

Annex C - UNEP Emissions Gap Report 2019

Recent policy changes in selected G20 members

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 ○ or negative ↓.

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 1: Possible actions to increase mitigation ambition in Argentina

Sector	Possible actions to increase mitigation ambition
Argentina	
<i>Energy supply</i>	<ul style="list-style-type: none"> • Refrain from extracting new, alternative fossil-fuel resources* • Reallocate fossil-fuel subsidies to support distributed renewable electricity -generation*
<i>Industry</i>	<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
<i>Transport</i>	<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
<i>Buildings</i>	<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*
<i>Agriculture and forestry</i>	<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 Annex B, table B-1 as clearly ambitious.

1.1 Energy supply

Recent policy 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 MtCO₂e 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 (CMMESA 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).

1.2 Industry

Recent policy 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 so- 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).

1.3 Transport

Recent policy 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 MtCO₂e 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.

1.4 Buildings

Recent policy 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.

1.5 Agriculture and forestry

Recent policy 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.

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 illegal¹ 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 (2018, 2015) 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 2: Possible actions to increase mitigation ambition in Brazil

Sector	Possible actions to increase mitigation ambition
Brazil	
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 Annex B, table B-1 as clearly ambitious.

¹ The National Institute for Space Research (INPE) does not have the capacity to determine the total amount of illegal deforestation. The MapBiomias Alerta platform (<http://alerta.mapbiomas.org/>) – developed by a group of NGOs and universities – was recently launched to answer this question, among others.

2.1 Energy supply

Recent policy 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 2017.²

↓ 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).

2.2 Industry

Recent policy 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.

2.3 Transport

Recent policy 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

² 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, 2018b), a higher share of natural gas power plants was projected to back-up the power system.

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, n.d.).

↑ 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 Itaqui (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).

2.4 Buildings

Recent change

↑ 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.

2.5 Agriculture and forestry

Recent change

↑ 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 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 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 Mt CO₂e 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 3: Possible actions to increase mitigation ambition in China

Sector	Proposed actions to increase mitigation ambition
China	
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 into 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 Annex B, table B-1 as clearly ambitious.

3.1 Energy supply

Recent policy 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.

3.2 Industry

Recent policy 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 (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 (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 Transport

Recent policy 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 5,767km, 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.

3.4 Buildings

Recent change

↑ By 2018, more provinces upgraded their building energy-efficiency standards from 65 per cent to 75 per cent³. 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.

3.5 Agriculture and forestry

Recent change

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

³ 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.

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).

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.

Table 4: Possible actions to increase mitigation ambition in the EU

Sector	Possible actions to increase mitigation ambition
European Union	
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 Annex B, table B-1 as clearly ambitious.

4.1 Energy supply

Recent policy 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, a multi-stakeholder commission has developed a proposal to phase out coal in the country that has not yet been incorporated into national law, whereas 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 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 effected 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.

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.

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).

4.4 Buildings

Recent change

↑ 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).

4.5 Agriculture and forestry

Recent change

↑ 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.

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 5. Possible actions to increase mitigation ambition in India

Sector	Possible actions to increase mitigation ambition
India	
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 Annex B, table B-1 as clearly ambitious.

5.1 Energy supply

Recent policy 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 PM2.5 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 powerplants 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 Bhavirkar 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.

5.2 Industry

Recent policy 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.

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 MtCO₂e 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 MtCO₂e 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.

5.4 Buildings

Recent change

↑ 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 MTCO₂e 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 MtCO₂e per annum. A similar but limited programme has distributed 2.06 million energy-efficient fans, reducing emissions by 0.1 MtCO₂e 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 et al., 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.

5.5 Agriculture and forestry

Recent change

↑ 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 (N. K. 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.

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).

Table 6. Possible actions to increase mitigation ambition in Japan

Sector	Possible actions to increase mitigation ambition
Japan	
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"> • Strengthen policy measures on the demand side to promote the use of wood products and ensure sustainable forest management in the forest industry • Support the creation of new schemes to utilize rice straw for new materials such as cellulose nanofibers

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

6.1 Energy supply

Recent policy 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 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 (IPCC 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).

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.

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.

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.

6.5 Agriculture and forestry

Recent change

↑ 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.

7 Mexico

Mexico is not in the track to comply with its NDC's goals. Policies implemented will be not enough to reduce 22% GHG by the year 2030 with respect to the baseline, a goal that is planned to be achieved with the country's own resources (CAT, 2019). Consequently, Mexico is also far to reduce 36% GHG by the year 2030 with respect to the baseline, the more ambitious NDC goal, which is conditioned to external funding and the transfer of clean technologies. For instance, the Mexican government reported in the Sixth National Communication on Climate Change to the UNFCCC (SEMARNAT and INECC, 2019) that the cumulative emissions mitigated for the period 2013-2017 totalled 70.2 MtCO_{2e} with respect of the 2013 baseline, a mitigation effort that is below what is needed to comply with its NDC and its long-term mitigation goal (-50% below 2000 emissions, established in the Mexican legal framework) (Montalvo *et al.*, 2019).

To set the country's emissions on a pathway to meet the unconditional NDC, Mexico must reduce the annual growth of its total emissions from an average rate of 0.86% during 2010-2015 (INECC, 2018), to 0.79% for the conditional goal and up to 0.55% annual growth rate by 2030 (Montalvo et al., 2019). The energy sector remains as the largest opportunity to reduce emissions in the short and long term, due to the contribution of emissions from vehicle transportation (22.8%) and electricity generation (20.3%) (INECC, 2018).

The efforts to decarbonize the electricity matrix has been reconfirmed by the federal government by slightly increasing Mexico's clean energy generation goal by 2024 up to 35.8% in its National Development Plan 2019-2024 (SENER, 2019). Some studies agree with the potential to reduce GHG emissions by increasing the deployment of renewable energy, among other policies, that could drive a faster decarbonized energy system (ClimateWorks, 2016) and therefore, reach the NDC's goals (Montalvo et al., 2019). In addition, other analysis show that there must be clearer and more ambitious policy decisions to increase renewable energy generation, capable to overcome the tensions between the fossil-fuel based energy agenda and the climate action stated in policy instruments by the Mexican government (ICM et al., 2018). The Ministry of Environment aims elaborate and launch in 2019 a revised National Strategy for Climate Change, which is intended to retake the Mid-Century Strategy's commitments, as well as provide the outlook for the Special Program for Climate Change (2020-2024), which describes the climate action to be taken by the federal government.

Table 7. Possible action to increase mitigation action in Mexico

Sector	Proposed actions to increase mitigation ambition
Mexico	
Energy supply	<ul style="list-style-type: none"> • Increase the clean energy power generation in the electricity mix up to 48% by 2027, 53% by 2030 and 60% by 2050. This requires the reactivation of the electricity market, expand the power interconnection grid infrastructure* • Develop PV distributed generation up to 20 GW • Phase out coal-based generation by 2030*
Industry	<ul style="list-style-type: none"> • Reduce 25% in methane leaks, venting and controlled combustion • Reduce fuel consumption in industry sector through cogeneration and improved heat conservation technologies
Transport	<ul style="list-style-type: none"> • Increase the deployment of electric vehicles by 2030 • Have stringent fuel efficiency standards for light and heavy-duty vehicles in place by 2020 • Expand sustainable massive public transport and non-motorized options, as well as a transportation demand management policy to reduce the motorization rate*
Buildings	<ul style="list-style-type: none"> • Implement stringent energy efficiency standards for sustainable construction in buildings • Increase the use of residential use of solar panels, heaters, and cooling technologies
Agriculture & forestry	<ul style="list-style-type: none"> • Reach the 0% deforestation rate target by 2030* • Improve forestry, guarantee the sustainable technification of agriculture and livestock farms, and increase the recuperation of grasslands.

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

7.1 Economy-wide

Recent policy changes

↑ The **Green Finance Unit** (April 2019) was created within the Ministry of Treasury (SHCP), with the aim to enable the conditions to foster decarbonized public investment and improve in-house capacities to deliver climate finance.

↑ The **Reform to the General Law on Climate Change (LGCC)** (April 2018): Addition of NDC GHG emission reduction targets including sectoral targets for a long-term mitigation pathway. This reform also recognizes the Paris Agreement goals as the overall aim for the national climate policy.

↑ The **Emissions Trading Scheme (2019)** is a national emissions trading scheme that will start the three-year pilot phase in 2020, the rules for its operation have been published by the Mexican Secretary of Environment. The regulatory framework for the ETS is expected to be fully operational by 2023.

Areas of possible additional actions

Possible action: Revise the **carbon tax** scheme to increase its scope and add gas or turbosine (for national consumption) to it. This would lead to an increase of GHG reduction and to provide additional income to support decarbonized public investments. It is also important to revise the carbon tax to guarantee its alignment with the upcoming implementation of the national emissions trading scheme.

Possible action: Support enhanced climate action at **subnational level**. Medium and large-sized cities are responsible to reduce emissions through local climate actions in urban development, transport, waste management and energy demand sectors. Improve local governments' capabilities on fiscal, financial, economy and policy mechanisms to enhance climate actions is crucial to reduce the gap of the GHG mitigation of federal competence and what is needed to comply with the NDCs.

Possible action: Strengthen the **transparency framework** for climate-based decision making by improving the MRV system to: i) follow up the mitigation action, ii) provide certainty to the emissions trading scheme and iii) provide certainty to the climate finance investments.

7.2 Energy supply

Recent policy changes

↓ The **National Electricity Outlook 2019-2033** (June 2019): The Ministry of Energy presented the electricity outlook which describes the main drivers for the power sector for the upcoming 15 years. The outlook limits a deeper deployment of renewable energy beyond the 35.8% by 2024 by increasing fuel oil, coal and gas generation, reducing wind power and not increasing solar power growth rates (ICM, 2019). Furthermore, the Ministry has cancelled the long-term power auctions and the transmission lines to evacuate renewable energy. Planning with less renewable energy in the future makes it more difficult for the government to meet its NDC goals as this means that other sectors would have to reduce emissions more. .

↓ The **National Development Plan (June 2019)**: Despite the recognition of the importance to reduce GHG emissions and increase renewable energy deployment, the energy supply policy in this plan adds a new additional refinery with the aim to increase gasoline, diesel and fuel oil production.

↑ The **Energy Transition Law** (December 2015) provides a framework for clean energy, energy efficiency and greenhouse gas emissions reductions, and sets targets for clean energy of 25 % in 2018, 30 % in 2021 and 35 % by 2024, which is supported by policy instruments, such as power auctions for wind and solar energy.

Areas of possible additional actions

Possible action: Set new and ambitious **clean energy generation goals** beyond 2024 to close the gap between the GHG baseline and the mitigation action required to comply with the conditional NDC goal. This implies to scale up to 48% by 2027, 53% by 2030 and 60% by 2050, the clean energy power generation goals. To increase the deployment of clean energy, it would be also needed for the country to retake the electricity market and expand the power interconnection grid infrastructure.

Possible action: Develop **solar PV distributed generation** up to 20 GW by 2030 to increase its penetration in the power mix up to 15%. Households, as well as small and medium commercial buildings, are the main target for the distributed generation increased deployment. Economic, fiscal and social co-benefits are associated with an increased distributed generation.

Possible action: **Coal phase out** by 2030. Commit the early retirement of coal-based power plants. It will result in reduced electricity generation from coal from 4.7 GW (BAU) to 0%.

7.3 Industry

Recent policy changes

↑ The **energy efficiency** of industrial-sector processes has been improved by optimizing inputs and by making use of waste from other sectors as raw material. Regulatory instruments have also been designed for the residential and business sector to achieve efficient energy use by applying more efficient technologies and renewable energy sources.

Areas of possible additional actions

Possible action: **Reduce methane emissions** into the atmosphere through capture and better containment in the oil and gas sector. The aim is to reduce 25% in methane leaks, venting and controlled combustion.

Possible action: **Reduce fuel consumption** in industry sector through cogeneration and improved heat conservation technologies.

7.4 Transport

Recent policy changes

↑ A **draft CO₂ Emission Standard for new light vehicles** (2019) was published for public consultation with the aim to reduce emissions for light vehicles within the next 15 years through improving the fuel consumption efficiency. Finalisation is pending.

↑ **Stringent air quality policies** (2019) at the local level have fostered GHG emissions policies. For example, Mexico City's policies to tackle bad air quality and reduce health impacts, have provided a

window of opportunity to increase ambition in transport mitigation actions. This case has been replied in other large-sized cities.

↑ **National Strategy for Electromobility (2019)** was drafted by the Ministry of Environment. This policy provides with the guidelines and incentives to increase the deployment of electric and hybrid vehicles at mass scale, as well as to increase the participation of electric vehicles for public transportation.

Areas of possible additional actions

Possible action: Increase the deployment of electric vehicles by 2030 and have stringent fuel efficiency standards for light and heavy duty vehicles in place by 2020. Expand sustainable massive public transport and non-motorized options, as well as a transportation demand management policies to reduce the motorization rate.

7.5 Buildings

Recent policy changes

(No major policy changes were carried out)

Areas of possible additional actions

Possible action: Implement stringent energy efficiency standards for sustainable construction in buildings, increase the use of residential use of solar panels, heaters, and cooling technologies.

7.6 Agriculture and Forestry

Recent policy changes

↑ The **“Seeding Life” Program (2019)** is a federal policy which aims to support rural stakeholders by providing them with fiscal and economic incentives to increase agroforest production while improving forest conservation.

↑ The **REDD+ National Strategy (2017)** seeks to achieve a continued reduction of LULUCF emissions and net zero deforestation by 2030.

↑ The **General Law for Sustainable Forest Development (April 2018)** replaces the 2003 general law for sustainable forest development. The new law includes the recognition of community forest management initiatives, the consolidation of social and environmental safeguards, the promotion of sustainable forest management, the assurance that the government purchases forest products with proper licensure, the integrated management of fire, and the assurance of the inclusion of women and young people in forestry activities.

Areas of possible additional actions

Possible action: Reach the 0% deforestation rate target by 2030, improve forestry, guarantee the sustainable technification of agriculture and livestock farms, and increase the recuperation of grasslands.

8 South Africa

South Africa's climate change mitigation policy framework is contained in the National Climate Change Response White Paper (NCCRWP) (Government of South Africa, 2011), which defines a "benchmark emissions trajectory range" or "peak, plateau, and decline" (PPD) trajectory as South Africa's long-term emissions goal. This long-term emissions range targets a peak in greenhouse gas emissions in 2025 (between 398 and 614 Mt CO₂eq), a decade-long plateau, and then a decline to 2050 (a minimum level of 212 Mt CO₂eq and maximum of 428 Mt CO₂eq). The PPD range forms the basis for South Africa's emissions target range for 2025 and 2030 as contained in its current NDC.

The PPD was established as the long-term national trajectory in 2011, as a reduction relative to a rapidly growing emissions baseline. But this was prior to many of the cost reductions in low-carbon technology seen over the last decade (Burton et al., 2019), and current emissions projections are very different (EScience Associates (Pty) Ltd. and Energy Research Centre, 2018; Mccall et al., 2019; Wright et al., 2018). It is now possible for South Africa to achieve at least the upper range of the NDC purely through investment in renewable energy in the electricity sector (which is now cheaper than fossil fuel and nuclear power) and the currently planned retirement of coal infrastructure, especially large coal-fired power plants. For example, new renewables were at least 40% cheaper than new coal plants already in 2015, the last time a competitive auction was held (Creamer and Bischof-Niemz, 2018). South Africa can achieve between 80 and 90% renewable energy in the electricity sector by 2050 at lower cost than other options (Mccall et al., 2019). The rapid techno-economic shifts which have taken place mean that meeting emissions reduction targets is far less costly than it was a decade ago, and investments made purely on the basis of cost (either through a market mechanism or through least-cost planning) would result in South Africa meeting the upper target of its emissions commitments without additional effort. Additional effort is, however, required to meet the lower range of the NDC and PPD, and additional effort will be similarly required in the long term if South Africa is to make a fair and ambitious contribution to the temperature goals laid out in the Paris Agreement.

Currently, South Africa is making progress on economy-wide tools to limit emissions, through the introduction of the long-awaited Carbon Tax Act, and through the Climate Change Bill, currently undergoing national consultations.

The Carbon Tax Act came into force in June 2019, and covers all sectors of the economy except agriculture, waste and the land sector. The tax will cover large emitters, and liquid fuels supply, and will impose a headline rate of R120/ton CO₂-eq, increasing at inflation plus 2% up until 2022 (approximately \$8/ton). However, all emitters will receive a tax-free allowance of 60% of this rate, and further allowances are available for process and fugitive emissions, trade-exposure, and efficiency performance compared to a sectoral benchmark. Finally, all firms can offset up to 10% of their emissions. In total, a maximum allowance may not exceed 95%. This implies an effective tax rate of between R6-R48/ton (\$0,4-3,2/ton). The level of the tax is adjustable after the end of phase 1 in 2022 and may be adjusted upwards (RSA, Act No. 15 of 2019).

The Climate Change Bill was published for public comment in June 2018, and is expected to become law by the end of 2019. The Bill provides for an integrated approach to climate policy and its implementation across government through the development of a “national environmentally sustainable development framework” to be revised every five years, to co-ordinate climate action across government departments and between different spheres of government; and establishes a Ministerial Committee on Climate Change, as well as Provincial Committees on Climate Change, to facilitate this co-ordination. The Act obliges the Minister to develop and regularly update a National Adaptation Strategy, in consultation with provinces and cities. The Act also specifies a framework for mitigation action. This consists three elements: (1) a "national greenhouse gas emissions reduction objective”, defined by the Minister in consultation with the Ministerial Committee, which specifies a long-term greenhouse gas emissions trajectory for the country as a whole, which is binding on “all organs of state in all spheres of government”; (2) Sectoral Emissions Targets (SETs) consistent with the national GHG emissions reduction objective, decided by the Minister in consultation with the Ministerial Committee - the Minister responsible for each SET will then draft a Sectoral Emissions Reduction Plan to implement SETs; and (3) for large emitters, the Act empowers the Minister to allocate binding carbon budgets to each emitter for three periods of five years, to be updated every five years. The Act also provides for the regulation of and phasing out of the use of synthetic greenhouse gases.

Thus the mitigation policy frameworks required for enhanced action are in progress. There is furthermore significant opportunity for transition in the power sector, not only because renewable energy is already substantially cheaper than coal, but also because there have been electricity supply interruptions over the past 15 years as state-owned utility Eskom struggles to manage an aging coal fleet and the under construction Medupi and Kusile coal plants are facing significant operational issues. Many years of below cost tariffs, cost and time overruns at the new coal plants, and corruption, have also led Eskom to an operational and financial crisis, with the utility declaring a multi-billion Rand loss this financial year. Government guaranteed debt for Eskom is now around 18% of the national budget, and the utility is considered the largest threat to the South African economy by Moody’s, the National Treasury and others. A recent bailout of R128bn (\$8,4bn) over three years is still insufficient to return the utility to financial health, even with planned tariff increases. Eskom is thus unable to meet its debt obligations of R440bn (\$29bn) without further bailouts, which the South African government cannot afford without jeopardizing its social obligations, debt-to-GDP-ratio and credit rating (and thus cost of borrowing).

The crisis may afford the opportunity for a rapid increase in energy efficiency and a large build out of utility scale RE and embedded generation in the industrial, commercial and residential sectors. On the other hand, the protection of Eskom, political opposition by unions to private ownership of renewable energy, and concerns about job losses and economic impacts in coal dependent Mpumalanga may hinder the roll out of RE and the phase out of coal.

Table 8. Possible action to increase mitigation action in South Africa

Sector	Proposed actions to increase mitigation ambition
South Africa	

Energy supply	<ul style="list-style-type: none"> • Halt new proposed coal-fired power plants contained in the draft Integrated Resource Plan (IRP) for electricity* • Accelerate roll out of new renewable energy capacity • Commit to a 2040 target for the phase out of coal in the power sector* • Develop a strategy for the transition of high emission-intensity liquid fuels supply (coal-to-liquids)
Industry	<ul style="list-style-type: none"> • Development of a climate compatible industrial development plan for the long-term decarbonisation of industry*
Transport	<ul style="list-style-type: none"> • Accelerate the shift of freight transport from road to rail and to low-carbon road transport such as hydrogen and electrification* • Target the development of electric transport (vehicles, buses) and modal shifts for urban passenger mobility in urban centres
Buildings	<ul style="list-style-type: none"> • Continue to tighten the standards to reach zero-emission buildings by 2030, and enforce existing and future standards* • Focus on the renovation of existing residential building stock to improve thermal performance

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

8.1 Energy supply

Recent policy changes

○ South Africa's electricity plan, the (draft) Integrated Resource Plan (IRP), envisages the retirement of 12GW of existing coal by 2030 and a further 34GW by 2050. However, it also includes new coal plants, and commits to keeping older plants running despite their rising age and costs, and lack of compliance with air pollution laws.

Areas of possible additional actions

Possible action: Halt new proposed coal-fired power plants contained in the draft Integrated Resource Plan (IRP) for electricity. According to a statement by the Department of Energy, substantial subsidies (R23bn/\$1,5bn) are required for the proposed new coal capacity contained therein (assuming only the construction and operation of the Thabametsi and Khanyisa plants, although more capacity is also envisaged post-2025). Furthermore, the inclusion of the 863MW would also result in around 200Mt CO₂-eq higher GHG emissions than a least-cost (RE plus flexible capacity) pathway (Ireland and Burton, 2018). Halting new coal would assist South Africa in meeting its G20 commitment to phase out inefficient of fossil fuel subsidies.

Possible action: Accelerate roll out of new renewable energy capacity: The draft IRP artificially limits the annual build of utility-scale wind and solar power and limits the annual build of embedded generation capacity. The result of constraining RE is to increase the risk of electricity supply interruptions in the short and medium term, and to force higher shares of coal and nuclear power into

the electricity plan. The latter results in higher electricity prices, lower economic output, and fewer jobs (Hartley et al., 2019, 2018), as well as a far slower transition away from coal power. Removing annual build limits for renewable energy is an important short-term contribution to a long-term 100% low carbon electricity goal.

Possible action: commit to a 2040 target for the phase out of coal in the power sector, which would allow the country to cost optimally meet its long-term climate policy goals. Such a commitment must be accompanied by a detailed just transition plan for structural transformation of the economy, support for coal dependent communities and workers, and protection of livelihoods (Burton et al., 2019).

Possible action: develop a strategy for the transition of high emission-intensity liquid fuels supply. Existing coal-to-liquids capacity provides 25% of South Africa's consumption and is an important input into the chemical value chain, and is responsible for about 10% of South Africa's emissions. Yet there exists no long-term plan for the future of Sasol's Secunda plant and the liquid fuels supply and chemicals industries in a carbon-constrained world.

8.2 Industry

Recent policy changes

↑ **Carbon Tax Act** covers the industrial sector through taxation of electricity and liquid fuels supply, as well as of direct emissions. However, the carbon price is set too low to drive large-scale transformation, which may be remedied in the second phase (after 2022).

○ South Africa's Draft Post-2015 Energy Efficiency Strategy (which has not been officially adopted) aims to reduce energy consumption in industry by 16% by 2030 compared to 2015 levels. However, the strategy does not address the long-term transition of high-carbon sectors.

↑ There is government support for industrial energy efficiency through energy audits and tax rebates. For example, the Industrial Energy Efficiency (IEE) programme was developed to focus on the promotion and implementation of energy management systems and energy systems optimisation in companies. To date, the IEE Programme has produced 2,140 GWh in cumulative energy savings and 2 Mt CO₂e in avoided GHG emissions through projects in participating companies. Similarly, Eskom's Integrated Demand Management (IDM) programme has so far resulted in cumulative energy savings of over 58,000 GWh and avoided 59 Mt CO₂e. Government provides multiple tax rebates available for firms implementing industrial energy efficiency and renewable energy (LEDS, 2018)

Areas of possible additional actions

Possible action: incremental improvement to existing industrial capacity is an important first step. However, the development of a climate compatible industrial development plan for the long-term decarbonisation of industry is required, with a variegated approach to target transition pathways for different sectors and energy end-uses.

8.3 Transport

Recent policy changes

↑ **The release of the Green Transport Strategy in July 2019** which has recognised explicitly the important role played by the transport sector in meeting South Africa’s environmental and development goals. The vision of the GTS is to reduce GHG emissions and other environmental impacts from the transport sector by 5% by 2050, while recognizing that transport services are integral to a well-functioning society. In practice, the department intends for transport emissions to reduce from a current share of 11% of national emissions to a share of 6% of national emissions by 2050, although this requires the release of a clarificatory note. The strategy states that it aims to “avoid the overinvestment of resources in technologies that are likely to be redundant in a future low carbon economy and the need to plan for the potential of new technologies that may result in disruptive, transformative and innovative change”. The strategy goals aim to

1. achieve a 30% shift of freight transport from road to rail... and 20% shift of passenger transport from private cars to public transport and eco-mobility transport.
2. convert 5% of the public and national sector fleet in the first seven years of the implementation of this strategy and an annual increase of 2% thereafter, to cleaner alternative fuel and efficient technology vehicles (ideally powered through renewable energy) and environmentally sustainable low carbon fuels by 2025, including the use of CNG, biogas and biofuels and the use of renewable energy to provide electricity for transport.
3. reduce fossil-fuel related emissions in the transport sector by promoting norms and standards for fuel economy and putting in place regulations that promote improved efficiency in fossil fuel powered vehicles and improved environmental performance of fossil fuels.
4. promote strategies and standards for delivering transport infrastructure, integrated transit planning and systems that build climate resilience in urban and rural communities, whilst minimising the environmental impact of transport infrastructure.
5. develop best practice guidelines to ensure that integrated, climate- friendly transport options are incorporated into land use and spatial planning at national, provincial and local levels.
6. Invest in sources of green energy’s infrastructure, such as biogas filling stations, electric car charging points, GIS integrator ICT technology platforms for locating stations, regulating future pricing and providing statistics.

Areas of possible additional actions

Possible action: accelerate the shift of freight transport from road to rail and to low-carbon road transport such as hydrogen and electrification (Caetano et al., 2017; Merven et al., 2019).

Possible action: target the development of electric transport (vehicles, buses) and modal shifts for urban passenger mobility in urban centres (CAT, 2018).

8.4 Buildings

Recent change

○ ↑ in 2011, South Africa set a goal for zero-emissions buildings by 2030 in its National Development Plan. The overall goal is supported by the National Energy Efficiency Strategy targets for buildings, and the National Building Regulations and Buildings Standards Act. The standards prescribe energy efficiency requirements of new buildings and stipulate the maximum energy demand and the maximum annual energy consumption for various kinds of buildings in various climate zones across the country (LEDS, 2019).

Areas of possible additional actions

Possible action: continue to tighten the standards to reach zero-emission buildings by 2030, and enforce existing and future standards (LEDS, 2019). Furthermore, focus on the renovation of existing residential building stock to improve thermal performance (CAT, 2018).

8.5 Agriculture and forestry

Recent change

The South African government recently conducted a national carbon sinks assessment in 2015, and undertook an AFOLU baseline study in 2016. These form the basis for developing policies and measures for the agriculture and land sectors, the process of which is currently underway

9 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.

Table 9. Possible actions to increase mitigation ambition in the United States of America

Sector	Possible actions to increase mitigation ambition
United States of America	
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 Annex B, table B-1 as clearly ambitious.

9.1 Energy supply

Recent policy 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.

9.2 Industry

Recent policy 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,⁴ 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).

9.3 Transport

Recent policy 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

⁴ Section 45Q of the United States Code provides a tax incentive for carbon capture, utilization and storage (CCUS) projects, with the goal of increasing the commercial deployment of these technologies. See [https://uscode.house.gov/view.xhtml?req=\(title:26%20section:45Q%20edition:prelim\)](https://uscode.house.gov/view.xhtml?req=(title:26%20section:45Q%20edition:prelim))

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.

9.4 Buildings

Recent change

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.

9.5 Agriculture and forestry

Recent change

↑ 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.

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