connecticut, Hawaii, Minnesota, New York, Ontario, Oregon, Quebec, Scotland, Wales, State of Washington (all part of the Powering Past Coal Alliance) ⁷⁷ Cities: Honolulu, Melbourne, Los Angeles, Rotterdam, Sydney, Vancouver (all part of the Powering Past Coal Alliance ⁷⁸) Businesses: 28 businesses in the Powering Past Coal Alliance ⁷⁹ Investors: None identified	3 G20 members (France, Canada, Italy) have passed legislation 2 G20 members (Germany, the United Kingdom) are currently in the process of passing legislation 15 G20 members have no binding phase-out plan
Stop financing and insuring coal-fired power plants elsewhere as of year x	No country has legally binding legislation to fully stop financing and insuring coal-fired power plants elsewhere	Regions: None identified Cities: None identified Businesses: None identified Investors: DBS Group Holdings Ltd. ⁸⁰ ; Oversea-Chinese Banking Corp. ⁸¹ ; Standard Chartered ⁸² ; Commonwealth Bank by 2030 ⁸³ ; National Bank for Economic and Social Development (BNDES) ⁸⁴ ; 22 banks stopped directly financing new coal mine projects worldwide and 23 banks stopped directly financing new coal plant projects worldwide ⁸⁵	No G20 members have legally binding legislation to fully stop financing and insuring coal-fired power plants elsewhere
Other energy industry			
Stop new fossil-fuel explorations and production as of year x	Ireland (2018 – oil and gas) ⁸⁶ , Denmark (2018 – oil and gas) ⁸⁷ , New Zealand (2018 – offshore oil and gas) ⁸⁸ , Belize (2017 – oil) ⁸⁹ , Costa Rica (2014–2021 – petroleum) ⁹⁰ , France (2040 – oil & gas) ⁹¹ <i>Example(s) of other intermediate action: The Netherlands (2030 – Groningen gas field)⁹², United States (TBC – Arctic oil and gas exploration), Canada (TBC – Arctic oil and gas exploration)⁹³</i>	Regions: None identified Cities: None identified Businesses: None identified Investors: AXA and Swiss Reinsurance Company Ltd. (stop insuring/underwriting oil pipelines, shale gas, tar sands and Arctic drilling), ADB, The African Development Bank Group (AfDB), World Bank Group ⁹⁴	1 G20 member (France) has passed legislation 19 G20 members have no binding commitments to stop new fossil-fuel explorations and production

^{xvi} Uncertainty remains as to whether all phase-out plans in the countries and regions mentioned are paired with a transition plan.
^{xvii} The Netherlands will ban co-firing in power plants but has left the door open for them to shift to other fuels.

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
Commit to zero fugitive emissions target for year x	<p><i>No country has committed to a zero fugitive emissions target</i></p> <p><i>Example(s) of other intermediate action: Canada (40-50 per cent by 2025)⁹⁵, 32 governments endorse the World Bank's Zero Routine Flaring by 2030 initiative⁹⁶</i></p>	<p>Regions: None identified Cities: None identified Businesses: Qatar Petroleum (under consideration)⁹⁷, 13 Oil and Gas Climate Initiative (OGCI) companies have a target of reducing methane intensity in up-stream gas and oil operations to below 0.25 per cent by 2025, with the ambition to reach 0.20 per cent⁹⁸ Investors: None identified</p>	No G20 members have a zero fugitive emissions target
Industry			
Ensure all new installations are low- carbon/ zero-emission and maximize material efficiency as of year x	<p><i>No country has legally binding legislation to phase-in low-carbon/ zero-emissions industrial technologies</i></p>	<p>Regions: None identified Cities: None identified Businesses: ThyssenKrupp (hydrogen-based steelmaking by 2050)⁹⁹, SSAB (fossil-free steelmaking by 2045)¹⁰⁰, Heidelberg (carbon-neutral concrete by 2050)¹⁰¹ Investors: None identified</p>	No G20 members have a target for all new installations to be low-carbon/zero emissions
Implement ambitious carbon pricing for industry by year x^{xviii}	<p>Sweden (€ 114 per tCO₂, industry outside the EU Emissions Trading System)¹⁰²</p> <p><i>Example(s) of other intermediate action: EU Emissions Trading System for selected industry sectors (€ 26–29 per tCO₂)</i></p>	<p>Regions: None identified Cities: None identified Businesses: None identified Investors: None identified</p>	No G20 members have implemented ambitious carbon pricing for the industry sector
Transport			
Shift to x per cent public transport by year x	<p>China (30 per cent by 2020, in large- and medium-sized cities)¹⁰³, India (45 per cent with no target year defined, share of railways in total land transport)¹⁰⁴, Indonesia (32 per cent in 2019)¹⁰⁵, Singapore (75 per cent in 2030)¹⁰⁶</p>	<p>Regions: None identified Cities: Copenhagen (75 per cent by 2025 by foot, bike or on public transit)¹⁰⁷, San Francisco (58 per cent by 2019)¹⁰⁸, New York (80 per cent by 2050, by foot, bike or on public transit)¹⁰⁹, London (80 per cent by 2041, by foot, bike or on public transit)¹¹⁰, Kuala Lumpur (40 per cent by 2030)¹¹¹, several European cities Businesses: None identified Investors: None identified</p>	<p>3 G20 members (China, India, Indonesia) have varying modal shift targets</p> <p>No conclusion possible for any other G20 member</p>

^{xviii} The Report of the High-Level Commission on Carbon Prices of 2018 recommends an average economy-wide price of at least US \$40–80/tCO₂ by 2020 and US\$ 50–100/tCO₂ by 2030 to close the emissions gap in order to meet the 2°C target (High-Level Commission on Carbon Prices, 2017; UNEP, 2018) technology, and equipment—needed to deliver on the temperature objective of the Paris Agreement, in a way that fosters economic growth and development, as expressed in the Sustainable Development Goals (SDGs). For this reason, economy-wide carbon prices would need to be higher in the respective years to close the emissions gap in order to meet the Paris Agreement's temperature goal of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
<p>Shift to 100 per cent share of new zero-emission motorbikes, cars and/or buses as of year x</p> <p><i>Extensive overview for countries, regions, cities and companies carried out by the Partnership on Sustainable, Low Carbon Transport (May 2019)¹¹²</i></p>	<p>2025 India (two-wheelers by 2023, TBC), Norway (cars)</p> <p>2030 Denmark (cars), Iceland (cars), India (cars, TBC), Ireland (cars), Israel (cars), Nepal (cars, TBC), Netherlands (cars), Scotland (cars by 2032), Slovenia (cars, TBC), Sweden (cars)</p> <p>2040 Canada (cars), France (cars), Indonesia (cars, TBC), Portugal (cars, TBC), Spain (cars, TBC), United Kingdom (cars)¹²²</p> <p>2050 Costa Rica (cars and buses), Japan (cars), Mexico (cars)</p>	<p>Regions: California (cars by 2040, buses by 2029)¹¹³, Hainan (cars by 2030), British Columbia (cars and trucks by 2040), Hawaii (cars and bus fleets by 2045), Australian Capital Territory (public fleet by 2021)</p> <p>Cities: Seoul (car fleet by 2027, but including compressed natural gas vehicles [CNG]), Bangalore (bus fleet by 2023), Rotterdam (bus fleet by 2029), Medellin (buses, TBC), Paris (cars and buses by 2025), Rome (cars by 2024), London (buses by 2025), Los Angeles (car fleet by 2050); 30 Chinese cities, including Guangzhou, Zhuhai, Dongguan, Foshan, Zhongshan, Nanjing, Hangzhou, Shaanxi and Shandong (bus and taxi fleet by 2022)¹¹⁴, Rio de Janeiro (public bus fleet by 2025)¹¹⁵, 13 European cities will ban all internal combustion cars by 2030¹¹⁶; Shenzen (bus and taxis, achieved)¹¹⁷</p> <p>Businesses: 49 companies as part of the EV100 initiative¹¹⁸, Volvo (50 per cent electric cars by 2025 and 100 per cent of all models available to be electric by 2019)¹¹⁹, Volkswagen (15 million cars by 2025)¹²⁰, Jaguar (all models available by 2020)¹²¹</p> <p>Investors: None identified</p>	<p>5 G20 members (Canada, France, Japan, Mexico, United Kingdom) announced targets</p> <p>2 G20 members (India, Indonesia) have announced a phase-in but it is pending confirmation</p> <p>13 G20 members have not announced a phase-in of new zero-emission motorbikes, cars and/or buses</p>
<p>Shift to 100 per cent carbon-free heavy goods transport and ships as of year x</p>	<p><i>No country has a legally binding target for 100 per cent carbon-free heavy goods transport and ships</i></p>	<p>Regions: None identified</p> <p>Cities: None identified</p> <p>Businesses: A.P. Moller-Maersk (net-zero carbon emissions by 2030 and carbon-neutral vessels by 2030)¹²³, Nippon Yusen (NYK) and Elomatic (concept for carbon-free ships by 2050)¹²⁴, e5 Lab Inc. (first zero-emission tanker by 2021)¹²⁵, 7 port authorities announced World Ports Climate Action Program to keep global warming well below 2°C¹²⁶</p> <p>Investors: None identified</p>	<p>No G20 members have a legally binding target for 100 per cent carbon-free heavy goods transport and ships</p>

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
Shift to 100 per cent carbon-free aviation as of year x	<p><i>No country has a legally binding target for 100 per cent carbon-free aviation</i></p> <p><i>Example(s) of other intermediate action: Norway (2040, short-haul flights)¹²⁷, Scotland (net-zero domestic aviation region by 2040 with trials of low/zero-emission flights beginning in 2021)¹²⁸</i></p>	<p>Regions: None identified Cities: None identified Businesses: None identified Investors: None identified</p>	<p>No G20 member has a legally binding target for 100 per cent carbon-free aviation</p>
Buildings			
Shift to 100 per cent (near-) zero energy buildings for new buildings as of year x	<p>EU28 (public by 2019, all by 2021), Japan (public by 2020, all by 2030), United States (public by 2030)</p> <p><i>Extensive overview for countries, regions, and cities by the International Partnership for Energy Efficiency Cooperation (IPEEC) (2018)¹²⁹</i></p>	<p>Regions: California (residential by 2020, commercial by 2030)¹³⁰, 6 regions have signed the Net Zero Carbon Buildings Commitment (by 2050)¹³¹ Cities: 23 cities have signed the Net Zero Carbon Buildings Commitment (by 2050)¹³² Businesses: 23 businesses have signed the Net Zero Carbon Buildings Commitment (by 2050)¹³³ Investors: None identified</p>	<p>6 G20 members (the EU28, including France, Germany, Italy and the United Kingdom as part of the EU28) have passed legislation</p> <p>14 G20 members have not passed legislation</p>
Fully decarbonize the building sector by year x	<p>EU28 (2050)</p>	<p>Regions: 6 regions have signed the Net Zero Carbon Buildings Commitment (by 2050)¹³⁴ Cities: Coalition of European cities, including Madrid, Wroclaw, Leeds, Dublin, Velika Gorica, Budaors, Padua, and Eskisehir (2050)^{135 136}; 23 cities signed the Net Zero Carbon Buildings Commitment (by 2050)¹³⁷ Businesses: 23 businesses have signed the Net Zero Carbon Buildings Commitment by 2050¹³⁸ Investors: None identified</p>	<p>5 G20 members (the EU28, including France, Germany, Italy and the United Kingdom as part of the EU28) have passed legislation</p> <p>15 G20 members have not passed legislation</p>
Phase out fossil fuels (for example, gas) for residential heating by year x	<p>Netherlands (2050)¹³⁹</p> <p><i>Example(s) of other intermediate action: United Kingdom (no connection to the gas grid by 2025, TBC)¹⁴⁰</i></p>	<p>Regions: None identified Cities: Amsterdam (2050)¹⁴¹, Vancouver (2050)¹⁴², Berkeley (n/a)¹⁴³ Businesses: None identified Investors: None identified</p>	<p>No G20 members have a legally binding target to phase out gas for residential heating</p>
Increase the rate of zero-energy renovations to x per cent per year	<p><i>No country has a legally binding target for the rate of zero-energy renovation across all buildings</i></p> <p><i>Example(s) of other intermediate action: EU28 (3 per cent, public buildings)¹⁴⁴</i></p>	<p>Regions: None identified Cities: None identified Businesses: None identified Investors: None identified</p>	<p>No G20 members have a legally binding target for the rate of zero-energy renovation</p>

Possible targets	National governments	Cities, regions, businesses, investors (examples, not comprehensive)	Status of G20 members
Agriculture and forestry			
Zero net deforestation by year x	<p>50 countries endorsed the New York Declaration on Forests (2030)¹⁴⁵</p> <p>67 countries pledged support for The World Wide Fund for Nature (WWF)'s call for zero net deforestation by 2020¹⁴⁶</p>	<p>Regions: 21 regions endorsed the New York Declaration on Forests (2030)¹⁴⁷ Cities: None identified</p> <p>Businesses: >50 businesses endorsed the New York Declaration on Forests (2030)¹⁴⁸; Consumer Goods Forum (some 400 c stakeholders) pledged to achieve zero net deforestation by 2020¹⁴⁹</p> <p>Investors: >12 banks have signed the 'Soft Commodities' Compact as part of the Banking Environment Initiative to achieve zero net deforestation across the four commodities of soy, palm oil, beef, paper, pulp and timber (PP&T)¹⁵⁰</p>	<p>12 G20 members (Canada, Germany, the European Union, France, Italy, Indonesia, Japan, Mexico, South Korea, Turkey, the United States, the United Kingdom) have signed the New York Declaration on Forests</p> <p>12 G20 members (Australia, Brazil, the European Union, France, Germany, India, Indonesia, Italy, Japan, Mexico, South Africa, the United Kingdom) pledged their support for WWF's call for zero net deforestation by 2020</p> <p>5 G20 members have no such commitments</p>

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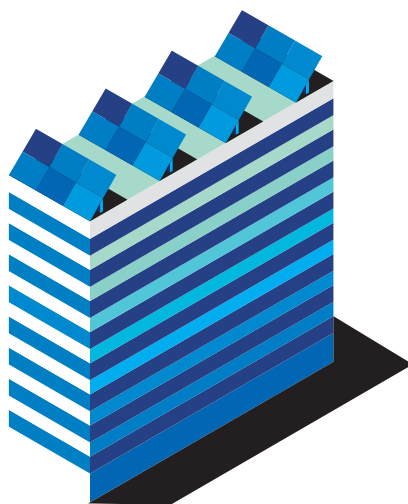
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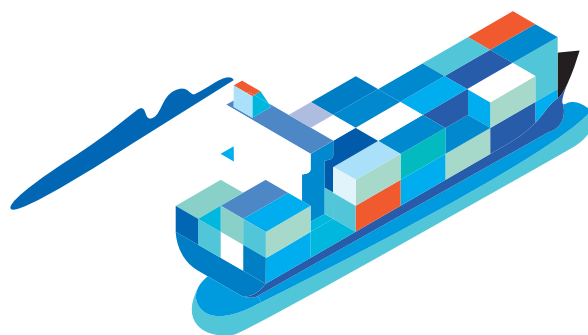
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