GHG mitigation scenarios for major emitting countries: 2018 update

Supporting information on emission projections

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1 Argentina

1.1 Assessment

NDC

Argentina resubmitted its revised Nationally Determined Contribution (NDC) on the 17th of November, 2016 with an unconditional absolute emissions reduction target, limiting emissions to 483 $MtCO_2e$/year by 2030, including land use, land use change and forestry (LULUCF) emissions. Argentina also put forward a conditional target to limit emissions to 369 $MtCO_2e$/year by 2030 including LULUCF. Argentina's contribution covers all sectors and six GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6). The government reports its inventories using Global Warming Potentials (GWPs) based on the IPCC Second Assessment Report (SAR).

Current policies

See Table S1 for policies covered in the projections. NewClimate Institute calculations were based on its analysis for the Climate Action Tracker.[1] The emissions projections under current policies excluding LULUCF was developed based on a business-as-usual (BAU) scenario developed for the Third National Communication (NC3) (Ministry of Environment and Sustainable Development of Argentina, 2015). In addition to the policies covered in the BAU scenario, the GHG mitigation impacts of the following policies implemented in recent years were also quantified:

- Biofuels Law (2016, no.26093), which requires a minimum 12% of bioethanol blend in transport fuels;
- Effect of the renewably capacities auctions (RenovAr)

Note that the projections do not meet the target of the Renewable Energy Law No. 27191 (2015), which aims to increase the share of renewables (including hydro smaller than 50 MW) in total power generation to 20% by 2025.

[1] http://climateactiontracker.org/countries/argentina (update November 2018)

Table S1: Overview of key climate change mitigation-related policies in Argentina. Source: (Ministry of Environment and Sustainable Development of Argentina, 2015).

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Economy-wide	National Program for Rational and Efficient Use of Energy (PRONUREE) (2007)	• 10–12% of energy savings by 2016 in residential, public/private services • Decrease electricity consumption by 6% compared to baseline scenario and energy savings of 1500 MW by 2016	Included through the BAU scenario.
Energy supply	Renewable Energy Programme in Rural Markets (2000)	Reduce GHG emissions by replacing small-diesel electricity generation with renewable energy systems	Included through the BAU scenario.
	Renewable Energy Law 27191. National Development Scheme for the Use of Renewable Energy Sources (RenovAr) (2016)	Total individual electric consumption to be substituted with renewable sources given the following schedule: 8% by 2017, 18% by 2023 and 20% by 2025	Included through the BAU scenario. No information available on implementation status. For the current analysis, we have assumed full implementation
	PROBIOMASA: promotion of biomass energy (2013)	Additional biomass capacity: each 200 MW electric and thermal by 2018, each 1325 MW electric and thermal by 2030	Included through the BAU scenario. No information available on implementation status. For the current analysis, we have assumed full implementation
	Energy Efficiency Project (2009)	USD 99.44 million to reduce 10.7 $MtCO_2e$ by the end of 2016 are the global benefits of the Energy Efficiency Project	Included through the BAU scenario.
	Carbon tax on energy	• Starting at \$10/tCO_2 (adjusted every trimester). Targeting emissions from transport fuels, natural gas and coal, as well as the country's burgeoning oil and shale gas industry.	Not quantified
Transport	Biofuels Law (updated 2016)	12% requirement of biodiesel or ethanol blend in the gasoline from 2016	Included through additional calculations

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Industry	N/A	N/A	
Buildings	Program for Rational and Efficient use of Energy in Public Buildings (2007)	Various measures in line with the 10% energy savings by 2016	Included through the BAU scenario.
Forestry & Agriculture	Minimum Budgets for Environmental Protection of Native Forest (Presupuestos Minimos de Proteccion) (2007) (+)	Regulatory frame to control the reduction of native forest surface and achieve lasting surface over time	Policy not included
	National Forest Management Plan with Integrated Livestock (Plan Nacional de Manejo de Bosques con Ganadería Integrada) (2015)	• To improve and maintain ecological and cultural processes in native forest and promote activities for a sustainable management of native forest • Contributes to sustainable use of native forests through incorporating livestock activities in native forest areas in a sustainable manner	Policy not included
	Investments for Cultivated forests (Inversiones Para Bosques Cultivados (2008)	Development of afforestation projects on a total of 500,000 ha of land based on economic incentives.	IIASA projection

1.2 Details of NewClimate calculations

Historical emissions

Historical emissions for 1990–2014 were taken from the national GHG inventory (Ministry of Environment and Sustainable Development, 2017).

Emissions projections under current policies

The current policies scenario was developed based on a business-as-usual (BAU) scenario for the NC3 (Ministry of Environment and Sustainable Development of Argentina, 2015). The year 2014 was used as base year and provides emissions projections for all sectors and six GHGs until 2030. In addition to the policies covered in the external current policies scenario, the "Biofuels Law" as well as the new "Renewable Energy Law" were published simultaneously or after the NC3. Therefore, their mitigation impact is unlikely to have been included in the emissions projections under current policies.

The "Biofuels Law" was adopted in March 2016 and requires a minimum of 12% of biofuels blend in transport fuels starting in 2016. To quantify its impact, we compared the current share of ethanol and biodiesel –as reported by the IEA (2016c)— and its associated emissions under a BAU scenario to a fixed share of 12% blend and its corresponding emissions expected under the "biofuels law". Given the

uncertain emissions along the supply chain of biofuels, the positive impact of this policy on total GHG emissions is unclear.

The targets under the Renewable Energy Law are supported by the auctioning scheme Renovar. The capacities tendered up to today (phase 1, phase 1.5 and phase 2) add up to about 4.4. GW. Assuming no capacities beyond those would be added up to 2030, the share of RE in electricity generation (excl. large hydro) would increase to about 6% in 2025, compared to 4% under the scenario in the NC3. The impact of this difference on emissions is minor (1 $MtCO_2$ in 2025, calculated with the average grid emissions factor in 2025 from the NC3 scenario). The RE share achieved through the current Renovar auctions is far below the target under the Renewable Energy Law of 20% by 2025. Because of the uncertainty of achievement of this target, we do not include it in the current policy projections.

Emissions projections under "planned policies"

In early 2018, the former Ministry of Energy (now Secretariat of Energy after a restructuring of the government) published alternative scenarios for the energy sector (Ministry of Energy and Mining Argentina, 2018), which lead to lower emissions than our current policy projections. Those scenarios assume meeting the renewable energy target and additional efficiency measures, that could be achieve with additional policies. We included those projections as a "planned policies" scenario by replacing energy-related emissions from the NC3 with the results of the Energy Scenarios.

1.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. The G4M emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017). For this assessment, only forestry related changes in LULUCF carbon pools were accounted for (i.e. afforestation, deforestation, and forest management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time according to the historical LULUCF estimates reported in the BUR1 (Government of Argentina, 2015).

To include policy measures related to Investments for Cultivated Forests (inversions para bosques cultivados) (Government of Argentina, 2008) in the projections of LULUCF emissions and removals under current policies, a nation-wide carbon price was induced that enhances the afforestation rate and reduces the deforestation rate over time. The carbon price was assumed to be implemented as of 2015 and assumed to be increasing by a yearly growth rate of 2% until 2030 such that a total of 500,000 hectares of forest would be cumulatively afforested during the period of 2015 to 2030. The short term impact on net emissions from this policy may be limited and only provide roughly 5 Mt CO_2 eq of additional sequestration per year as of 2030. This as the increment of the selected tree species is relatively small for the first 10 years after being planted. However, the long-term impact of the policy may prove to be larger as the growing increment of the trees increases.

2 Australia

2.1 Assessment

NDC

Australia submitted its Nationally Determined Contribution (NDC) on the 11th of August, 2015 and ratified the Paris Agreement on the 9th of November, 2016. In its NDC, Australia intends to reduce GHG emissions by 26–28% from 2005 levels including land use, land use change and forestry (LULUCF) by 2030. Australia's target covers all sectors (energy, industrial processes and product use, agriculture, LULUCF, and waste) and gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3). However, Australia's target excludes emissions and removals related to non-anthropogenic disturbances, in particular wildfires.

Current policies

The emissions projections under current policies of PBL were based on updated IMAGE model calculations including high impact policies identified in the CD-LINKS project (Table S2). The NewClimate Institute projections were based on the Climate Action Tracker analysis.[2]

The ERF [3] is the main instrument in the Australian Direct Action plan and plays a major role in achieving the NDC target (Australian Government, 2015a). Since the start in 2015, two auctions were held resulting in 92 $MtCO_2e$ committed reductions aggregated over the period 2015–2024 (average contract period observed for the first two auctions was around 9 years). Almost 95% of the reductions can be found in the AFOLU sector (including waste). The total committed funding is $AUD 2.55 billion. If the average auction price is assumed to apply for the remaining period until 2024, approximately 100 $MtCO_2e$ aggregated reductions over the period 2015 to 2024 can be expected on top of current commitments. Therefore, the annual reductions in this period were estimated at 21.5 $MtCO_2e$/year. It is not clear yet to what extent the ERF is continued after this period. The ERF also includes the former Carbon Farming Initiative. Besides the ERF, Australia's Renewable Energy Target (RET) Scheme aims to achieve a 23.5% share of renewables in electricity production. Next to these two policies, Australia also introduced fuel taxes of $AUD 0.3814 per litre on gasoline and diesel. These taxes also apply to liquefied petroleum gas (LPG) as well as heating and process use. However, this was not taken into account in our assessment.

[2] http://climateactiontracker.org/countries/australia (update April 2018)

[3] Details about the ERF are available at: http://www.cleanenergyregulator.gov.au/ERF/Pages/default.aspx

Table S2: Overview of key climate change mitigation policies in Australia (Australian Government, 2015a, Australian Government, 2015b, Australian Government, 2015c)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	Emissions Reduction Fund (ERF) (2014) (+)	Auctions are set up to purchase emissions reductions at the lowest available cost, thereby contracting successful bidders[1)]	Included in government emissions projections	Not included
Energy supply	Renewable Energy Target (RET) (2010) (+)	25% of electricity should come from renewable sources by 2020, 35% by 2025 and 50% by 2030, compared to 13% in 2014. The new target[2)] for large-scale generation of 33,000 GWh in 2020 would double the amount of large-scale renewable energy being delivered by the scheme compared to current levels	Included in government emissions projections	Included as 19.4% by 2020, 31.6% by 2025 and 39% by 2030 for Oceania region in TIMER – 27% by 2020, 44% by 2025, and 49% by 2030 reached
Transport	Fuel tax (2015)	Fuel tax is set at AUD 0.3814 per litre for diesel and gasoline and AUD 0.013 per litre for biodiesel [3)]	Not included	Included through a negative vehicle subsidy
Forestry & Agriculture, Waste	Emissions Reduction Fund (2014): Vegetation & Agriculture	• Include protecting native forests by reducing land clearing, planting trees to grow carbon stocks, regenerating native forest on previously cleared land. • Encourages sustainable farming, adaptation, and uptake of techniques for reducing emissions such as dietary supplements or efficient cattle herd management, capturing methane from effluent waste at piggeries, and enhancing soil carbon levels through adaptive farming practices. • In total, 6.1 $MtCO_2e$/year reductions of LULUCF emissions in 2020 from 2010 expected.	IIASA projection	IIASA projection
	20 Million Trees Programme (2014)	Plant 20 million trees by 2020 (20,000 ha) in order to re-establish green corridors and urban forests.	IIASA projection	IIASA projection

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
	Emissions Reduction Fund (2014): Agriculture	Ensures that advances in land management technologies and techniques for emissions reduction and adaptation will lead to enhanced productivity and sustainable land use under a changing climate.	Now replaced by ERF	Policy not included in IIASA projections
Other	HFC reduction under the Montreal Protocol (2016)	Reduce HFC emissions by 55% by 2030, relative to 2010 (85% by 2036)	Included through additional calculations	Included through additional tax on f-gases (which include PFCs as well); -60% achieved

The emissions projections under current policies of the net LULUCF emissions developed by IIASA, which supplement the NewClimate and PBL projections, exclude emissions and subsequent removals from non-anthropogenic natural disturbances in line with Australia's 2017 GHG Inventory Submission to the UNFCCC (Government of Australia, 2017).

2.2 Details of NewClimate calculations

Emissions projections under current policies

The emissions projections under current policies are based on the Climate Action Tracker analysis[4] and start from the Australian Government's emissions projections from December, 2017 (Australian Government, 2017). These projections were developed based on current policies and measures, but do not include the planned phasedown of HFCs. As a starting point, we took the emissions projections from the Australian Government as a current policies scenario. We then additionally accounted for Australia's stated target of reducing HFC emissions to 85% of 2010 levels by 2036. We interpreted this target to mean HFC emissions of 55% of 2010 levels in 2030. To calculate the expected emissions reductions from reaching this target, we quantified the expected HFC emissions in 2030 with the policy and subtracted the difference between this value and the current policy projections for HFC emissions from the current policy scenario.

2.3 Details of PBL calculations

PBL results for Australia were based on calculations for the Oceania region (including Australia, New Zealand, and a few other islands, see the IMAGE wiki for more details). It was assumed that Australia has a constant share of Oceania's regional emissions, based on the year 2015 (about 87%). Besides Australia, New Zealand is also located in this region, but the current policies scenario only includes Australian policies as identified in the CD-LINKS project (CD-LINKS, 2018, NewClimate Institute, 2016). These policies were modeled by calculating the effect of Australia's targets in the Oceania region,

[4] https://climateactiontracker.org/countries/australia (update April 2018)

assuming business-as-usual for New Zealand; e.g. a 25% share of renewable energy in electricity production (by 2020) translated into a 30% share for Oceania.

2.4 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the Carbon Farming Initiative and the 20 Million trees Programme). For this assessment, only forestry related changes in LULUCF carbon pools in Australia were accounted for (i.e. Afforestation, Deforestation, and Forest Management) and total LULUCF emissions and removals where harmonised to the 2015 level of net emissions from Australia's 2017 National Inventory Reporting to the UNFCCC (Government of Australia, 2017). All non-forest related LULUCF emissions and removals were assumed to remain constant over time according to harmonised 2015 estimates (Government of Australia, 2017). The projection also excludes emissions and subsequent removals from non-anthropogenic natural disturbances in line with Australia's 2017 GHG Inventory Submission to the UNFCCC.

To include policy measures related to afforestation and the planting of trees (the 20 Million Trees Programme) in the emissions projections under current policies, a nation-wide carbon price was induced that enhances the afforestation rate and reduces the deforestation rate over time. The carbon price was assumed to be implemented as of 2014 and increased linearly until 2020 such that the 20,000 hectares of green corridors and urban forests would be cumulatively planted from 2015 until 2020. After 2020, the carbon price was assumed to remain constant until 2030. In addition to the 20 Million Trees Programme, the emissions projections considered the Carbon Farming Initiative, which was implemented as a direct reduction of the total net LULUCF emissions. This initiative is expected to lead to an additional reduction of net LULUCF emissions in 2020 of 6.1 $MtCO_2e$/year. The mitigation efforts associated with this policy were assumed to start in 2014 and thereafter linearly increase over time, reaching the targeted reduction of 6.1 $MtCO_2e$/year in 2020. After 2020, the targeted reduction was assumed to remain constant over time.

3 Brazil

3.1 Assessment

NDC

Brazil ratified the Paris Agreement and submitted its Nationally Determined Contribution (INDC) on the 21st of September, 2016. The Brazilian NDC establishes an absolute target relative to 2005, reducing GHG emissions by 37% in 2025 and indicating further reductions of 43% by 2030. These percentage reductions are relative to reported emissions of 2.1 $GtCO_2e$/year in 2005, thus corresponding to emission levels of 1.3 $GtCO_2e$/year in 2025 and 1.2 $GtCO_2e$/year in 2030 (including LULUCF), using IPCC AR5 GWP-100. Brazil´s NDC is economy-wide, covers all IPCC sectors and six GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6), and is unconditional. Actions to achieve the targets focus mainly on the forest sector and on increasing the share of biofuels and renewable electricity in the Brazilian energy mix.

Current policies

Policies on the forestry sector (see Table S3) have a significant impact on total emissions; in particular, the enforcement of the Brazilian Forest Code and efforts to reduce deforestation in the Amazon and Cerrado regions. Even though the annual deforestation rate in the Legal Amazon has risen during the last two years, it is expected that successful implementation and enforcement of the proposed measures can lead to a long-term reduction of net GHG emissions.

The emissions projections under current policies by NewClimate Institute were based on the Climate Action Tracker analysis.[5] The PBL emissions projections were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S3). The IIASA projections of net AFOLU emissions accounts for both land use and agriculture-related policies, and is based on the REDD-PAC project report (REDD-PAC Brazil, 2015) and further detailed in Sotrerroni et al. (2018). The projection presented in the REDD-PAC project is based on full implementation of the Brazilian Forest Code, including rules such as the recovery of Legal Reserves (LR), Small Farm Amnesty (SFA), and Environment reserve quotas (CRA). These policies are expected to have a significant impact on future land use emissions in Brazil as of 2030. Projections presented in REDD-PAC Brazil (2015) estimate that the implementation of the Forest code could potentially reduce emissions by roughly 340 $MtCO_2e$/year by 2030.

[5] http://climateactiontracker.org/countries/brazil (update April 2018)

Table S3: Overview of key climate change mitigation-related policies in Brazil. Source: (Government of Brazil, 2017, Government of Brazil, 2008, IEA, 2016c, Ministry of Mines and Energy, 2012, REDD-PAC Brazil, 2015)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)[1)]	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	2020 pledge anchored in national law (2010)	Not specified	Not included separately	Not included separately
Energy supply	10-year National Energy Expansion Plan (2011)	• 16.5 GW wind, 13 GW biomass, 5.6 GW small hydro and 88.5 GW large hydro installed by 2025 (currently under construction) • 41.4% renewable share in total primary energy supply by 2022 (45% by 2024)	Follows the projections of IEA WEO 2017 (Current Policies Scenario)	• Capacity targets included as such, except small hydro (not represented in TIMER); wind capacity target assumed to be met onshore. • Renewable share in primary energy: checked if met after implementation of capacity targets (25% reached by 2024)
	National Plan on Climate Change (2008)	16% renewable electricity (excl. hydro) by 2020 (supported by renewable energy auctions, Government of Brazil, 2007)	Follows the projections of IEA WEO 2017 (Current Policies Scenario)	Checked if met after implementation capacity targets; 16% reached by 2024
Transport	National Plan on Climate Change (2008)	Not specified	Not included separately	Not included separately
	National Biodiesel Programme (2005)	Biodiesel share in diesel of 7% from 2015 and 10% from 2019 onwards	Follows the projections of IEA WEO 2017 (Current Policies Scenario)	Implemented as 24% biofuel share (bioethanol + biodiesel) from 2015 onwards
	Ethanol Blending Mandate (1993; last amendment in 2015)	Bioethanol share in gasoline of 27% in 2015	Follows the projections of IEA WEO 2017 (Current Policies Scenario)	Implemented as 24% biofuel share (bioethanol + biodiesel) from 2015 onwards

Sector	Policies (marked with "(+)" when mentioned in the NDC document)[1)]	Description	NewClimate quantification of impact	PBL quantification of impact
	Inovar-Auto (2012)	30% tax on cars sold between 2013 and 2017, but not for cars meeting 1.82 MJ/km. Expected average fuel efficiency 1.14 MJ/pkm by 2017	Follows the projections of IEA WEO 2017 (Current Policies Scenario)	Implemented as fuel efficiency standard of 1.82 MJ/pkm by 2017
	RenovaBIO	Improve carbon intensity of biofuels (gCO_2e/MJ) by 7% between 2017 and 2028		Not implemented.
Forestry & Agriculture	The Brazilian Forest Code (2012) (+)	• Enforcement of the Brazilian Forest Code for the Cerrado region and the rest of Brazil • Restoring and reforesting 12 million hectares of forests by 2030	IIASA projection	IIASA projection
	National Plan on Climate Change (2008)	• Reducing deforestation rates in all Brazilian biomes, in order to reach zero illegal deforestation.	IIASA projection	IIASA projection
	The Low-Carbon Agriculture (ABC) Plan) (2010) (+)	• Restoring an additional 15 million hectares of degraded pasturelands by 2030 • Enhancing 5 million hectares of integrated cropland-livestock-forestry systems by 2030	IIASA projection	IIASA projection
	Plan for Prevention and Control of Deforestation in	• Zero illegal deforestation by 2030 in the amazon and	IIASA projection	IIASA projection

Sector	Policies (marked with "(+)" when mentioned in the NDC document)[1)]	Description	NewClimate quantification of impact	PBL quantification of impact
	the Amazon (2004)	compensating for greenhouse gas emissions from legal suppression of vegetation by 2030		
	Action Plan for the Prevention and Control of Deforestation and Forest Fires in the Cerrado biome (2010)	• Focus on reducing the deforestation rates and forest degradation, as well as the incidence of forest fires in the Cerrado biome	Not included separately	Not included separately

[1)] *The energy- and industry-related NDC policies were not quantified, but partly covered in the emissions projections under current policies*

3.2 Details of NewClimate calculations

The calculation steps described below were adapted from the Climate Action Tracker analysis.[6]

Current policies

The projections under implemented policies were based on the following:

- Energy-related CO_2 emissions: the historical emissions data for 2014 described above was multiplied by the emission growth rates for 2014–2030 in the Current Policies Scenario of World Energy Outlook 2017 (IEA, 2017b);
- Process-related CO_2 emissions: assumed the trend of last 10 historical years of these emissions continue up to 2030;
- Non-CO_2 emissions: historical emissions data was multiplied by the growth rates of the non-CO_2 emissions projected in the US EPA (U.S. EPA, 2012) ;
- CO_2 emissions from LULUCF: historical emissions data was multiplied by the growth rates of emissions up to 2030 as in the REDD PAC study (REDD-PAC Brazil, 2015).

These scenarios cover all relevant implemented policies, thus no additional quantification of the impact of individual measures was necessary.

3.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the GLOBIOM-Brazil model. GLOBIOM-Brazil includes a series of refinements that reflect Brazil's specificities (Câmara et al., 2015). The model computes consumption and trade for each of the 30 regions of the world; it also

[6] http://climateactiontracker.org/countries/brazil.html (update April 2018)

computes production and land use at the 50 km×50 km grid level for the most important crops and animal products in Brazil. Production is endogenously adjusted to meet the demand for all 30 economic regions, which include Brazil. In this framework, deforestation depends on the feedback between future agricultural demand and biophysical and regulatory constraints on land. This means that the deforestation rate is not first estimated separately, for example on the basis of historical trends, and then spatially allocated using land characteristics.

The projections were based on the scenarios presented in the REDD-PAC project report (REDD-PAC Brazil, 2015) and the recent publication by Soterroni et al. (2018). Population and GDP changes for this projection follow the assumptions from the SSP 2 scenario. The projection has been developed to capture the future impacts of all key provisions of a rigorously enforced Brazil's Forest Code (Soterroni et al., 2018). It includes the full control of illegal deforestation after 2010, the amnesty of the Legal Reserve (LR) debts for small farms (SFA) before 2010, the environmental reserve quota mechanism after 2020, and the mandatory restoration of LR debts after 2020. Legal deforestation or conversion of LR surpluses is allowed at all times in all biomes, with the exception of the Atlantic Forest, which is protected by more restrictive legislation. The LR debts not waived by the SFA are fully paid by the farm owner, either by purchasing quotas from the environmental reserve quota system for the LR surpluses in the same biome or by taking illegally converted areas out of agricultural production for native vegetation restoration.

It should be noted that the scenario as developed includes a strict compliance with the Brazilian forest code, the Low-Carbon Agriculture plan and the Plan for Prevention and Control of Deforestation in the Amazon. The Brazilian forest code is strictly implemented and where control of illegal deforestation is implemented in all biomes, with requirement for forest restoration. If such measures were to be loosened or not enforced, it has been shown that the net deforestation rate in Brazil may increase significantly (Rochedo et al., 2018).

The LULUCF projection as developed were harmonised to net AFOLU emissions in 2014. The historical emission data was taken from SEEG (SEEG, 2017), which is based on the national inventories prepared for Brazil by the Ministry of Science, Technology and Innovation. The LULUCF projections considered the development of emissions and removals for the major LULUCF related reporting categories (i.e. Forest Land, Cropland, Grassland, and Other Land).

It should be noted that there are large differences between the reported values for 2010 in FAOSTAT (788 $MtCO_2e$/year) and by SEEG (358 $MtCO_2e$/year), related to differences in methods, pools and subcategories covered as well as data being used (Ministry of Science and Technology of Brazil, 2016).

4 Canada

4.1 Assessment

NDC

Canada submitted its Nationally Determined Contribution (NDC) and ratified the Paris Agreement on the 5th of October, 2016 and submitted a revision on the 11th of May, 2017. In the NDC, Canada proposes an economy-wide target to reduce its GHG emissions by 30% below 2005 levels by 2030. Canada's NDC is said to include all sectors and GHGs. However, there is some uncertainty about the treatment of LULUCF (Grassi and Dentener, 2015) and to the accounting approach that will be used. The initial 2016 NDC suggested that Canada is considering applying the net-net accounting approach[7], while the revised NDC stated that Canada is examining its approach to accounting for the LULUCF sector. Furthermore, the country declares its target to include all IPCC sectors (excluding emissions from natural disturbances).The emissions and removals from the LULUCF sector do not appear to be included in the base year estimates presented in the NDC. The NDC states that a potential increase of the LULUCF sink has not been included in the target but may contribute to its achievement[8]. For that reason, it is possible that the LULUCF sector will be treated based on an accounting approach separately from the other sectors.

The PBL and NewClimate Institute estimates of the NDC emission levels assume that Canada would apply the net-net accounting rule. This implies that the LULUCF sector can provide credits or debits for the fulfillment of the NDC target. However, the actual NDC emission target is not impacted by fluctuations of the LULUCF emissions and removals.

Current policies

Canada's policy with the largest projected effect is the fuel efficiency standard for passenger vehicles, which is harmonised with US standards and introduced in two phases. Another policy is the carbon standard for newly built coal-fired power plants. This standard is projected to have only a small effect on 2020 emission levels, as it does not affect existing power plants.

The emissions projections under current policies by NewClimate Institute (excluding LULUCF) were based on the Climate Action Tracker analysis (see section 4.2). The projections up to 2030 were taken from the Pan-Canadian Framework on Clean Growth and Climate Change (see Table S4) (Government of Canada, 2016). The PBL emissions projections were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S4).

[7] In this approach, the reported net emissions in each year of the accounting period minus the net emissions in the base year. In the situation where the net emissions have decreased, a country may issue credits (i.e. removal units, or RMUs) and if net emissions have increased, it must cancel units (i.e. take on debits). The net-net LULUCF accounting method implies that credits and debits from the LULUCF sector are treated in the same way as any other GHG inventory sector.

[8] The NDC states that "Additionally the potential increases in stored carbon (carbon sequestration) in forests, soils and wetlands have not been included in the projected emissions reductions figure of 175 Mt. For a country such as Canada, carbon sequestration could make an important contribution to the achievement of the 2030 target. "

Table S4: Overview of key climate change mitigation policies in Canada. Source: (Government of Canada, 2014b, Government of Canada, 2014a, Government of Canada, 2015)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Energy supply	CO_2 standard for new power plants (2012)	• 420 gCO_2/kWh from 1 July 2015	• Included in scenario from Pan-Canadian Framework	• Implemented by not allowing new power plants to be installed with 420 gCO2/KWh or higher.
	Regulations to address methane in the oil and gas sector	• Reduce CH_4 intensity (ktCO2e/Mtoe) emissions from oil and gas by 40-45% by 2025, relative to 2012. Implementation starts in 2020	•	• Implemented as end-of-pipe measure, assuming total gas production remains the same as in reference scenario.
Transport	Efficiency standards light commercial vehicles (2004)	• 34.1 mpg (14.9 km/l) by 2017, 55 mpg (23.2 km/l / 0.91 MJ/pkm) by 2025	• Included in scenario from Pan-Canadian Framework	• Included as 0.91 MJ/pkm from 2025 onward (0.9 MJ/pkm achieved)
	Efficiency standards heavy-duty trucks (2013)	• Differs per type of truck (aligned with federal-level regulations in the US) – 1.38 MJ/tkm by 2027 for medium trucks, 0.92 MJ/tkm by 2027 for heavy trucks	• Included in scenario from Pan-Canadian Framework	• Included as such (0.93 MJ/tkm achieved)
	Renewable fuel regulations (biofuel bill - amendment to CEPA) (2008)	• Bio-ethanol share in gasoline of 5% from 2011 onwards • Biodiesel share in diesel of 2% from 2011 onwards	• Included in scenario from Pan-Canadian Framework	• Included as 3.7% biofuel share (bioethanol + biodiesel) from 2011 onward (4.4% achieved)
Buildings	EcoENERGY efficiency (2011)	• Supported the implementation of energy codes, among other things, to improve energy	• Included in scenario from Pan-Canadian Framework	• Included as building codes for space heating, resulting in reduction of energy use per m^2

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
		efficiency of buildings.		
Forestry & Agriculture	The Growing Forward 2 (2013)	• Supports the initiatives to advance environmentally sustainable agriculture	• Not included	• Not included
	Green Construction through Wood Program (2018)	• Supports projects and activities that increase the use of wood as a building material in infrastructure projects.	• Not included	• Not included
	Forest Bioeconomy Framework for Canada (2017)	• Supports the use of forest biomass for advanced bio-products and innovative solutions	• Not included	• Not included
Other	Regulation of HFCs	• Reduce HFC emissions by 85% by 2036, relative to baseline (maximum allowable HFC consumption: 2.9 $MtCO_2eq$, based on baseline of 19.1 $MtCO_2eq$)	• Included	• Included through additional tax on f-gases (which include PFCs as well); 90.7% reduction achieved, relative to TIMER baseline (remaining emissions 2.1 $MtCO_2eq$ by 2036)

Under current policies, IIASA projects that net LULUCF emissions in Canada will slightly increase by 2030 as compared to 2005 levels. Assuming that Canada will apply the net-net accounting approach, Canada thereby has to take on a debit of land use credits by 2030, as the net LULUCF emissions in 2030 are expected to be slightly higher than 2005 levels. This development of the LULUCF emissions is in part because the projections do not consider emissions and removals associated with non-anthropogenic natural disturbances; this is in contrast to Canada's decision to exclude natural disturbances from the LULUCF reporting (Government of Canada, 2016).

4.2 Details of NewClimate calculations

Emissions projections under current policies

The emissions projections under current policies by NewClimate Institute were based on the Climate Action Tracker analysis.[9] The calculation steps described below were adapted from the latest Climate Action Tracker update.

The projections for 2015 to 2030 were taken from Canada's 7th National Communication and 3rd Biennial Report and are based on the "With Measures" scenario (Government of Canada, 2017a). The report presents projections considering future impacts of policy measures enacted as of September 2017 . It presents three scenarios (low emissions scenario, reference scenario and high emissions scenario) reflecting different assumptions about oil and gas prices as well as GDP growth rate. Due to uncertainty in GDP growth rate and oil and gas prices, we show the current policies pathway as a range based on the low and high emission scenarios. Canada has recently introduced its national carbon pricing plan, to be implemented by provinces and territories in 2018. It is not yet clear how much this plan would contribute to reducing national emissions. This policy was not quantified in our projections, as more details of the plan would be needed for this purpose.

4.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. The national projections were based on the forest harvest projection levels from the SSP2 database (Fricko et al., 2016) and harmonised to historical data sets as presented in Canada's 2017 National Inventory Reporting (Government of Canada, 2017b). For this assessment, only forestry related changes in LULUCF carbon pools for Canada were accounted for in the projection of the net LULUCF emissions (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time according to the levels provided in the 2017 National Inventory Reporting (Government of Canada, 2017b). To be consistent with the assumptions specified in the 2017 National Inventory Report, the projection excludes the emissions and removals related to non-anthropogenic natural disturbances in managed forests, related to wildfires and to insects (Government of Canada, 2017b).

[9] https://climateactiontracker.org/countries/canada (update April 2018)

5 Chile

5.1 Assessment

NDC

Chile submitted its Nationally Determined Contribution (NDC) on the 29th of September, 2015 and ratified the Paris Agreement on the 10th of February, 2017 (Government of Chile, 2015). The NDC includes unconditional and conditional emissions mitigation targets for 2030, which cover emissions from all sectors except for LULUCF as well as an additional target specifically addressing LULUCF. The unconditional target is a GHG emission intensity (tCO_2e/GDP) reduction target of 30% below 2007 levels by 2030. The conditional target is a 35% to 45% reduction of GHG emission intensity, subject to international financial support in the form of grants: "An international monetary grant shall be deemed any grant, which allows the implementation of actions that have direct effects on greenhouse gas emissions within adequate time frames."

For the LULUCF sector, Chile has conditionally committed to the sustainable development and recovery of 100,000 hectares of forest, which will account for GHG sequestrations and reductions of around 0.6 $MtCO_2$/year in 2030. This commitment is subject to the approval of modifications to the Native Forest Recovery and Forestry Promotion Law. Moreover, Chile has agreed to reforest 100,000 ha, which is projected to lead to sequestrations of about 0.9–1.2 $MtCO_2$/year in 2030, conditional on the extension of Decree Law 701 and approval of a new Forestry Promotion Law.

The GHG emissions in 2030 under Chile's NDC estimated by NewClimate Institute were based on its analysis for the Climate Action Tracker.[10] The estimated emission level is significantly lower than last year's analysis, which is mainly a result of using the lower economic growth projections by the Chilean government (Government of Chile, 2017c) for our calculations.

The IIASA projections of the net LULUCF emissions for Chile under the NDC target show an increase in net sequestration within the land use sector, mainly related to increasing forest area and reduction of deforestation.

Current policies

Current emissions projections under current policies for Chile excluding LULUCF were calculated by NewClimate Institute and were based on its analysis for the Climate Action Tracker.[10]

Chile's overarching Climate Action Plan 2017–2022 is the instrument articulating climate change policy for all sectors (Government of Chile, 2017b). It guides climate mitigation actions in all sectors and intends to advance mitigation measures by maintaining the national GHG inventory, developing policy, implementing MRV systems, and fulfilling Chile's international commitments.

Chile's central policies in the energy sector are the Non-Conventional Renewable Energy Law (NCRE) Law 20698, the Energy Efficiency Action Plan and the 2050 Energy Strategy. The NCRE Law aims to achieve a 20% renewable energy target in 2025 by committing 45% of the installed capacity between 2014–2025 to come from non-conventional renewable energy sources (defined as wind, hydro up to 20MW, biomass, geothermal, solar and tidal).The Energy Efficiency Action Plan aims for a 12% reduction of the final energy demand below BAU by 2020, with the largest reductions envisioned in the industry and mining sector. Finally, the 2050 Energy Strategy sets a target of 60% renewable electricity generation (including large hydro) in 2035 and 70% in 2050 (Ministerio de Energia del Gobierno de Chile, 2015). We have quantified the impact of the 2050 Energy Strategy in the "planned policies scenario" projections because most of the recently adopted policies are aligned to the goals of this

[10] https://climateactiontracker.org/countries/chile (update August 2018)

strategy. If Chile follows this planned policies scenario it would achieve its unconditional NDC target in 2030.

In early 2018, Chile's Ministry of Energy agreed with major utilities to cease the construction of new coal power plants that do not incorporate CCS technologies (Ministerio de Energia del Gobierno de Chile, 2018). This agreement also included an aim to phase out coal that is aligned to the 2050 Energy Strategy. Chile's most recent energy planning documents, the Mitigation Plan for the Energy Sector (referred to as Mitigation Plan) and the Energy Sector's Long Term Strategy, already assume a decreasing share of coal electricity generation towards 2050 (Government of Chile, 2017c, 2017d).

Chile also reformed in early 2018 its Distributed Generation Law (also referred to as the "Net Billing" Law) (Law 20.571) as a measure to foster decentralised renewable energy deployment. The reform included a tripling of installed capacity threshold from 100 kW to 300 kW, which aims to support and promote larger projects of self-consumption of electricity (Government of Chile, 2018). The emission reduction implications of this reform were not estimated.

The carbon tax, which was implemented in 2017 at $5USD/tCO_2$ for electricity plants larger than 50 MW, was not quantified, as it is unclear if its likely small effects will be added to other implemented policies.

The Chilean electromobility strategy – from 2017 – sets out a goal and action plan towards achieving a 40% share of electric passenger vehicles as well as a 100% electrified public transport by 2050 (Government of Chile, 2017a).The emission reduction impacts of this strategy have not been quantified due to lack of data.

The IIASA projections of net LULUCF emissions under current policies see a relatively stable development of the net emissions over time. Under current policies, it is projected that the net LULUCF sink would increase from 2010 until 2030, mainly driven by an increased carbon uptake from afforestation efforts. The current policies scenario includes the National Forest and Climate Change Strategy as well as National Reforestation programs, which jointly are expected to increase the annual afforestation rate as well as a build-up of the forest carbon stock over time.

Policies such as the National Strategy on Forest and Climate Change (2013) aim to link Chile's forestry initiatives with the existing carbon market, specifically through the generation and commercialization of emission reduction certificates (carbon credits) and, at the same time, to attract foreign investment and financial support for the reforestation and forest protection activities through the REDD+ mechanisms. However, these policies were currently not accounted for in the current policies scenario due to undefined measures and to the vague wording of the law, which gives room to forest agents to take advantage of loopholes in the law.

5.2 Details of NewClimate calculations

Historical emissions

Historical emissions from 1990 to 2013 (using Global Warming Potentials from the IPCC Second Assessment Report) were taken from Chile's NC3, published in December 2016 (Government of Chile, 2016b).

Emissions projections under current policies

NewClimate Institute's estimates under current policies are based on its analysis for the Climate Action Tracker[11]. Total emissions projections were estimated as the sum of projections for individual sectors: agriculture, waste, energy, and Industrial Processes and Product Use (IPPU):

[11] https://climateactiontracker.org/countries/chile (update August 2018)

- Projections for waste and agriculture sectors are taken from MAPS Chile (Línea Base 2013, PIB bajo) (Government of Chile, 2014). The base year of the MAPS Chile scenario is 2013, and it is based on macroeconomic projections from 2013 (low case GDP growth, an average annual GDP growth of 3% through 2030) and includes implemented policies up until 2013.
- The energy sector projections are taken from the Mitigation Plan's current implemented policies scenario (Government of Chile, 2017c). The policies included in this scenario include the Unconventional Renewable Energy Law (Law 20.257/2008), the carbon tax (Law 20.780/2014), and the results of electricity supply tenders as of December 2017 (Government of Chile, 2017c). Some newer policy developments such as the update on the Distributed Generation Law (also referred to as the "Net Billing" Law) (Law 20.571), which triples the capacity threshold for installed capacity for projects of self-consumption, or the Electromobility Strategy are not quantified due to lack of available data.
- The IPPU sector emissions were projected by assuming a continuation of historical emissions trends from the inventory due to lack of available national projections.

Chile's Mitigation Plan also includes a scenario developed in the context of Chile's National Energy Policy towards 2050 (also referred to as the 2050 Energy Strategy), we quantify this as planned policies. This scenario includes the targets of electricity generation from renewable energy of at least 60% by 2035 and 70% by 2050. The CAT analysis estimates that by following the planned policies pathway presented on the Mitigation Plan, Chile will achieve its 2020 pledge, its unconditional NDC target and come close to achieving its conditional NDC target.

We did not quantify the effect of the carbon tax, which was implemented at $5 USD in 2017 for stationary sources with over 50MWt[12] capacity and covers only 40% of carbon emissions (Government of Chile, 2016b). It is not clear if the effects of the tax are additional to efficiency measures included in the BAU, and are in any case likely to be small. The MAPS Chile project estimated that if a carbon tax of $5 USD were applied to *all* sources of carbon, the emission reductions from BAU would be 3.61 $MtCO_2$/year in 2020 and 5.17 $MtCO_2$/year in 2030, or about 3% of BAU emissions (Government of Chile, 2014). Since the actual law covers only ~40% of emissions, the reduction is likely to be even smaller.

[12] Refers to the thermal energy input of a power plant. It gives an indication of fuel input in a power plant. Conventionally, a power plant's capacity is given in terms of electricity output (in MWe or MW).The closer the thermal energy input of a plant is to the electrical power output (in. MWe), the more efficient a power plant is.

Table S5: Overview of key climate change mitigation-related policies in Chile. Source: (Government of Chile, 2013a, 2013b, 2014, 2016a, 2016b, 2017a, 2018; Ministerio de Energia del Gobierno de Chile, 2015, 2018)

Sector	**Policies (marked with "(+)" when mentioned in the NDC document)**	**Description**	**NewClimate quantification of impact**
Economy-wide	Climate Action Plan 2017-2022 (2017)	• Climate change policy overarching instrument. It guides climate mitigation actions and intends to advance climate mitigation measures.	• Not considered due to its overarching nature
	Energy Efficiency Action Plan (2012)	• 12% reduction of final energy demand below business-as-usual (BAU) in 2020 (as projected from 2010)	• Included in current policies scenario (through Mitigation Plan's current policy scenario)
Energy supply	Agreement between the government and major utilities to cease construction of new coal power plants without CCS (2018)	• This agreement also included the aim to phase out coal. The timeline is not yet specified.	• Included in planned policies scenario
	Law 20698: Non-Conventional Renewable Energy Law (NCRE) (2013) (+)	• Utilities larger than 200MW to generate 5% of electricity from non-conventional renewable sources in 2013 with continued increase to 12% in 2020, 18% in 2024 and 20% in 2025. The non-conventional renewable energy sources do not include hydro larger than 40MW.	• Included in current policies scenario (through Mitigation Plan's current policy scenario)
	Energy Plan 2050 (2016)	• Target to generate 60% of electricity from renewable sources (incl. large hydro) in 2035 and 70% in 2050	• Included in planned policies scenario
	Law 20780: "Green tax on stationary sources" (2017)	• Carbon tax of $5 USD/ton CO_2 implemented in 2017. Applies to stationary sources with capacities greater than $50MW_{th}$.	• Included in current policies scenario (through Mitigation Plan's current policy scenario)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
	Reform to the Distributed Generation Law ("Net Billing") (2018)	• The law promotes projects that produce electricity for self-consumption. The reform includes a tripling of the threshold for installed capacity (from 100 to 300kW).	• Not quantified
Transport	Law 20780: "Green tax" second stage (+) (2016)	• The second stage of the "green tax" mandates: 50% tax increase of NO_X emissions by 2016 (10% for gasoline-based vehicles and 40% for diesel based vehicles). By 2017, there will be another 50% tax increase.	• Included in current policies scenario (through Mitigation Plan's current policy scenario)
	Energy Efficiency Action Plan (2012)	• Vehicle labeling system and setting of minimum energy efficiency standards for vehicles to achieve an economy-wide reduction of 12% below BAU in 2020	• Included in current policies scenario (through Mitigation Plan's current policy scenario)
	Electromobility Strategy	• Target of 40% share of electric passenger vehicles and 100% electrified public transport by 2050	• Not quantified
Industry	Energy Efficiency Action Plan (2012)	• Promote energy management systems, energy efficient technologies, and cogeneration to reduce energy consumption	• Included in current policies scenario (through Mitigation Plan's current policy scenario)
Buildings	Law 20.571/2016 (2016)	Incentivise the use of solar heating through tax cuts for developers	• Not quantified
	Energy efficiency in public buildings (2012)	• 20% of energy savings below BAU by 2020	• Not quantified
	Energy Efficiency Action Plan (2012)	• Promote energy efficiency in buildings and introduce labeling scheme and efficiency standards for appliances	• Included in current policies scenario (through Mitigation Plan's current policy scenario)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Forestry	National Strategy for Climate Change and Vegetation Resources (2010)	• 100,000 hectares of recovery and sustainable forest management of native forests • 100,000 hectares of afforestation, mainly native tree species	• Included in the current policies scenario

5.3 Details of IIASA calculations

The LULUCF emissions and removals for Chile under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the National Forest and Climate Change Strategy and the Forestation program). The emissions projections under current policies of LULUCF emissions and removals have been harmonised for the year in 2010 based on estimates reported on the UNFCCC portal (UNFCCC, 2019). For this assessment, only forestry related changes in LULUCF carbon pools for Chile were being accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time.

For the emissions projections under current policies to reach consistency with policy measures related to reforestation and recovery of forest land, a nation-wide carbon price was induced as of 2015 that enhances the national afforestation and reforestation rates over time. The carbon price was assumed to be implemented as of 2015 and increase linearly until 2030 such that a cumulative total of 200,000 hectares of land will be reforested and recovered from 2015 until 2030.

6 China

6.1 Assessment

NDC

China submitted its Nationally Determined Contribution (NDC) on the 3rd of September, 2016. It includes an intention to peak CO_2 emissions around 2030, making best efforts to peak earlier, to reduce the carbon intensity of GDP by 60–65% from 2005 levels by 2030 and to increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030 as well as to increase the forest stock volume by around 4.5 billion m^3 from 2005 levels by 2030. Although China's NDC is framed in terms of CO_2, the discussion text also implies action on other gases. China's NDC also includes a comprehensive list of actions. The GHG targets cover CO_2 but the sectors to which the targets apply are not specified.

The PBL and NewClimate estimates give a large range of potential impacts of China's NDC on national emissions. The studies assessed in UNEP (2015), which includes PBL and Climate Action Tracker projections, show an even wider range resulting from different assumptions on GDP growth rate, different base year data and different estimates of emissions other than CO_2 emissions from the energy sector (and cement), etc. In addition, the higher estimates of LSE, CROADS and Climate Advisers in UNEP (2015) are based on the NDC intensity target calculations only.

An official estimate is not available. However, two national estimates for CO_2 emissions from the energy sector (and cement) are available from NCSC (Sha et al., 2015) and updated calculations from Energy Research Institute (ERI) (Jiang et al., 2013). Three studies (Climate Action Tracker, IEA and PBL) that estimated both China's current policy scenario and the NDC scenario demonstrate a further reduction from emissions projections under current policies to the NDC in 2030 (den Elzen et al., 2016b). Only NCSC's estimate of 15.2 $GtCO_2e$/year adjusts for the effect of including energy statistics from the 2014 economic census, which leads to a much higher estimate for China's CO_2 emission in 2030 (around 1 $GtCO_2e$/year higher than the pre-adjustment estimate) (Sha et al., 2015). A study of LSE (Green and Stern, 2016), taking into account recent changes in China's economy and energy system, concludes that energy CO_2 emissions are likely to peak before 2025.

Current policies

In December 2017, China announced a new national emissions trading system, which will initially apply only to the power sector (expected to be fully operation by 2020) but may be expanded to other sectors in the future. For details on the features of the China's national ETS as announced in December 2017 (see Table 1 of Jotzo et al. (2018)). The National Development and Reform Commission announced it will reduce steel capacity by around 30 million tonnes and coal output by about 150 million tonnes in 2018, thus achieving targets from the Five-Year Plan ahead of the original target year 2020.

The PBL emissions projections are similar to den Elzen et al. (2015) and based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S6). Policies covered in NewClimate Institute calculations are summarised in Table S6.

Table S6: Overview of key climate change mitigation policies in China. Source: (State Council, 2015, The People's Republic of China, 2012, The People's Republic of China, 2014a, The People's Republic of China, 2014b). Note: Policy targets may change significantly under the 13th Five Year Plan (2016–2020) currently in action.

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	National Action Plan on Climate Change (2014)	• Emission trading program expected to be operational for the power sector by 2020	• Not included	• Not included
	13th Five Year Plan (2016–2020)	• Cap on total primary energy use in 2020 at 5.0 billion tce • Decrease CO_2 intensity by 18% between 2015 and 2020 • Decrease energy intensity (TPES/GDP) by 15% by 2020, relative to 2015	• Both cap and intensity: checked if met after implementation of other policies (yes: targets overachieved)	• Both cap and intensity: checked if met after implementation of other policies (yes: targets overachieved)
	The Thirteenth Five Year Energy Development Plan (2016–2020)	• Limit share of coal to 58% of total energy consumption	• Checked if met after implementation of other policies (yes)	• Not included separately, but checked if met after implementation of other policies (yes, 54% by 2020)
Energy supply	Energy Development Strategy Action Plan 2014–2020	• Cap on coal consumption in 2020 at 4.1 billion tce (84.5 EJ/year) • A 10% target share of gas in primary energy supply in 2020 • 15% non-fossil share in TPES in 2020	• Cap on coal: checked if met after implementation of other policies. • Gas share: assumed that coal-gas shift will take place until gas reaches 10% share • Non-fossil share: checked if met after implementation of other policies.	• Cap on coal and target share of gas: checked if met after implementation of other policies (targets overachieved: coal 78 EJ, gas 15% by 2020) • Non-fossil share checked if met after

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
		• Renewable electricity: 340 GW hydropower excl. pumped storage, 210 GW wind, 105 GW solar PV, 5 GW solar thermal, 15 GW biomass, 0.1 GW tidal[4)] • 800 million m^2 collector area • 10 million tonnes ethanol, 2 million tonnes biodiesel • 58 GW nuclear power (150 GW by 2030)	• Renewable power and nuclear capacity targets included as per the 13th Five-Year-Plan (340 GW hydro, 210 GW wind, 110 GW solar, 15 GW biomass, 58 GW nuclear) • Collector area and ethanol/biodiesel targets not included	implementation of other policies (19.2% reached by 2020) • Renewable power and nuclear capacity targets included as such (wind target assumed to be met onshore, tidal not included) • Collector area and ethanol/biodiesel targets not included
	Action Plan for Upgrading of Coal Power Energy Conservation and Emission Reduction Released (2014)	• Reduce average net coal consumption rate of new coal-fired power plants to 300 g of standard coal per kWh)	• Follows the projections of IEA WEO 2017 Current Policies Scenario	• Older plants are retired if average efficiency of installed capacity is higher than target between 2015 and 2020, aiming for 40% efficiency for new coal plants and 38% efficiency for the total coal fleet.
Transport	Vehicle fuel economy standards (2005)	• Fuel efficiency of new heavy-duty trucks: 1.2 MJ/tkm by 2021	• Follows the projections of IEA WEO 2017 (Current Policies Scenario): China 5 emission standards for light-duty vehicles, China IV emission standards for heavy-duty vehicles (gasoline), and China V emissions	• Implemented: 1.1 MJ/pkm for light-duty vehicles by 2020, and 1.23

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
			standards for heavy-duty vehicles (diesel).	
	Biofuel targets	• Ethanol blending mandates 10% in selected provinces	• Follows the projections of IEA WEO 2017 (Current Policies Scenario)	• Implemented as 1.1% biofuel share (bioethanol + biodiesel) by 2020 – 1.2% reached.
	"Made in China 2025" standards for auto industry	• Fuel economy standards of 5L/100 km by 2020 • 1 million units of new energy vehicles sold in 2020	•	• Implemented: share of electric and plug-in vehicles reaches 2% by 2020 (1.5% aimed for) and 5.9% of production (6% aimed for). This is done by enforcing the share of new electric cars in the TIMER model.
Industry	"Made in China 2025" CO_2 intensity target (2013)	• Manufacturing industries reduce their CO_2 emissions per unit of added value by 22% by 2020 and 40% by 2025 from 2015 levels[1),]	• Not explicitly included	• Checked if reached after implementation of other policies; overachieved (31% by 2020 and 47% by 2025)
	Green industry development plan (2016–2020) China 2016	• Decrease energy consumption per value added by 18% between 2015 and 2020.	• Not explicitly included	• Checked if reached after implementation of other policies; overachieved (36% by 2020)
Buildings	Appliance standards and labelling programme	• Supplemented with subsidies and awareness-raising campaigns*	• Follows the projections of IEA WEO 2017 (Current Policies Scenario)	• Not included

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
	National Building Energy Standard	• 30% of newly constructed to meet standards by 2020	• Follows the projections of IEA WEO 2017 (Current Policies Scenario)	•
Forestry	Promotion of afforestation and sustainable forest management	• Increasing the forest area by 40 million hectares and the forest stock volume by 1.3 billion m^3 from 2005 levels by 2020.	• Not included	• IIASA projection
	Program Plan of Fast Growing and High Yielding Timber Plantations (2001)	• Establishment of at least 15 million hectares of fast-growing, high-yield plantations, of which 5.8 million hectares of fast-growing pulpwood plantations	• Not included	• IIASA projection
	Mid and Long-Term Plan for National Forest Management (2011)	• Building young and mid-aged forest tending areas and transformation of low-yield forest area in the range of 35 million hectares	• Not included	• Not included in IIASA projections
	National Afforestation and Greening Plan 2011 – 2020	• Initiative for enhancing afforestation and greening of dry areas. Increase the forest cover to 21.6% by 2015	• Not included	• IIASA projection
	Natural Forest Resources Conservation	• Afforestation of 2.5 million hectares of land	• Not included	• IIASA projection

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
	Programme (2011)			
	Programme for Conversion of Slope Farmlands into Forests (2014)	• Convert 533,000 hectares of slope farmlands to forests. • Afforest 55,000 hectares of barren hills and sandy wastelands.	• Not included	• IIASA projection

Both PBL and NewClimate calculations were supplemented with the IIASA projections on LULUCF emissions and removals. The LULUCF emissions projections under current policies by IIASA are based on land use and forestry-related policies, particularly afforestation measures and the development of tree plantations. However, current policies to promote afforestation and increase of the forest stock volumes are projected to lead to relatively minor net emission savings by 2030 as policy targets are expected to already be achieved within currently implemented policies.

6.2 Details of NewClimate calculations

Historical emissions

We obtained energy-related emissions from the IEA Statistics and Balances (IEA, 2017a), a time series from 1990 until 2015.

Non-energy-related emissions were calculated as the sum of CO_2 process emissions from industry and non-CO_2 emissions. We obtain these from the data submitted to the UNFCCC for 2000 and 2005, and from China's BUR1 for 2012 (People's Republic of China, 2016; UNFCCC, 2017).

NDC

The estimate of the 2020 and 2030 pledges reflects China's announcement to aim at a share of non-fossil fuels in primary energy consumption of 15% and 20% (excluding biofuels), respectively, as well as reaching a share of 10% in gas in primary energy supply by 2020. For these targets, we started from the current policies scenario of the WEO2017 and added the effect of recently-adopted policies including the target for gas of at least 10% and a share of 20% non-fossil fuels (excluding biomass), insofar as these are not yet reached by the WEO2017 Current Policies Scenario.

Because the NDC contains the target of peaking CO_2 emissions latest in 2030, the implications for what an "NDC scenario" constitutes can be interpreted in a variety of ways—for instance, the least ambitious way would be to assume emissions keep rising and simply peak in 2030 or a more ambitious interpretation would be to assume that this peaking happens somewhat earlier. We took the peak level of the "continued coal abatement" scenario as the lower bound of CO_2 emissions under the NDC scenario and the scenario of emissions reaching *only* the non-fossil and gas targets as the upper end of the range of the NDC scenario by 2030.

For the calculation of the intensity target, we used historical data from China's Statistical Yearbook and GDP projections from WEO2017 and IMF. Our projections were based on the GDP growth rate from the IEA World Energy Outlook 2017 (5.8% annual growth between 2020 and 2025 and 3.7% annual growth between 2025 and 2030). We used the IMF 2017 as an alternative scenario for 2016 to 2020 (average of 6.4% annual growth). It would seem unlikely that the Chinese government is actually planning for a lower GDP growth rate than in our central estimate case, as the 13th Five Year Plan targets a growth of 6.5% until 2020 (The People's Republic of China, 2016).

Based on projections (as described above), however, non-CO_2 GHG emissions will continue to grow. This growth is likely to determine the absolute level of total GHG emissions in 2030 as well as the continuing upward trend points to a need for further policies. China has started to implement some of the actions on non-CO_2 emissions indicated in the NDC (see section on current policies), but those are not yet concrete enough to quantitatively include them in our assessment.

Emissions projections under current policies

The emissions projections under current policies by NewClimate Institute were based on its analysis for the Climate Action Tracker.[13] For projections of energy-related CO_2 emissions, we used projections from the World Energy Outlook 2017 (IEA, 2017b). We adjusted the renewable energy capacity based on the most ambitious numbers among those reported in the Bloomberg New Energy Finance report (BNEF, 2013) and official communications from China (NDRC, 2016).[8]

For non-CO_2 emissions, the approach for extrapolating historical data series beyond 2012 was as follows: non-energy-related emissions were calculated as the sum of CO_2 process emissions from industry and non-CO_2 emissions. We obtained these from the data submitted to the UNFCCC for 2000 and 2005, and from China's BUR1 for 2012 (People's Republic of China, 2016, UNFCCC, 2019). This data was extrapolated to past and future years (up to 2030) using growth rates of the sum of process and non-CO_2 emissions. The latter was calculated as follows:

- CO_2 emissions from processes (excluding cement making) and non-CO_2 emissions from JRC & PBL (2014), giving a data series for 1990–2010.
- Growth rates from the US EPA projections of non-CO2 emissions were used to extrapolate the non-CO2 emissions series from JRC & PBL (2014).
- CO_2 process emissions were obtained from Boden & Andres (Boden and Andres, 2016) for cement-related emissions and from JRC & PBL (2014) for all other types, again giving a data series for 1990–2010. This data series was extrapolated to 2030 using the growth rates in cement emissions from the 2016 IEA Energy Technology Perspectives for non-OECD regions (IEA, 2016a).

The resulting time series 1990–2030 of (a) non-CO_2 emissions and (b) CO_2 process emissions were then added up. Their aggregate growth rate was subsequently applied to the non-CO_2 emissions time series 2000-2012. The resulting data series constitutes the "current policies scenario" of non-CO_2 emissions.

China's cap on coal, at 58% of total primary energy consumption in 2020 (Lin, 2017), would be overshot in 2030 following the WEO2017 projections. Therefore, we adapted the mix of energy demand based on recent trends in declining coal consumption in China. Measured in tonnes, China's coal consumption declined for three straight years: by 2.9% in 2014, 3.7% in 2015 and 4.7% in 2016 (National Bureau of Statistics of China, 2017, Nature, 2017). However, the actual reduction in energy use was reportedly lower, at 1.3% (Korsbakken and Peters, 2017), discounting for the poor quality of coal. Data from China's national statistics (National Bureau of Statistics of China, 2016) also indicate that the difference in coal consumption between February 2016 and February 2017 was 1.3%. We used the ratio between the

[13] https://climateactiontracker.org/countries/china (update November 2018)

latter number and the reduction in tonnes to estimate the reduction in energy demand from coal in 2015 and 2016.

We considered two scenarios of further development of coal abatement, representing optimistic and pessimistic assumptions. The optimistic **continued coal abatement** scenario assumes that a similar rate of reduction as in 2016 can be kept up in the next decade up until 2030. The pessimistic **stalled coal abatement** scenario assumes that coal use will stabilise after the recent reductions at close to today's level and no further reductions beyond those in the last three years will occur.

To then quantify emissions reductions from the fuel switch, we considered two options of fuel mix development. The first was to maintain the total primary energy demand as in the current policies scenario of the WEO 2017 (from coal towards gas and renewables, which helps achieve the NDC targets on share of gas and non-fossil fuels). The second option was to allow for some flexibility in the total primary energy demand and assume that the coal reduction was accompanied by increasing efficiency, additional to the already expected development of renewable energy and gas.

6.3 Details of PBL calculations

The China region in TIMER contains a few additional countries (see the IMAGE wiki for more details), which are small enough in terms of emissions to not do a downscaling.

6.4 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (Promotion of afforestation and sustainable forest management, Program Plan of Fast Growing and High Yielding Timber Plantations, National Afforestation and Greening Plan, Natural Forest Resources Conservation Programme and Programme for Conversion of Slope Farmlands into Forests). For this assessment, only forestry related changes in LULUCF carbon pools for China were being accounted for (i.e. Afforestation, Deforestation, and Forest Management) and total net LULUCF emissions were harmonised to the BUR1 (The People's Republic of China, 2017) estimates of net LULUCF emissions in 2012. All non-forest related LULUCF emissions and removals (including the Harvested Wood Product carbon pool) were assumed to remain constant over time at the levels provided in the BUR1 (The People's Republic of China, 2017).

For the projections under current policies to reach consistency with policy measures related to forest area (i.e. afforestation, reforestation, greening initiatives and the establishment of fast-growing timber plantations) a nation-wide carbon price was induced as of 2010 that enhances the national afforestation and reforestation rates over time. The carbon price was assumed to be implemented as of 2010 and increase linearly until 2020 such the forest area would be increased by 42.5 million hectares and that the forest carbon stock would increase by 1.3 billion m^3 (including above and below ground biomass) by 2020 as compared to 2005 estimates. In addition, the selected carbon price as selected ensures that the national forest coverage reaches 21.6% of the country's land area by 2020. Both newly afforested and reforested lands were accounted for in the targeted increase of the forest land area. After 2020, the carbon price was set to linearly increase until 2030 such that a cumulative total of 15 million hectares of high yield plantation would develop during the period of 2010 until 2030, and that an additional 588 thousands hectares of land will be afforested during the period to fulfil the Programme for Conversion of Slope Farmlands into Forests.

7 Colombia

7.1 Assessment

NDC

Colombia submitted its Intended Nationally Determined Contribution (INDC) on the 7th of September 2015. Colombia ratified the Paris Agreement on the 13th of June 2017 and submitted its First NDC to the UNFCCC registry on the 12th of July 2018. The unconditional target is to reduce its GHG emissions by 20% from BAU level by 2030, and the conditional target commits to raising the target level to a 30% reduction below BAU level, subject to the provision of international support. The NDC has an economy-wide scope, includes 6 gases acknowledged by the Kyoto protocol (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) and applies SAR GWP.

The coverage of the LULUCF sector in the NDC is unclear. On the one hand, the NDC document states that the AFOLU (agriculture, forestry and other land uses) sector is included in the overall target. On the other hand, it also states that the BAU scenario excludes removals from natural forests that remain as natural forests subjected to the negotiations concerning the accounting rules. The natural forests in Colombia corresponded to a net sink of 263 $MtCO_2e$/year in 2010 (IDEAM et al., 2015).

Colombia's BAU emissions pathway from 2010 represents a level of 278 $MtCO_2e$/year by 2020 and 335 $MtCO_2e$/year by 2030. Therefore, the unconditional and conditional targets translate to 235 $MtCO_2e$/year and 268 $MtCO_2e$/year in 2030, respectively, including carbon emission and removals from forest plantations and permanent crops.

Current policies

See Table S7: Overview of key climate change mitigation policies in Colombia. Source: (IEA, 2013; CCAP, 2016; Congreso de la República, 2016; Ministry of Environment and Sustainable Development, 2016; Transport NAMA Database, 2017b; Unidad de Planeación Minero Energética de Colombia, 2017; Ministerio de Ambiente y Desarrollo Sostenible, 2017b, 2017a; Ministerio de Hacienda y Crédito Público, 2017; NAMA Facility, 2017; Transport NAMA Database, 2017a; Consejo Nacional de Política Económica y Social, República de Colombia and Departamento Nacional de Planeación, 2018)

for coverage of current policies.

The emissions projections under current policies excluding LULUCF by NewClimate Institute build upon adjusted BAU emissions projections provided in Colombia's NDC and the additional quantification of currently implemented policy measures. BAU projections provided in Colombia's NDC have been harmonised with inventory data, which led to significant reductions in BAU emission levels in 2020 and 2030 (see further explanation in Section 7.2).

The quantification of each policy measure is provided by the Universidad de los Andes (2016), which the MAPS Colombia Project cited upon formulating Colombia's NDC as well as sectoral mitigation action plans. NewClimate Institute's projections only consider those mitigation measures indicated with a high probability of being implemented and high probability of achieving the intended mitigation levels (rated as "4 out of 5" and "5 out of 5"). Moreover, only the measures planned to be implemented either by the end of 2016 or already implemented were considered. The upper bound of the projections considers five measures with a "5 out of 5" score, whereas the lower bound of the projections further consider eight additional measures with a "4 out of 5" score. In addition, the mitigation impact of three NAMAs (one in the buildings sector, two in the transport sector) has been further accounted for in the lower and

upper bound of the projections. The total annual GHG reductions of mitigation measures range from 6 to 14 $MtCO_2e$/year in 2020 and 19 to 53 $MtCO_2$/year in 2030 respectively.

It should be noted that the aforementioned mitigation measures are not directly linked to implemented policies, thus leading to a high degree of uncertainty of the projections. In conjunction with the uncertainty linked to BAU emission projections, the projections presented here should be treated with caution and the entire process will be followed closely to further enhance future assessments.

The projections of LULUCF emissions and removals for Colombia as developed by IIASA, which supplement the NewClimate projections, is based on updated G4M estimates and have been harmonised to historical data sets as presented in Colombia's BUR1 (IDEAM et al., 2015). Colombia's BUR1 (IDEAM et al., 2015) exclude removals related to forest land (i.e. UNFCCC reporting category Forests remaining Forests) in their reporting of the LULUCF sector.

LULUCF estimates including and excluding removals related to forest land are provided in the BUR1 (Table 2.10), but the emissions projections have been harmonised to be consistent with the national reporting and only accounts for the pools and sources of emissions and removals that are considered in the BUR1. The projections see a decrease of the net LULUCF emissions over time, mainly driven by efforts to reduce the annual deforestation rate, as well as reforestation of forest areas that previously have been deforested.

The emissions projections under current policies include the National Development Plan of Colombia, which aims to reduce the yearly deforestation rate from 121,000 ha/year in 2013 to 90,000 ha/year by 2018. This expected reduction of the yearly deforestation rate is achieved in the emissions projections under current policies, while on the other hand, the target of zero net deforestation by 2020 of the Amazing Vision Program is not accounted for. The Amazing Vision Program was adopted as of 2016 but it is still uncertain how the target of zero net deforestation by 2020 would be achieved. Therefore, the policy was not included in the IIASA current policies scenario.

Still, it is projected that under the current policies scenario for Colombia, the net LULUCF sink would be enhanced by 2030 as compared to levels in 2010.

Table S7: Overview of key climate change mitigation policies in Colombia. Source: (IEA, 2013; CCAP, 2016; Congreso de la República, 2016; Ministry of Environment and Sustainable Development, 2016; Transport NAMA Database, 2017b; Unidad de Planeación Minero Energética de Colombia, 2017; Ministerio de Ambiente y Desarrollo Sostenible, 2017b, 2017a; Ministerio de Hacienda y Crédito Público, 2017; NAMA Facility, 2017; Transport NAMA Database, 2017a; Consejo Nacional de Política Económica y Social, República de Colombia and Departamento Nacional de Planeación, 2018)

Sector	Policies (marked with "(+)" when mentioned in the INDC document)	Description	NewClimate quantification of impact
Economy-wide	Decree 926 (June 17)	• This decree establishes a mechanism for exemption of the national Carbon Tax (Law 1819 Art 221). The national carbon tax is charged to all liquid fossil fuels since beginning of 2017. For exemption, actors in the value chain of liquid fossil fuels (including end users) need to demonstrate carbon neutrality, which can be achieved through offsets from external projects on, e.g., renewable energy and energy efficiency	• Not included
	Resolution No.1988 (September 2017) Resolution No.585 (October 2017)	• The resolution No. 1988 establishes the adoption of environmental goals in different sectors as described in the PAI (Indicatory Action Plan on energy efficiency) 2017-2022. The goals are translated into measures that include use of natural gas and electricity in the transportation sector, energy efficient lighting, cooling and heat in the industry sector, and energy efficiency in the commercial and residential buildings sector. The resolution No.585 establishes procedures to carry out those measures.	• Not included
Energy supply	Colombian Low-Carbon Development Strategy (+) (ECDBC) (2012)	• Through the implementation of 8 Sectorial Mitigation Action Plans (SMAPs), approved by the relevant sectoral Ministries, the ECDBC aims to deviate from BAU emissions growth, estimated to be over 60% from current levels by 2030	• Partially reflected trough selected mitigation measures
	Law 697: Programme for rational and efficient use of energy and other forms of non-conventional Energy (PROURE) (2010)	• PROURE plans to achieve a 20% and 30% of RE sources by 2015 and 2020, respectively	• Not included
Buildings	NAMA Project – For the domestic refrigeration sector (2017–2021)	• Reduction of emissions from the domestic refrigeration sector by providing technical support and capacity building	• Included

Sector	Policies (marked with "(+)" when mentioned in the INDC document)	Description	NewClimate quantification of impact
		• GHG emissions reduction of 16.8 $MtCO_2e$ over the lifetime of the equipment, and an annual reduction of around 3.8 $MtCO_2e$/year by 2030 (50% reduction from BAU in the sector)	
	National policy for sustainable buildings (March 2018)	• Planning for sustainable construction to 2030. The Board of the National Economic and Social Policy (CONPES) approved on March 2018 the national policy for sustainable buildings with a target to make new construction in Colombia more energy efficient.	• Not included
Transport	NAMA Project – Colombia Transit Development (TOD) (2015–2019)	• Construction of lasting infrastructure and buildings that will lock in efficient land use and travel patterns • Estimated reductions of annual GHG emissions by 3.6 to 5.5 $MtCO_2e$/year by 2040.	• Included
	NAMA Project - Sustainable road-based freight transport Colombia (2015–2016)	• Renovation of the cargo vehicle fleet with the aim to improve economic competitiveness and environmental performance of the freight transport sector • Estimated reductions of annual GHG emissions by 0.52 $MtCO_2e$/year	• Included
Forestry	The National Development Plan of Colombia (+) (2015)	• Reduction of the annual deforestation rate from 121,000 hectares in 2013 to 90,000 hectares by 2018	• IIASA projections
	The Amazon Vision Program (+) (2016)	• Achieve zero net deforestation by 2020	• Policy not included in IIASA projections
	REDD+ Zero Deforestation in the Amazon by 2020 (2009)	• REDD+ consists of 4 phases strategy with a total of 18.5 million USD for planning and implementation	• Policy not included in IIASA projections

7.2 Details of NewClimate calculations

Historical emissions

Historical emissions for the years 1990, 1994, 2000, 2004, 2010 and 2012 were taken from Colombia's BUR1 (IDEAM et al., 2015)) with linear interpolation added for all years in-between.

Emissions projections under current policies

The emissions projections under current policies for Colombia by NewClimate Institute were based on new country-level analysis as Colombia has not been analysed by the Climate Action Tracker. The projections were built upon adjusted BAU emission projections provided in Colombia's NDC and the additional quantification of currently implemented policy measures by the Universidad de los Andes (Universidad de los Andes, 2016).

To account for this downward reduction in emission levels for 2012, NDC BAU projections have been harmonised with latest inventory data in two following two ways to reflect the range of uncertainty:

- For the ***upper bound of BAU projections***, growth rates of INDC BAU scenario have been applied to 2012 inventory emissions provided in the BUR1 (IDEAM et al., 2015).
- For the ***lower bound of BAU projections***, the difference between 2012 inventory emissions provided in the BUR1 (IDEAM et al., 2015) and the emission levels assumed under the NDC BAU scenario (i.e. a difference of 58 $MtCO_2e$/year) have been subtracted from NDC BAU emission projections for each year between 2013 and 2030.

With regard to the impact quantification for the policies not considered under the BAU projections, the analysis of the Universidad de los Andes (Universidad de los Andes, 2016) considered mitigation measures that are aligned with the National Development Plan and that are currently planned for each sector. In total, 58 mitigation measures have been evaluated for Colombia's NDC formulation in the more restrictive scenario proposed by the MAPS Colombia Project, excluding those measures which have not been considered viable by governmental institutions or sectoral unions.

Measures rated as "5 out of 5" that were considered in the current policies are the following:

- Measure No. 7: Energy efficiency - GRB with new technology
- Measure No. 28: Carbon substitution for biomass in the cement industry
- Measure No. 31: Substitution of 100,000 old, low-efficiency engines
- Measure No. 64: Optimization in the glycol use as natural gas dehydration
- Measure No. 66: Process improvement by condensate recovery in storage systems crude

Measures rated as "4 out of 5" that were considered in the current policies are the following:

- Measure No. 67: Capture of vent gas issued by mechanical pumping wells (applied to 70% potential oil, gas and carbon wells)
- Measure 71d: Direct Reduced Iron (DRI) production with Midrex technology
- Measure 72: Process improvement by a rational sheepherding
- Measure 82: Technical assistance and fertilization in potato crops
- Measure 84b: Solid waste composting with increasing reductions of 5% every 5 years
- Measure 86a: Capture and burning of CH_4 in sanitary landfills
- Measure 88a: Capture and burning of CH_4 in residual domestic waters
- Measure 90a: Capture and burning of CH_4 in residual industrial waters

It should be noted that the aforementioned mitigation measures are not directly linked to implemented policies, thus leading a high degree of uncertainty with regards to NewClimate Institute's emissions projections under current policies. In addition, the mitigation impact of the following three NAMAs that are currently under implementation was considered in the analysis:

- NAMA for the domestic refrigeration sector (2017–2021)
- NAMA for Colombia Transit Development (TOD) (2015–2019)
- NAMA for sustainable road-based freight transport Colombia (2015–2016)

For the first two NAMAs, for which no annual emission reduction estimates by 2020 and/or 2030 are available, linear interpolation between the start year of the NAMA and the final year for which an annual emission reduction estimate has been available (i.e., 2030 for the NAMA for the domestic refrigeration

sector and 2040 for the NAMA on Colombia Transit Development) has been applied to obtain estimates for 2020 and/or 2030.

7.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the National Development Plan of Colombia). For this assessment, only forestry related changes in LULUCF carbon pools for Colombia were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to reporting from Colombia's BUR1 (IDEAM et al., 2015).

For the emissions projections under current policies to reach consistency with policy measured related to the reduction of the national deforestation rate, a nation-wide carbon price was induced as of 2015 that reduces the deforestation rate and enhances the afforestation rate over time. The carbon price was assumed to be implemented as of 2015 and increased linearly until 2018 such that the annual deforestation rate would be reduced from 121,000 ha/year to 90,000 ha/year as of 2018. After 2018, the carbon price was assumed to remain constant over time.

8 Democratic Republic of the Congo (DRC)

8.1 Assessment

NDC

The Democratic Republic of Congo (DRC) aims to reduce its GHG emissions (including LULUCF) by 17% below BAU by 2030 under its NDC. The targeted GHG emissions correspond to 357 $MtCO_2e$/year in 2030 including LULUCF and a 73 $MtCO_2e$/year reduction in 2030 compared to a BAU scenario. The country's target is conditional on international financial support of USD 12.5 billion. In the emission trajectories depicted in the NDC document, LULUCF emissions, which represent over 80% of the country's emissions, would increase from 190 $MtCO_2e$/year in 2010 to 300 $MtCO_2e$/year in 2030. The NDC states that the reduction in LULUCF emissions for reaching the NDC target will mainly be achieved through afforestation and reforestation measures.

Current policies

Due to the limited availability of information on existing policies, the emissions under current policies for the non-LULUCF GHG emissions were projected by applying two different approaches. In the first approach, we assumed that the emissions will grow at the compound annual average growth rate historically observed for 2000–2015 (2%/yr). In the second approach, we applied the compound annual average growth rate for 2015–2030 estimated from Steibert et al. (2013) (3.6%/yr).

The CO_2 emissions projections for the LULUCF sector was developed by IIASA, based on the recent REDD-PAC project report for the DRC (see Table S8 for coverage of policies) (REDD-PAC DRC, 2016), then harmonised to 2015 historical GHG emissions. In that report, the GLOBIOM model was applied to provide a BAU projection taking into account current forestry and agriculture policies that have been implemented and legislated within the country. One of the policies with the largest impact on the projections of net LULUCF emissions is the enforcement of protected areas and prohibiting the expansion of agriculture into forest concessions.

While current peatland emissions in the DRC are reported to be minor, they may become large in the future if concessions are provided for the vast peat land areas and they were to become exploited in an industrial manner (Dargie et al., 2017).

8.2 Details of IIASA calculations

IIASA results for the Democratic Republic of Congo were based on national estimates utilizing the GLOBIOM model. Emissions projections under current policies for the Democratic Republic of Congo were based on the scenarios presented in the REDD-PAC project report for the Democratic Republic of the Congo (REDD-PAC DRC, 2016) and have been harmonised to net AFOLU emissions in 2012 presented in the NC3 by the Democratic Republic of Congo (Democratic Republic of the Congo, 2015). The LULUCF projection thereby considers the development of emissions and removals for the major LULUCF related reporting categories (i.e. Forest Land, Cropland, Grassland, and Other Land).

Table S8: Overview of key climate change mitigation policies in the Democratic Republic of the Congo. Source: (REDD-PAC DRC, 2016)

Sector	Policies (marked with "(+)" when mentioned in the INDC document)	Description	NewClimate quantification of impact
Forestry & Agriculture	Protection of permanent forest domains (Plan de convergence COMIFAC) (2015)	• No expansion of agriculture into protected forest areas • No expansion of agriculture into forest concessions	• IIASA projections
	Afforestation and reforestation measures (Plan de convergence COMIFAC) (2015) (+)	• Increase the national forest cover	• Policy not included in IIASA projections
	Sustainable timber management (Plan de convergence COMIFAC) (2015)	• Sustainable timber harvests in existing forest concessions following management plans	• IIASA projections

9 Ethiopia

9.1 Assessment

NDC

Ethiopia aims to limit its GHG emissions including LULUCF to 145 $MtCO_2e$/year or lower by 2030 under its NDC. The NDC document describes a total reduction of at least 255 $MtCO_2e$/year or 64% compared to the "business-as-usual" (BAU) scenario projection. Excluding LULUCF, the targeted emission level is 40% below BAU or 185 $MtCO_2e$/year. The NDC implementation is partially conditional on the support of an unspecified combination of domestic and international financial resources.

The NDC projection is based on the projections included in the NDC, which directly provides LULUCF emission projections up to 2030 for the NDC scenario. The mitigation measures proposed by the Ethiopian government include protection of forest areas, re-establishment of forests, and an increase of carbon stocks.

Current policies

The emissions projections under current policies excluding LULUCF are significantly lower than the BAU scenario in the NDC document (310 $MtCO_2e$/year in 2030) because of the differences in the historical emissions data used as well as the downward revision of the BAU emission growth projection in Ethiopia's Second National Communication (SNC) (Federal Democratic Republic of Ethiopia, 2015).

NewClimate Institute calculations were based on its analysis for the Climate Action Tracker.[14] The projection for non-LULUCF sectors is based on the BAU scenario reported in the SNC. It is not clear from the SNC which existing or planned policy measures were considered in the BAU scenario, but the SNC notes that "the exponential growth of emissions will resume from 2018" without focused implementation of policies. By contrast, the other scenario presented in the SNC, i.e. "CRGE scenario", assumes full implementation of the Climate Resilience and Green Economy Strategy (CRGE), which identifies and prioritizes more than 60 potential climate change mitigation and adaptation initiatives until 2030 (Federal Democratic Republic of Ethiopia, 2011).

In this analysis, NewClimate Institute assumed that most of the currently implemented policies were taken into account in the "BAU scenario", although to varying extent. Most of the measures implemented under the Growth and Transformation Plan (GTP) phase I (2010–2015), which defines Ethiopia's medium-term strategic framework for the five-year period and also includes some initiatives under the CRGE (Federal Democratic Republic of Ethiopia, 2010), were considered in our analysis.

The GTP I encompasses the National Biogas Programme (NBP) (Ethiopia Rural Energy Development and Promotion Centre (EREDPC), 2007) and the Scaling-Up Renewable Energy Program for Ethiopia (SREP) (Federal Democratic Republic of Ethiopia - Ministry of Water and Energy, 2012). These policies were not considered in our analysis, as the SNC suggests there is no project plan beyond the stage of a feasibility study. However, most recent information suggests that Ethiopia is preparing several tenders for renewable electricity by 2020 under its energy plan (PV Magazine, 2017). In addition, the 2nd phase of the National Biogas Programme seems to be underway (SNV, 2017).

[14] http://climateactiontracker.org/countries/ethiopia (update November 2017)

Table S9: Overview of key climate change mitigation policies in Ethiopia. Source: (Federal Democratic Republic of Ethiopia, 2011, Federal Democratic Republic of Ethiopia, 2016, Federal Democratic Republic of Ethiopia, 2015, Federal Democratic Republic of Ethiopia, 2010, Federal Democratic Republic of Ethiopia - Ministry of Water and Energy, 2012, Ethiopia Rural Energy Development and Promotion Centre (EREDPC), 2007)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Economy-wide	Climate Resilience and Green Economy Strategy (CRGE) (2011) (+)	• Strategy with various mitigation initiatives to limit economy-wide GHG emissions in 2030 to 150 $MtCO_2e$/year (250 $MtCO_2e$/year below BAU) • Development of up to 25 GW in renewable power capacity by 2030 (hydro 22 GW, geothermal 1 GW and wind 2 GW)	• Some initiatives under the CRGE included as part of BAU scenario in Second National Communication
Energy supply	Scaling-Up Renewable Energy Program for Ethiopia (SREP Investment Plan) (2012)	• Increase power generation capacity from the present level of 2 GW to 10 GW by 2015 and to 25 GW by 2030 • Focus on five major investment projects of wind, geothermal and hydroelectric energy generation	• Not included as Second National Communication suggests there is no project plan beyond the stage of a feasibility study
	National Biogas Programme (2007)	• Construction of 20,000 biogas plants by 2017 (2nd phase: 2014–2017)	• Not included as Second National Communication suggests there is no project plan beyond the stage of a feasibility study
Transport	Intra-Urban Electric Rail NAMA (2012)	• Replace 50% of the cargo transport with electric rail transport • Expected emissions reduction of 8.9 $MtCO_2e$/year by 2030	• Excluded due to uncertain development status
Forestry	Afforestation and reforestation actions (part of the CRGE) (2011) (+)	• Target is 7 million hectares of afforestation and reforestation by 2030. 17,000 hectares of forest to be brought under protection and natural regeneration over a planning period of 30 years.	• IIASA projections

A second phase of the GTP (GTP II) defines the medium-term strategic framework for the five-year period between 2016 to 2020. Published in May 2016, the GTP II aims for the full implementation of

Climate Resilience and Green Economy Strategy (CRGE) until 2025 (Federal Democratic Republic of Ethiopia, 2016). However, the GTP II neither specifies on the basis of which specific policies the full implementation of the CRGE shall be achieved until 2025 nor on how international funding will contribute to its full implementation, in particular, the additional reduction of 147 $MtCO_2e$/year until 2025 (Federal Democratic Republic of Ethiopia, 2016, page 212). For this reason, the GTP II is not included in the present current policies scenario of Ethiopia, but the process will be closely followed and the CRGE's implementation regularly revisited.

For the LULUCF sector, the IIASA current policies scenario of the net LULUCF emissions considers full implementation of the Comprehensive Mitigation Analysis Program as well as the Afforestation and Reforestation actions. However, it is uncertain to what extent these measures will be fulfilled and the scenario only assumes that the target of 7 million hectares of afforestation and reforestation will be met by 2040.

9.2 Details of NewClimate calculations

Historical emissions

The historical dataset was based on the UNFCCC GHG inventory data for 1990 and 1994 (with linear interpolation added for the years in between) (UNFCCC, 2017a) and the GHG inventory provided in the second National Communication for 1994–2013 (Federal Democratic Republic of Ethiopia, 2015); the inventory data uses the 100-year global warming potentials (GWPs) of the IPCC Fourth Assessment Report (AR4). F-gases are only partially reported and their contribution is negligibly small (Federal Democratic Republic of Ethiopia, 2015). Consequently, F-gases are not included in the reported historical emissions for 1994–2013.

Emissions projections under current policies

The emissions projections under current policies (excluding the LULUCF sector) assumes GHG emissions will grow according to the BAU scenario reported in the Second National Communication (Federal Democratic Republic of Ethiopia, 2015). When comparing the inventory data (1994–2013) and the BAU projections (2010–2030) provided in the Second National Communication, some difference in emission levels emerge for the years 2010 to 2013 as the BAU scenario uses the base year 2010 for its future projections. For this reason, we harmonise the BAU projections by applying emission growth rates between 2010 and 2030 projected in the BAU scenario of the SNC to the 2010 historical data in the first step to account for AR4 GWP values used in the BAU projections. For the projections, linear interpolation was applied between last inventory emission data for 2013 and the harmonised baseline projections for 2020 as well as the harmonised emission data between 2020–2025 and 2027–2029.

The BAU scenario provided in the SNC considers several currently implemented measures implemented under the Growth and Transformation Plan (GTP) phase I (2010–2015) as current policies (Federal Democratic Republic of Ethiopia, 2015, pp 36-51). The GTP I encompasses the National Biogas Programme (NBP) (Ethiopia Rural Energy Development and Promotion Centre (EREDPC), 2007) and the Scaling-Up Renewable Energy Program for Ethiopia (SREP) (Federal Democratic Republic of Ethiopia - Ministry of Water and Energy, 2012). These policies were not considered in our analysis, as the SNC suggests there is no project plan beyond the stage of a feasibility study. The Intra-Urban Electric Rail NAMA was also excluded due to its uncertain development status.[15]

[15] As of 29th of June 2017, the UNFCCC NAMA database only lists an Ethiopia's National Railway Network and Addis Ababa Light Rail Transit (LRT) NAMA under 'NAMA for recognition' comprising both the extension of the national railway network as well as the construction of the Light Rail Transit (LRT) system in Addis Ababa. Source: [Accessed on 29 June 2017 under http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaForRecognition.aspx?ID=108&viewOnly=1)

9.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the Afforestation and Reforestation actions). For this assessment, only forestry related changes in LULUCF carbon pools for Ethiopia were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals pools were assumed to remain constant over time and have been harmonised to the historical level of net emissions reported on the UNFCCC portal (UNFCCC, 2017a).

For the projections to reach consistency with policy measured related to afforestation and reforestation actions, a nation-wide carbon price was induced as of 2015 that enhances the afforestation rate and reduces the deforestation rate over time. The carbon price was assumed to be implemented as of 2015 and increased linearly until 2030 such that the 7 million hectares of afforestation and reforestation cumulatively occurred from 2015 until 2030. In addition, the protection of forests was implemented in the current policies scenario through protection of forest areas both from deforestation and non-sustainable forest management.

10 European Union

10.1 Assessment

NDC

The EU submitted its Nationally Determined Contribution (NDC) on the 5th of October, 2016 and committed to reducing GHG emissions by at least 40% by 2030 from 1990 levels. All sectors and seven GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3) are covered and 100-year GWPs from the IPCC AR4 are used (UNFCCC, 2015). The LULUCF sector is included in the target, but a decision on how to include land use is specified to be taken at a later stage. This study assumed neither accounting approaches and exclude the LULUCF sector from the calculations of NDC target.

For 2020, the EU made unconditional and conditional pledges of reducing its GHG emissions by 20% and 30% from 1990 levels, respectively.

Current policies

The emissions projections under current policies by NewClimate Institute (excluding LULUCF) were based on the Climate Action Tracker analysis[16]. The Climate Action Tracker analysis uses the EEA projections (EEA, 2018) and the EU Reference Scenario (Capros et al., 2016) as the basis for calculations (see further detail in section "Details of calculations"). The PBL emissions projections were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (see Table S10 for coverage of policies).

Compared to the 2017 report, the emissions projection range has been revised downward mainly due the revised historical emissions data (about 75 $MtCO_2e$/year lower in 2010, excluding the LULUCF sector) and the revised data harmonisation year (2016). The rate of emissions reductions observed between 2010 and 2015 was faster than our model projections for the same period.

Most important policies in the EU are the EU ETS, the Renewable Energy Directive, the Energy Efficiency Directive, the F-gas regulation and the effort sharing regulation, and directives particularly targeted at the buildings and the transport sector (see Table S10).

Other new policies, not quantified here, include proposed CO_2 emission standards for light-duty vehicles (European Commission, 2017) and the amendment to the Energy Performance of Buildings Directive (Official Journal of the European Union, 2018b), which aims at full decarbonisation of the building stock by 2050, while new buildings should be nearly zero energy as of 2020. If these recently adopted and agreed policies are fully implemented, EU emissions are estimated to be reduced by around 45% by 2030, according to the new EU climate action progress report (European Commission, 2018).

[16] https://climateactiontracker.org/countries/eu (update April 2018)

Table S10: Overview of key climate change mitigation policies in EU (European Commission, 2015, European Commission, 2016, EEA, 2018, European Parliament, 2009b, European Parliament, 2009c, Official Journal of the European Union, 2009, European Parliament, 2009a, European Parliament, 2012, European Council, 2017, Official Journal of the European Union, 2018a, European Commission, 2017, Official Journal of the European Union, 2018c)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy/ state-wide	EU ETS Directive (2003/87/EC revised by Directive 2018/410/EU)	• Emission cap on emissions from electricity/heat and industry of 43% below 2005 levels, by 2030, by reducing the cap at an annual rate of 2.2%, from 2021 onwards.	• Not included	• Included through tax on industry and energy supply sectors (32% reduction reached
	Effort sharing decision (annual GHG targets for non-ETS sectors in the period 2012-2030)	• Reduce GHG emissions from non-ETS sectors by 30% by 2030, relative to 2005	• Not included (considered planned policy)	• Not included (considered planned policy)
Energy supply	Renewable Energy Roadmap/ Directive (2009/28/EC)	• Target of 20% renewable energy by 2020	• Included through external scenarios	• Checked if met after implementation of other policies (14.9% reached)
	Energy Efficiency Directive (2012/27/EC)	• Target of 20% energy efficiency improvement by 2020	• Included through external scenarios	• Checked if met after implementation of other policies,
Buildings	Eco-design Framework Directive (Directive 2009/125/EC)	• Specific standards for a wide range of appliances	• Included through external scenarios	• Not included
	Building Energy Efficiency Directive (2012)	• Near zero energy buildings by 2020 (residential) and by 2018 (public)	• Included through external scenarios	• Implemented as building standard of 0 MJ/m^2 by 2020 (for new buildings)
Transport	Regulation of CO_2 emissions from passenger vehicles (443/2009)	• Passenger vehicle emission standard of 95 g CO_2/km, phasing in for 95% of vehicles by 2020 with 100%	• Included through external scenarios	• Implemented as 0.81 MJ/pkm by 2021 for light-duty vehicles (planned 2030 target of

		compliance by 2021		0.57-0.69 MJ/pkm also met)
		• Light commercial vehicle standards of 147 g CO_2/km by 2020	• Included through external scenarios	• Implemented as 37.5% reduction of CO_2 emissions between 2021 and 2030
		• New heavy-duty trucks: 0.94 MJ/tkm by 2021 (14% improvement between 2015 and 2021)	• Not included	• Included (1.09 MJ/tkm and 14.2% improvement reached)
	Directive 2009/28/EC Biofuel target	• 10% quota for RE in transport fuels (also electricity)	• Included through external scenarios	• Included as such
Other	F-gas regulation	• Reduce emissions of fluorinated gases by 37% by 2020 and by 79% by 2030, relative to 2015	• Included through additional calculations	• Included through additional tax on f-gases (which include PFCs as well

10.2 Details of NewClimate calculations

NewClimate calculations were taken from the Climate Action Tracker analysis and adjusted to match the list of policies above. Excerpts of the methodological description are provided below.

Emissions projections under current policies
For projections of emissions including currently implemented policies, we used two datasets:

The first is the data submitted by member states and aggregated by the European Environment Agency (EEA, 2017). The data was based on 100-year Global Warming Potentials from the IPCC Fourth Assessment Report. We applied the growth rates of this data set to historical values to make the two datasets directly comparable.

EEA provides two scenarios: With Existing Measures (WEM), and With Additional Measures (WAM). WEM includes all policies implemented on member state level by the preparation of the report (most member states submitted data in the first half of 2017). WAM additionally includes planned measures on member state level at the time of preparation of the report.

The second is the EU Reference Scenario (Capros et al., 2016), developed by a consortium of research institutions published through the European Commission. This scenario includes all directives and regulations at EU level, assuming that all of those are already or will be implemented on member state level in time to meet the policies' aggregate objectives.

The EU Reference Scenario's historic data varies slightly from the latest submission of inventories to the UNFCCC, thus we harmonise the projections applying their growth rates to the inventory data.

Both base scenarios for the analysis (EEA 2017 and the EU Reference Scenario) exclude the full implementation of the F-gas regulation. We thus calculate the target levels resulting from the anticipated reductions, and compare those to the emissions in the base scenarios. The EU Reference Scenario does not provide projections on a gas level, so this comparison is only possible for the EEA scenario. We subtract the difference in emissions from the base scenarios (assuming that F-gases in the EU Reference Scenario behave similarly to the EEA scenario).

Note that the PRIMES scenarios result in significantly lower projections, mainly because of the different choice of policies included. The projections are more optimistic than the aggregate of member states' data, which only considers those policies that have already been implemented on a national level (by mid-2017). While member states implement existing EU directives and regulations, the reported data should move in the direction of the current PRIMES reference scenario.

10.3 Details of PBL calculations

As the European Union is represented by two regions in the IMAGE model (Western Europe and Central Europe), emission projections of both regions were added to get one emission projection for the EU. These regions include a few non-EU28 countries, see the IMAGE wiki for more details. Policy measures were applied equally to both regions, i.e. the same settings for fuel efficiency standards and carbon taxes (ETS) were applied to both Western Europe and Central Europe. More specifically, ETS was implemented by applying a carbon tax to the sectors that are covered by the ETS (e.g. energy supply and industry) in order to reach the emission reduction targeted by the ETS.

10.4 Details of IIASA calculations

IIASA results for the European Union were based on national estimates utilizing the GLOBIOM and G4M models. The emissions projections under current policies for the European Union were those of the LULUCF reference scenario presented in Capros et al. (2016) and have been harmonised to net AFOLU emissions in 2015 provided in the 2017 National Inventory Reporting (European Environment Agency, 2017). The LULUCF projection thereby considers the development of CO_2, N_2O and CH_4 emissions and removals for all LULUCF related reporting categories (i.e. Forest Land, Cropland, Grassland, Wetland, Settlements, Other Land).

11 India

11.1 Assessment

NDC

India submitted its Nationally Determined Contribution (NDC) for the period 2021 to 2030 on the 2nd of October, 2016. It includes the following intentions: "[…] to put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation; to adopt a climate-friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development; to reduce the emissions intensity of its GDP by 33 to 35% by 2030 from 2005 level; to achieve about 40% cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF); to create an additional carbon sink of 2.5 to 3 $GtCO_2e$/year through additional forest and tree cover by 2030" (UNFCCC, 2015). The sectors and gases covered by the intensity target are not specified.

An official estimate of emissions under the NDC is not available. National estimates for CO_2 emissions from the energy sector (and cement) are available from Dubash et al. (2014), which are not included here. From Damassa et al. (2015), there are national "all GHG" projections including land-use for India based on a relatively large range of GDP assumptions (6.3–7.4% average GDP growth for the period 2005–2030), resulting in emissions of 5.7–7.5 $GtCO_2e$/year in 2030.

The NewClimate Institute estimates on the emissions under the NDC were based on the Climate Action Tracker analysis.[17] The estimate assumes a 7% GDP growth per year between 2017 and 2030, based on the National Electricity Plan which expects this growth up to 2027. The range in PBL's NDC projections is based on GDP growth rates taken from the IEA World Energy Outlook (WEO) 2014 (IEA, 2014) and the SSP2 database (Fricko et al., 2017), which is, respectively, 6.4% and 7.4% annual growth between 2005 and 2030. The Planning Commission from India (Planning Commission Government of India, 2014) assumes an annual growth equal to the IEA WEO 2014. The upper-end of the emissions range based on the intensity target was used as maximum PBL estimate. As a minimum estimate, we used the combined effect of emission intensity targets, non-fossil targets and afforestation targets. These were calculated using the PBL TIMER energy model.

The IIASA projection of the net LULUCF emissions for India under the NDC is based on the scenarios presented in den Elzen et al. (2016a) and Forsell et al. (2016). The scenarios are in line with a statement concerning the land use sequestration potential in India of The Planning Commission (Planning Commission Government of India, 2014).

Current policies

Policies include renewable energy targets and the market-based mechanism Perform Achieve and Trade (PAT) scheme for energy efficiency. Dubash et al conclude from a multi-scenario comparison, that India's energy related emissions will at the most double by 2030, and that projected emissions trajectory are compatible with the 2030 emissions intensity target (Dubash *et al.*, 2018).

For the PAT scheme, the PBL projections took into account the impacts expected in the post-2015 Cycle II period in emissions projections under current policies, while the NewClimate Institute projections only considered the first Cycle, which ended in 2015.

For renewables, the Indian government has recently revised its solar PV deployment target from 20 GW in 2022 to 100 GW in 2022 (MNRE, 2017). In 2018, India announced it would increase its total RE target

[17] https://climateactiontracker.org/countries/india/ (update April 2018)

from 175 to 225 GW in 2022. It is, however, difficult to assess whether the existing support schemes are sufficient to achieve the revised target. Concerns have been raised about the feasibility of such rapid additions of renewables. Our projects assume India reaches its 175 GW target.

In April 2018, the Central Electric Authority (CEA) published the National Electricity Plan, revising a draft document from December 2016, which provides electricity demand forecasts for the period 2017–2027, and calculates installed capacities from conventional and renewable energy sources needed to meet that demand (Central Electricity Authority, 2016, Central Electricity Authority, 2018). The plan foresees capacity additions for renewable energy, nuclear, and gas, in parallel to substantial electricity demand reductions. These projections result in much lower electricity generation and GHG emissions from coal than earlier estimates. Whereas emissions from coal in previous projections led to almost 2 $GtCO_2$ in 2030, they are at 1.2 $GtCO_2$/year in 2030 under the Draft Electricity Plan, according to NewClimate estimates.

Table S11: Overview of key climate change mitigation policies in India (*planned policies in italics*). Source: (Government of India, 2016, The Gazette of India, 2017, BEE, 2015, Government of India, 2015a, Government of India, 2015b, Ministry of Consumer Affairs Food and Public Distribution, 2015, MNRE, 2009)

Sector	**Policies (marked with "(+)" when mentioned in the NDC document)**	**Description**	**NewClimate quantification of impact**	**PBL quantification of impact**
Economy-wide	Clean energy cess (coal tax) (2010)	• Implemented in 2010; currently a tax of INR 400/tonne is imposed on coal, lignite and peat	• Included through external scenario (IEA WEO 2017)	• Not included
Energy supply	Renewable energy targets and support schemes (12th Five Year Plan (2012–2017), National Solar and Wind Missions (2010) (+)	• Capacity targets for 2022: 10 GW biomass, 5 GW small hydro, 100 GW solar, 60 GW wind (total 175 GW). Aspirational target: 227 GW in 2022[1)] • Budgetary support for solar power under the National Solar Mission [2)] • Renewable Purchase Obligations scheme (2003)[2)]	• Included through own quantification. The share of RE in electricity production reaches 23% in 2022.	• Renewable capacity targets included (assumed to be supported by the other policies): 100 GW solar (109 GW reached), 60 GW wind (64 GW reached), and 10 GW biomass (7.4 GW reached by 2022 due to depletion rules in TIMER, but target achieved in

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
		• Renewable Energy Certificate (REC) mechanism (2011) [2)]		2029); small hydropower not represented in TIMER. As a result, the share of renewables in electricity production reaches 23.5% by 2020.
	Twelfth Five Year Plan (2012–2017): supercritical power generation	• Base new thermal power plants mainly on supercritical technology from 2017 onwards. Implemented as power plant standard after 2016 for new coal-fired power plants, resulting in 47% efficiency (840 gCO_2/kWh – middle of the range presented by IEA (2013b))	• Included through external scenario (IEA WEO 2017)	• Implemented as power plant standard of 8200 gCO_2/kWh from 2016 onwards
	Electricity Plan	• Capacity additions for various energy technologies • Demand reductions • Slow-down in installation of new coal fired power plants	• Included through own calculations	• Included in planned policies as additional calculations (see November 2017 report)
Transport	Fuel economy standards	• 1.3 MJ/pkm – 130 g CO_2/km by 2017 and 0.9 MJ/pkm – 113 g CO_2/km by 2022, for light-duty vehicles	• Included through external scenario (IEA WEO 2017)	• Implemented (1.2 MJ/pkm in 2017 and 0.8 MJ/pkm by 2022 reached)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
	Electric vehicle target (2018), Faster Adoption and Manufacturing of Hybrid and Electric vehicles I (FAME I) (2015)	• 15% share in car stock by 2023, 30% by 203 • Subsidy for hybrid and full electric vehicles • No licensing required for EV charging stations	• Not included	• Included (6.4% reached)
	Support for biofuels (2007)	• 5% blending target for ethanol with petrol (no timeline set)	• Included through external scenario (WEO 2017)	• Implemented as 4.2% biofuel share (bioethanol + biodiesel) by 2017 Biofuel shares for gasoline and diesel are translated into one target based on heat content and enforced in the model(4.3% reached) Target not met due to depletion rules in TIMER
		• 20% blending target for bioethanol in gasoline, 5% biofuel in diesel by 2030 (proposed target)	• Not considered	
Industry	Energy efficiency in industry (PAT scheme) (2011)	• Currently in the second phase • The first phase was expected to save 6.6 Mtoe (4.8% energy reduction in the industries covered, representing around 60% of primary energy consumption) and to reduce 26 $MtCO_2e$ over the 2012–2015 period	• Included through external scenario (WEO 2017)	• Included; first phase (2015) resulting in 306 PJ savings relative to TIMER baseline, second phase (2019) resulting in 1627 PJ savings relative to baseline

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Forestry	Green India Mission (2011)	• Increase the forest/tree cover in moderately dense forests: 5 million hectares • Improve forest/tree cover in forest areas: 5 million hectares	• IIASA projection	• IIASA projection
Agriculture	National Mission on Sustainable Agriculture (2012) (+)	• Enhancing food security and protection of resources such as land, water, biodiversity and genetics	• Not included	• Not included

[1] *Based on: Planning Commission Government of India (2011)*

[2] *Not quantified separately*

11.2 Details of NewClimate calculations

NewClimate calculations were taken from the Climate Action Tracker analysis. Excerpts of methodological description are provided below:

Historical emissions
Historical data was based on official inventory data up to 2010:

- GHG inventory data from the UNFCCC data platform with data for 1994, 2000 and 2010
- GHG inventory data from the 2nd National Communication (Government of India, 2012), with data for 2007

We interpolate linearly between the years and assume that the trend throughout 1994 to 2010 can be extended backward to 1990.

For years after 2010, there are no official emissions projections. We thus use a combination of IEA WEO data (non-electricity sector energy related emissions), National Electricity Plan (electricity sector emissions), US EPA (non-CO2 emissions), and growth rates of cement production from IEA ETP for CO2 process emissions.

Emissions projections under current policies
The emissions projections consists of the following elements:

- energy-related CO_2 emissions excl. the power sector based on the Current Policies Scenario of the WEO 2017 (IEA, 2017).
- Electricity sector related emissions, based on the National Electricity Plan (Central Electricity Authority, 2018). We adjusted the data to reflect the achievement of the updated renewable energy targets. The overall electricity generation remains at the level of the National Electricity Plan, while the additional renewable capacities replace fossil fuel-based plants, taking into

account respective full load hours of the different technologies. As it is unclear which fossil fuel-based technologies would be replaced, we use the average grid emissions factor to calculate emissions reductions.

- Process CO_2 emissions: we applied the growth rates of projected production of cement in India from the "Technology Roadmap: Low-Carbon Technology Roadmap for the Indian Cement Industry" (WBCSD and IEA, 2013a) to historical emissions from the UNFCCC (UNFCCC, 2018b). We assumed an efficiency improvement of 1% per year and that the rate of growth was the same for other CO_2 processes in India.
- Non-CO_2 emissions: We applied growth rates from US EPA to the last historical inventory year (2010).

11.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the Green India Mission). For this assessment, only forestry related changes in LULUCF carbon pools for India were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to the level of emissions and removals reported on the UNFCCC portal (UNFCCC, 2017a).

For the projections to reach consistency with policy measured related to reforestation and recovery of forest land, a nation-wide carbon price was induced as of 2015 that enhances the national afforestation and reforestation rates, thereby providing additional forests and increasing tree cover rates. The carbon price was assumed to be implemented as of 2015 and increase linearly until 2030 such that a cumulative total of 5 million hectares of forest land will be restored from 2015 until 2030.

12 Indonesia

12.1 Assessment

NDC

Indonesia's NDC states that the country "[…] has committed to reducing unconditionally 26% of its greenhouse gases against the business as usual scenario by the year 2020. Indonesia is committed to reducing emissions by 29% compared to the business as usual (BAU) scenario by 2030". Furthermore, "Indonesia's target should encourage support from international cooperation, which is expected to help Indonesia to increase its contribution up to 41% reduction in emissions by 2030" (Republic of Indonesia, 2016a). Indonesia defines its baseline emissions as 2,881 $GtCO_2e$/year in 2030; the emission targets can be derived from this baseline using the reduction targets. The NDC covers all sectors and CO_2, CH_4, and N_2O.

Current policies

A significant share of Indonesia's emissions originates in the forestry and land use sector, due to deforestation, peatland destruction, and land-use change. At the same time, there is a large uncertainty in LULUCF emissions, particularly related to peat oxidations (not including peat fires), which can be in the order of 30% to 50% of total LULUCF emissions. Uncertainty concerning emissions from peat fires is also high and it is well known that these emissions vary significantly between years. This has made it difficult to develop emission projections for Indonesia and to assess whether the 2020 pledge and 2030 NDC are expected to be achieved with current policies.

As a result, Indonesia's emission reductions resulting from the policies assessed in our analysis are projected to be smaller than the uncertain amount of emissions from land-use changes and forestry. Therefore, emission projections that assume the implementation of current policies are mainly illustrative. For the energy sector, the renewable energy and biofuel targets set for 2025 are projected to lead to emission reductions, compared to BAU projections; however, total emissions are still projected to increase further.

The emissions projections under current policies by NewClimate Institute were based on its analysis for the Climate Action Tracker.[18]

PBL calculations used the IMAGE model, including high impact policies identified in the CD-LINKS project (CD-LINKS, 2017) (Table S12). PBL projections were supplemented with IIASA projections of LULUCF emissions.

[18] http://climateactiontracker.org/countries/indonesia (update November 2018)

Table S12: Overview of key climate change mitigation policies in Indonesia (ADB, 2016, Kharina et al., 2016, Republic of Indonesia, 2016a, Republic of Indonesia, 2016c, Ministry of Energy and Mineral Resources of Indonesia, 2018)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Energy supply	Renewable energy targets (2014) (+)	• 15%–23% share of renewable energy in primary energy supply by 2025 (supported by feed-in tariffs, Government of Indonesia, 2012)	• Checked if achieved after implementation of other policies (not the case)	• Checked if achieved after implementation of other policies (7% reached by 2025)
	National Electricity Plan (RUKN, 2015)	• 23% new and renewable energy (including nuclear) by 2025 (planned: 25%)	• Range of current policies results in 17%–23% new and renewable energy by 2025	• Checked if met after implementation of capacity target (15% reached by 2025)
	Electricity Supply Business Plan (RUPTL, 2018)	• Added electricity capacity by 2022: 2.4 GW hydro, 1.2 GW geothermal, 1.1 GW solar/wind	• Split of electricity production (which gives 23% renewable energy in 2025) according to RUPTL used as lower range of projections • Additionally included the target of 27 GW of coal-fired power plants included in the plan.	• Implemented as installed capacity targets for 2019 and 2022 based on 2015 installed capacities: o 6.4 GW hydro by 2019 and 6.8 GW by 2022 (based on 2015: 4.4 GW) → 7.4 GW reached by 2019 and 2022; o 1.9 GW geothermal by 2019 (2.2 GW achieved) and 2.4 GW by 2022 (2015: 1.2 GW); o 0.6 GW solar and 1.2 GW wind by 2019, 1.05 GW

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
				solar and 1.65 GW wind by 2022 (2015: 0.5 GW solar, 1.1 GW wind; 0.2 GW addition of solar/wind equally divided) → 5.6 GW solar and 5.3 GW wind achieved by 2022 (3.4 GW solar + wind by 2019)
Transport	Biofuel targets (2013)	• 15% share of biofuels in all transportation fuels by 2025 (25% biodiesel, 20% bioethanol)	• Current policies reach 5% biofuels in 2025 in TPED for transport. (Additional scenario exists quantifying the effect of reaching 30% blending mandate in transport and industry by 2025.)	• Implemented as 22.5% biofuel share (bioethanol + biodiesel)
Forestry	Presidential Instruction number 6/2013 on Forest Moratorium	• Restricting oil palm extension to peatland or to primary forest as defined in the Ministry of Forestry land cover map	• IIASA projection	• IIASA projection

The IIASA projections of net LULUCF emissions accounts for forestry and land use related policies and was based on the CIFOR project report (Mosnier et al., 2017). The LULUCF emissions projections under current policies by IIASA take into account the Presidential Instruction number 6/2013 on Forest Moratorium. Illegal logging is one of the major sources of GHG emissions in Indonesia. The country has made efforts to control the problem through national law enforcement and trade-based measures such as FLEGT-VPA. Although only a fraction of the volumes logged illegally are likely to be curbed, FLENS and FLEGT-VPA policies are still estimated to have a notable impact on reducing CO_2 emissions by 2030, ranging from 70 $MtCO_2e$/year (national estimates based on Ministry of Finance, 2009) to 130 $MtCO_2e$/year (IIASA estimate; Admiraal et al., 2015). The large difference between the estimates

derives from the very uncertain figures in both the CO_2 sequestration estimates of the IIASA current policies assessment (especially for peatland) and the anticipated impacts of policies that are largely due to varying estimates of the forests affected by illegal logging.

The current policies scenario by IIASA takes into account emissions from peat oxidation caused by deforestation. However, emissions from forest fires and related peat oxidation are highly uncertain and estimates are shown excluding and including (historical) peat fires emissions. Estimates of historical peat fires were kept constant from 2012 onwards according to the estimates provided by the BUR1 by Indonesia (Republic of Indonesia, 2016b), due to the high uncertainty of future developments. The projection was also harmonised to historical 2012 levels of emissions based on the GHG inventory data as reported in the BUR1 by Indonesia (Republic of Indonesia, 2016b).

12.2 Details of NewClimate calculations

Historical emissions
We used the historical data provided by the NC3 (Republic of Indonesia, 2018a) for the year 2014, BUR1 (Republic of Indonesia, 2016b) for the period 2000-2012, and for the period before 2000, we used data reported to the UNFCCC with linear interpolations between 1994 and 2000.

Emissions projections under current policies
We constructed the range of projections based on different assumptions of what might happen to the currently largely coal-based power sector in Indonesia in the future. The scenarios were based on the BAU scenario from APERC, which "assumes current policies and trends continue" (APERC, 2016b). According to this BAU, the share of coal in power generation is projected to increase from 51% in 2013 to 58% in 2020 and 60% in 2030. Emission factors from the IEA's Current Policy Scenario for non-OECD Asia were multiplied by the projected generation levels from coal, oil and gas in TPES according to this BAU to derive the upper bound of our Current Policy Scenario for the energy sector, representing the continued use of coal. Note that this scenario is consistent with increasing installed capacity of coal by 25 GW between 2013 and 2025.

A second current policies scenario was constructed by looking at the projections of fuel mix according to the RUPTL 2018 – 2027 (Republic of Indonesia, 2018b), which foresees a stronger shift from coal to gas in the power sector, in accordance with the National Energy Policy. In the RUPTL projections, coal reaches a share of around 60% by 2020 in power production, but afterward drops back down to 54% by 2025, with gas, hydro and geothermal power, making up the difference. We extrapolated this development until 2030 in a linear fashion and used this new fuel mix in the power sector, along with projections of overall power demand from APERC, to construct the lower bound of our Current Policy Scenario, representing a shift from coal to gas.

In neither scenario the target of 23% renewables in TPES is reached.

We subsequently harmonised the resulting time series of energy-related CO_2 emissions to historical data from the BUR1 and added process emission projections from the 3nd National Communication and non-CO_2 emissions (from agriculture and waste) projections from the US EPA (US EPA, 2012). Finally, we harmonised the resulting time series to the historical data series on overall emissions excluding LULUCF from the BUR1, to construct an overall reference level for emissions excluding LULUCF.

12.3 Details of PBL calculations

The Indonesia region in TIMER contains a few additional countries (see the IMAGE wiki for more details), which are small enough in terms of emissions to not do a downscaling.

12.4 Details of IIASA calculations

The IIASA projections on LULUCF emissions and removals for Indonesia is based on national estimates using the GLOBIOM model. The emissions projections under current policies was based on the CIFOR project report (Mosnier et al., 2017) and was harmonised to net AFOLU emissions in 2012 provided in the BUR1 by Indonesia (Republic of Indonesia, 2016b). The LULUCF projection considers the development of emissions and removals for the major LULUCF related reporting categories (i.e. Forest Land, Cropland, Grassland, and Other Land). However, the estimates do not include emissions and removals from forest fires and related peat oxidation; these sources of emissions were kept constant over time according to the 2012 estimates reported in the BUR1 by Indonesia (Republic of Indonesia, 2016b).

13 Japan

13.1 Assessment

NDC

In its NDC, Japan commits to reducing GHG emissions by 26% by 2030 compared to 2013 levels, equivalent to a 25.4% reduction from 2005 levels (officially reported value) and a 3% increase from 2010 levels. All sectors and seven GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3) are covered and 100-year GWPs from the IPCC AR4 are used (UNFCCC, 2015). Japan is expected to apply the gross-net accounting approach[19], meaning that the removals in the LULUCF sector are accounted for each year without comparison to the target year for the commitment period.

According to the official estimate that has been included in the NDC document, Japan's NDC would equate to emissions levels of 1,042 $MtCO_2e$/year in 2030 (based on GWPs from the IPCC AR4). The PBL and NewClimate estimates agree on the impact of Japan's NDC on its emissions.

The Japanese Government also intends to allow the use of carbon credits from the Joint Crediting Mechanism (JCM). Japan's NDC foresees the potential use of credits equalling between 50 and 100 $MtCO_2e$ during the period up to 2030. The impact of JCM is not included in the NDC quantification by the Japanese government.

According to Japan's NDC, net LULUCF emissions are expected to be reduced by about 37 $MtCO_2e$/year as of 2030, compared to 2013 levels, and thereby provide land use credits in the same order of magnitude. Approximately 75% of this reduction will be based on forest carbon sinks measures while the remaining 25% will be the result of cropland management, grazing land management, and revegetation. This enhancement of the net LULUCF sinks corresponds to 2.6% reduction of total emissions in 2013.

Current policies

We subtracted the expected land-use credits as well as other emission credits from our current policies emissions projections.

Table S13 shows an overview of key climate change mitigation-related policies in Japan and how they are taken into account in deriving emissions projections under current policies. The PBL projections were based on updated IMAGE model calculations, including high impact policies as identified in the CD-LINKS project.

[19] In this approach the actual reported net emissions (or removals) in each year of the commitment period is accounted for without comparing the estimates with a base year. The gross-net LULUCF accounting method thereby implies that the emissions and removals from the LULUCF sector is in the commitment period treated in the same way as any other GHG inventory sector.

Table S13: Overview of key climate change mitigation-related policies in Japan (Government of Japan, 2013, IEA, 2017, METI, 2018c, METI, 2018a, METI, 2018d, METI, 2018e, Government of Japan, 2017)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	Global warming countermeasures tax (2012)	• An upstream tax of 289 JPY/tCO_2 (around 2.3€) is imposed on fossil fuels on top of existing petroleum and coal tax	• Included through IEA WEO 2017 Current Policies Scenario	• Not included
	Energy Conservation Act (June 2018 amendment)	• New certification system to allow for an inter-business initiative to enhance systemic energy savings • Ensures the coverage of e-commerce retailers under the Act	• Not included	• Not included (final energy consumption is reduced by 7.6% between 2010 and 2030, due to implementation of other policies)
Energy supply	2018 Basic Energy Plan and the long-term energy demand and supply outlook (+)	• Renewable electricity (incl. large hydro): 22–24% by 2030 (supported by FIT scheme)	• Recalculation on electricity mix was conducted; the 2030 target is overachieved (22–26%)	• Renewable electricity target included, achieves the 2030 target at 23%
	Renewable Energy Act (feed-in tariff) (2012)	• Electric utility operators required to purchase all electricity generated at designated prices; applicable to most renewable technologies	• Included through IEA WEO 2017 Current Policies Scenario	• Not included (assumed to support renewable electricity target of Basic Energy Plan)
Buildings	Energy Conservation Act (2007;)	• Energy reduction of 1%/year and annual reports to the government by large operators • Energy efficiency standards for buildings and houses larger than 300 m^2	• Included through IEA WEO 2017 Current Policies Scenario	• Not included (current efficiency in model already approximately 500 PJ/m^2)
Transport	Top Runner Programme:	• 20.3 km/l by 2020	• Included through IEA	• Included as 1.07 MJ/pkm for light-

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
	vehicle efficiency standards (1999)		WEO 2017 Current Policies Scenario	duty vehicles from 2020 onward
F-gases	Act on Rational Use and Proper Management of Fluorocarbons (2013)	• Stricter control of the entire F-gas chain (GWP targets for equipment types, obligation of F-gas destruction for entities re-using recovered F-gases)	• Included through additional calculations	• Included through cost curves (which include PFCs as well), HFC emissions projected to be reduced by 14 $MtCO_2e$ by 2020, relative to TIMER baseline
	Ozone Layer Protection Act (2018 amendment)	• Regulation on production and import volumes to comply with the Kigali Amendment of the Montreal Protocol	• Not included (assumed limited impact on the emissions up to 2030)	• Not included (assumed limited impact on the emissions up to 2030)

A relatively large range of projections is caused by the uncertainty about the future role of nuclear energy, as it is not yet fully clear whether this will occur and which energy carriers will replace nuclear electricity capacity. The lower end projection by NewClimate Institute assumes all nuclear reactors that applied for restart as of September 2018 would be approved and reconnected to the grid after necessary additional safety measures are taken. The resulting electricity mix in 2030 (22% renewables, 16% nuclear and 60% coal and gas). The upper end projection, by contrast, assumes there is no additional nuclear power generation in 2020 and 2030, except for 14 reactors which are approved for restart. The resulting electricity mix in 2030 is 26% renewables, 5% nuclear and 66% coal and gas.

In July 2018, the new Basic Energy Plan was adopted by the Cabinet (METI, 2018e). The electricity generation mix target laid out in the NDC remained unchanged, but the document now refers to renewables as "main power sources", which implies a major policy shift from the current 2014 Basic Energy Plan's "important low-carbon and domestic power source". Nuclear power remains as an "important power source".

Renewable electricity generation has grown steadily in recent years. In 2012, the Renewable Energy Act was introduced to support Japan's stated NDC renewable electricity share target of 22–24% by 2030. It institutes a feed-in tariff (FIT) and general funding for distribution networks. The FIT has provided very favourable rates, particularly for solar PV, which led to a large increase in PV installations. The share of renewable energy in total electricity generation has increased considerably from 10% in 2010 to 16% in FY2017 (IEA, 2018).

Effective from April 2017, the Ministry of the Economy, Trade and Industry (METI) revised the scheme with a stated intention of avoiding a "solar bubble" and to achieve a more balanced growth of renewable

energy while minimizing the costs (METI, 2016). An important instrument newly introduced is the auctioning scheme for solar PV installations larger than 2MWe. The first two auctions were not successful (METI, 2017b; Green Investment Promotion Organization, 2018).

March 2017 also saw a last-minute rush-in of biomass project applications before the tariff rates were lowered – the total biomass capacity approved under the FIT scheme to date amounts up to more than 12 MW (METI, 2017a). If all the approved capacity is implemented, though unlikely, the total biomass capacity would reach 16 GW (METI, 2017a), which is more than double the amount expected under the 2030 electricity mix target (Government of Japan, 2017). Many of the approved projects planned to co-fire imported palm oil with coal and hence there have been serious concerns about the overall environmental integrity of Japan's renewable energy policy (METI, 2017a; Renewable Energy Institute, 2017).

On **energy efficiency**, an amendment of the Energy Conservation Act was adopted in June 2018 (METI, 2018a) to achieve the energy savings target under the NDC. The amendment establishes a new certification system which allows for an inter-business initiative to enhance systemic energy savings in addition to energy savings at an individual operator level, and ensures the coverage of e-commerce retailers under the Act. The amendment is to enter into force by December 2018.

13.2 Details of NewClimate calculations

Emissions projections under current policies: energy-related CO_2 emissions

The emissions projections under current policies by NewClimate Institute were based on its analysis for the Climate Action Tracker.[20] For the analysis of current policies scenario projections, we used the IEA World Energy Outlook (WEO) 2017 Current Policies Scenario (IEA, 2017), which covers various climate related policies implemented as of mid-2017 and their impact on energy-related CO_2 emissions as a basis. The GDP for 2030 assumed in the IEA WEO 2017, based on World Bank and International Monetary Fund estimates, is 16% lower than that assumed in the NDC.

The WEO foresees a relatively large share of nuclear energy plants in electricity generation for 2030 (17%). While this is overachieved by the current assumptions of the government (Basic Energy Plan), it is not completely supported by the rate of restart of currently shut down nuclear power plants. We explored "high nuclear" and "limited nuclear" scenarios:

For the **full nuclear restart scenario**, it is assumed that all 25 nuclear reactors (plus two applied to resume construction) that applied for restart as of September 2018, amounting up to 27.6 GW, will resrtart after additional safety measures were implemented and complete their extended 60-year lifetime (with an average 6500 hours/yr operation, comparable to about 6400 hours/yr assumed in IEA WEO 2017's Current Policies Scenario). The changes in nuclear power generation compared to the IEA WEO 2017's Current Policies Scenario is balanced by coal and gas power. The ratio of coal and gas power converges to 1:1 by 2030 and the average capacity factor of nuclear power plants was assumed to be 80%. The resulting electricity mix in 2030: 22% renewables, 16% nuclear, 30% coal and 30% gas was found to be similar to that in WEO 2017 CPS.

For the **limited nuclear scenario**, it is assumed that on average only half of twelve reactors that are allowed to restart as of September 2018, amounting up to 14.3 GW, will generate electricity until they reach their 60-year extended lifetime but with a much shorter 3250 hours/yr operation on average taking into account the possible court cases and unplanned inspections, and that no further plants will be reconnected. The electricity supply gap is filled by renewables and fossil fuel power (coal and gas

[20] https://climateactiontracker.org/countries/japan/ (update November 2018)

power)—the ratio between renewables and fossil fuel power remains the same as in IEA WEO 2017 and the ratio between coal and gas power converges to 1:1 by 2030. As a result, the share of renewables in total electricity generation in the second case reaches 26% in 2030, exceeding the target set in the 4th Strategic Energy Plan (22–24%), but the share of fossil fuel-fired power generation also increases significantly (33% coal and 33% gas) as the nuclear power share remains at 5%.

After the recalculation of the 2030 electricity mix, CO_2 emissions were recalculated— CO2 emission factors per technology were assumed to be identical to those in the WEO 2017 CPS. Finally, the growth rates of energy-related CO_2 emissions up to 2030 recalculated based on the IEA WEO 2017 CPS were applied to the 2016 historical energy related CO_2 reported in the national GHG inventory report submitted to the UNFCCC.

Emissions projections under current policies: other emissions

For other emissions, the quantification approach has been updated since the last update to account for the recent policy developments, recent trends in F-gas emissions as well as the changes in the GWPs used to express GHG emissions. The projections from the Ministry of the Environment (MOEJ, 2012a) are no longer used.

For the emissions of non-energy CO_2, CH_4 and N_2O, we assumed that the intensity of these emissions per unit GDP will reduce linearly towards 2030 following the historical trends observed between 2010 and 2016. The GDP growth projections up 2030 were taken from IEA (IEA, 2017).

For F-gas emissions, the expected impacts of the Act on Rational Use and Proper Management of Fluorocarbons (2013 amendment) to enhance management of F-gas use and the Ozone Layer Protection Act ('F-gas Act', 2018 amendment) to regulate production and imports of F-gases to comply with the Kigali Amendment were also considered. Our calculations show that the HFC emission levels to be about 8 $MtCO_2e$/yr higher in 2020 and 22 $MtCO_2e$/yr in 2030 compared to the levels targeted under the NDC (MOEJ, 2012b; MOEJ and METI, 2014; Government of Japan, 2015).

As described in the current policy projections section, the F-gas Act has not been successful in improving the recovery rate of refrigerants from end-of-life refrigeration and air conditioning equipment in 2015 was only 38% (METI and MOEJ, 2017). Based on the historical trends reported in METI and MOEJ (METI and MOEJ, 2017), we assume that the HFC recovery rate will not improve over time (40% for 2020-2030). We also assume that the leakage rates for the in-use stock will also not improve under current policies. Regarding the 2018 amendment of the Ozone Layer Protection Act, the business-as-usual consumption levels are projected to be below the Kigali cap at least until 2025 (METI, 2018b); the Kigali cap for Japan becomes significantly lower only in 2029. Since there is some time lag between consumption and emissions, we assume that the amended Ozone Layer Protection Act will not affect the HFC emission levels up to 2030.

The point of departure for the revised F-gas emission projections is the business-as-usual (BAU) projections provided in the background document of the Plan for Global Warming Countermeasures (MOEJ, 2016)—the Plan projects F-gas emissions to increase from 39 $MtCO_2e$/yr in 2013 to 77 $MtCO_2e$/yr in 2030 under a BAU scenario (expressed in AR4 GWP terms). The three measures: (i) enhanced recovery from end-of-life equipment, (ii) avoidance of leakage from in-use equipment, and (iii) switch to lower GWP F-gas and non-F-gas refrigerants are expected to reduce emissions to the NDC target level of 29 $MtCO_2e$/yr in 2030. In our assessment, we assume that only part of the NDC implementation plan would be achieved, i.e. the switch to lower GWP F-gas and non-F-gas refrigerants. The resulting F-gas emissions projections in 2030 are 66 $MtCO_2e$/yr, which is more than double the NDC target level; the new projections are roughly 20 MtCO2e/yr higher than our previous projections.

13.3 Details of PBL calculations

On the electricity sector, the nuclear power capacity in 2030 was assumed to be 21.7GW (also in the No Policy baseline), which equals the capacity for roughly 20 reactors. The 22–24% target share for renewable electricity was set to be reached without nuclear but with solar PV, CSP, wind (both onshore and offshore), hydropower, other renewables such as geothermal, and biomass (with or without CCS).

13.4 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. The G4M emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017). For this assessment, only forestry related changes in LULUCF carbon pools for Japan were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to historical datasets provided in the 2017 National Inventory Reporting (Ministry of the Environment Japan, 2017).

IIASA projections of LULUCF emissions and removals under current policies were similar to Den Elzen et al. (2015) and were harmonised to historical level of net emissions from Japan's 2017 GHG Inventory Submission to the UNFCCC (Ministry of the Environment Japan, 2017).

14 Kazakhstan

14.1 Assessment

NDC

In its NDC, Kazakhstan commits to an unconditional target to reduce GHG emissions including LULUCF by 15% below 1990 levels by 2030. Conditional on additional international investments, access to the low carbon technologies transfer mechanism, the green climate fund, and flexible mechanisms for countries with economy in transition, Kazakhstan aims to reduce its GHG emissions including LULUCF by 25% below 1990 levels by 2030. The NDC covers the agriculture, forestry, industry (including mining), transport, buildings (including waste and green cities), and electric power sectors, and the GHGs CO_2, CH_4, N_2O, HFCs, PFCs, SF_6.

Under "Fair and ambitious targets, taking into account national circumstances", the NDC furthermore states that "under a revised and conservative business as usual scenario which takes into account potentially lower GDP growth rates the target proposed by Kazakhstan amounts to a 22% reduction in GHG emissions by 2030 compared to BAU projected emissions. Under favorable economic conditions and an increase in oil prices, the unconditional target proposed by Kazakhstan would amount to a 34% reduction in GHG emissions by 2030 compared to BAU projected emissions."

In addition, in the NDC document, Kazakhstan pledged an updated pre-2020 contribution of a 7% reduction below 1990 levels by 2020, including LULUCF. The previous 2020 pledge enshrined in the Copenhagen Accord and the Cancun Agreements is a 15% reduction below 1990 levels by 2020, including LULUCF.

Current policies

Our latest projections show that, as in the 2017 report, Kazakhstan will miss both its 2020 and 2030 emissions reduction targets. Table S14 presents an overview of key climate change mitigation-related policies in Kazakhstan and how they were taken into account in deriving emissions projections under current policies. Due to the modelling approaches taken, some uncertainty remains regarding the extent to which the policies in Table S14 were assumed to be implemented – the NewClimate Institute calculations were based the Climate Action Tracker analysis,[21] which has been adapted to better reflect the implementation status of current policies (see details on the calculations); the PBL projections for Kazakhstan were downscaled from the projections for the region "Central Asia".

The "Concept of Kazakhstan's Transition to Green Economy" of 2015 is considered to be an overarching strategy to reduce GHG emissions in the long term. While the strategy is without a substantial plan for implementation as of today and therefore not considered in the current policies scenario, the energy intensity target of this strategy is already met in PBL's business-as-usual scenario. For NewClimate Institute calculations, the achievement of the target could not be verified due to the lack of energy balance data.

The IIASA projections of LULUCF emissions and removals under current policies were based on updated G4M estimates (Table S14) and were harmonised to 2015 using historical datasets provided in the 2017 National Inventory Reporting (Republic of Kazakhstan, 2017).

Table S14: Overview of key climate change mitigation policies in Kazakhstan (Ministry of Environment and water resources of the Republic of Kazakhstan, 2013, Government of Kazakhstan, 2016, Decree

[21] http://climateactiontracker.org/countries/kazakhstan (update April 2018)

of the President of the Republic of Kazakhstan, 2013, Republic of Kazakhstan, 2012, Republic of Kazakhstan, 2009, Braliyev, 2007, Government of the Republic of Kazakhstan, 2018, ICAP, 2019)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Economy-wide	Concept for Kazakhstan's Transition to Green Economy (2015) (+)	• Reduction of energy intensity per GDP of 25% by 2020, of 30% by 2030 and of 50% by 2050 compared to 2008 levels • Share of renewable energy production by wind and solar in total electricity production of not less than 3% in 2020 and 30% by 2030	• Policy considered as an overarching strategy without a substantial plan for implementation as of today. Thus, this policy is excluded from the current policies scenario.
	Strategic Development Plan before 2020 (Decree No. 922) (2010)	• Aim to increase renewable energy share in total energy consumption to 1.5% by 2015 and 3% by 2020 • Reduction of energy intensity by at least 10% by 2015 and by at least 25% by 2025 as compared to 2008[1)]	• Not included (only indirectly via renewable energy capacity deployment under the Action Plan for the development of alternative and renewable energy in Kazakhstan for 2013–2020)
	Concept of Transition of the Republic of Kazakhstan to Sustainable Development for the Period 2007–2024 (Presidential Decree No. 216 of 2006) (2006)	• 5% of national energy consumption provided by renewable sources by 2024	• Not included (only indirectly via renewable energy capacity deployment under the Action Plan for the development of alternative and renewable energy in Kazakhstan for 2013–2020)
Energy supply	Support scheme for renewable energy (2014)	• Feed-in-tariff for wind, solar, small hydro and biogas plants	• Not included as there is limited information on the current status of the support scheme and its expected mitigation impact from the support scheme for renewable energy
	Action Plan for the Development of Alternative and Renewable Energy in Kazakhstan for 2013–2020 (2013)	• Plan to build around 106 renewable energy installations with a total installed capacity of 3,054.55 MW into operation by 2020	• Not explicitly modelled based on the assessment of the current status (IRENA, 2018a)(KOREM, 2018)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
		(including 1,787 MW wind; 539 MW hydro; 713.5 MW solar; 15.05 MW biomass)	
	National Allocation Plan for GHG emissions under KAZ ETS for 2018–2020 (December 2017)	• Cap of 162 $MtCO_2e$/year for 2018-2020	• Not included because of the uncertainty on the potential mitigation impact.
Buildings	Program on modernization of housing and communal services (2012)	• Reduction of emissions associated with housing and communal services by 10% by 2030	• Not explicitly included in Without Measures (WOM) scenario of Second Biennial Report CTF submission workbook
Forestry	Strategic Plan of the Ministry of Environment and Water Resources (2014)	• Wildfire suppression activities. A reduction of associated emissions by 0.3 $MtCO_2e$/year by 2030. • Combating land degradation and desertification. A reduction of associated emissions by 25 $MtCO_2e$/year by 2030 compared to 1991 levels.	• IIASA projections
	State Program for Agro-industrial Complex Development of the Republic of Kazakhstan (2017)	• Reduction of forest felling volumes that is expected to increase associated sinks by 0.1 $MtCO_2e$/year by 2030 compared to 1991 levels. • Increasing forest area and forest area regeneration. An increase of associated sinks by 0.3 $MtCO_2e$/year by 2030 compared to 1991 levels.	• IIASA projections

14.2 Details of NewClimate calculations

Emissions projections under current policies

NewClimate Institute calculations refer to the two scenarios up to 2030 reported in the Third Biennial Report (BR3) (Ministry of Energy of the Republic of Kazakhstan, 2017): "Without measures" (WOM) scenario and "With current measures" (WCM) scenario. The WOM scenario "reflects a possible change of greenhouse gas emissions without any measures to reduce them" and the modelling base year is 2010, whereas the WCM scenario "includes adopted and planned measures and policies aimed directly at reducing greenhouse gas emissions or have indirect impact on reduction of GHGs" and the modelling base year is 2015.

Although the two scenarios are not consistent with the "current policies scenario" defined in this study, there is limited information about the status of energy and climate policy implementation in Kazakhstan. Therefore, we took the WOM scenario-based projections as the upper end projections, and the WCM scenario-based projections as the lower end projections.

For the WCM scenario, the calculation steps were as follows:

1) Linear interpolation was done for the years without emissions projections
2) Annual growth rates were calculated for each year between 2016 and 2030.
3) Annual GHG emissions until 2030 were calculated by multiplying the GHG emissions for 2016 reported to the UNFCCC (UNFCCC, 2018b) by the annual growth rates derived in the second step.

In contrast to the 2017 report, the 2018 report did not consider the *Action Plan for the development of alternative and renewable energy in Kazakhstan for 2013–2020* (hereinafter, "Action Plan") (Ministry of Energy of the Republic of Kazakhstan, 2015). An assessment by NewClimate Institute concluded that the renewable energy deployment will remain well below the targets set under the Action Plan; the total installed capacity of renewable technologies in 2017 were still far from the targets (IRENA, 2018a) and it is not fully clear whether the planned renewable energy auctions (KOREM, 2018) would secure the capacity installation that is enough to meet the Action Plan's targets by 2020.

For the WOM scenario, we took a different approach as the modelling base year was 2010. We adapted the projections for GHG emissions from energy and industrial processes sectors as per GHG inventories submitted to the UNFCCC (2018b); in 2016 these two sectors accounted for 99% of national total CO_2 emissions (excluding LULUCF), and CO_2 emissions accounted for 92% of total GHG emissions from these two sectors (UNFCCC, 2018b). The calculation steps were as follows:

1. The GDP (constant 2010 USD) elasticity of GHG emissions from energy and industrial processes sectors were calculated for 2010–2020 and 2020–2030 based on the data provided in the BR3. The elasticity values observed were 0.44 for 2010–2020 and 0.76 for 2020–2030.
2. The GDP projections for 2018–2030 were revised by applying the compound annual growth rate estimated from the information in the BR3 to the 2017 historical data from the World Development Indicators database ((World Bank, 2018).
3. The GHG emissions projections for energy and industrial processes sectors were recalculated by applying the GDP elasticity values quantified in the first step to the revised GDP projections in the second step.

GHG emissions projections from other sectors (agriculture, waste and others) from the WOM scenario were used as reported.

14.3 Details of PBL calculations

The emissions projections under current policies by PBL is based on the IMAGE SSP2 baseline. Most targets considered in the current policies scenario were met or exceeded in the business-as-usual scenario, including renewable capacity targets under the Action Plan. The feed-in-tariffs of the Support scheme for renewable energy were assumed to support the Action Plan targets and thus not quantified separately in the TIMER model. Building policies were also not quantified in the TIMER model. The Kazakhstan region in the TIMER model ("Central Asia") includes other countries, besides Kazakhstan (see the IMAGE wiki for more details). The results were downscaled based on 2015 emissions (Kazakhstan share approximately 52%).

14.4 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the Strategic Plan of the Environment and Water Resources). For this assessment, only forestry related changes in LULUCF carbon pools for Kazakhstan were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and were harmonised to the 2017 National Inventory Reporting (Republic of Kazakhstan, 2017).

For the projections to reach consistency with policy measures related to afforestation and reforestation actions, a nation-wide carbon price was induced that enhances the afforestation/reforestation rate and reduces the deforestation rate over time. The carbon price was assumed to be implemented as of 2015 and increased linearly until 2030 such that a cumulative total of 5,000 hectares of land would be reforested and afforested from 2015 until 2030. Furthermore, policies directly related to Wildfire suppression, Reduction of forest felling volumes, and Combating lend degradation and desertification are implemented by directly assuming that the mitigation target (in terms of $MtCO_2eq$) will be fulfilled. This as no direct quantifier for these policy targets could be found and used for quantifying the potential impact of the policy utilizing the G4M model. The G4M projections of future emissions and removals are therefore directly reduced by the corresponding mitigation that the policy is expected to provide.

15 Mexico

15.1 Assessment

NDC

In its NDC, Mexico aims to reduce GHG emissions by 22% (unconditional) and by 36% (conditional) from BAU by 2030. The NDC provides the resulting 2030 emission levels in $MtCO_2e$ in AR5 GWPs. The target covers all sectors (energy, industrial processes and product use, agriculture, LULUCF, and waste) and six GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6).

Current policies

Table S15 shows an overview of key climate change mitigation-related policies in Mexico and how they were taken into account in deriving emissions projections under current policies. Mexico's General Climate Change Law from 2012 provides overarching strategies and goals with regard to climate change (Government of Mexico, 2015b). This law was reformed in 2014, 2015, 2016, and 2018. Notably in 2018,

it was reformed to include Mexico's NDC commitments—also at sectoral level—and to establish a national emissions market, which was previously only voluntary.

The more specific second Special Program on Climate Change (2014-2018) provides a plan to reduce GHG emissions by implementing specific measures in all sectors (Government of Mexico, 2014a). A third edition of the Program will have to be developed by Lopez Obrador's—president for the period 2018-2024—administration as established in the General Climate Change Law.

Mexico's Energy Transition Law (24/12/2015)[22] provides a framework for clean energy, energy efficiency and greenhouse gas emissions reductions. The law contains clean energy targets for the years 2018 (25% of generation), 2021 (30%) and 2024 (35%). An assessment of the new Law's target done by NewClimate Institute, reveals that this target is less ambitious compared to what was proposed by previous renewable energy laws as well as the Secretariat of Energy (SENER) projections. This is due to the fact that the clean energy target definition used by Mexico includes not only renewable energy but also other energy sources, which include, among others, fossil-based cogeneration.

The latest Energy Outlook published by the Mexican government suggests that fossil-based cogeneration could reach a share as high as 5% of total electricity generation in 2030 (SENER, 2017a). This is a substantial share, especially considering that in 2012 the share of cogeneration was 0%. As a result, the share of zero-emission energy sources might be lower than what the target suggests: for 2024 the Energy Outlook suggests that the share of cogeneration could be as high as 5%, which could potentially reduce the share of zero-emission energy sources to 32% under the clean energy target.

Mexico set a carbon tax of $3.7 USD/ton CO_2 in 2014, which excluded natural gas (SEMARNAT, 2014). At the end of 2017, the regulation for the use of emission reduction credits for compliance under the carbon tax in Mexico came into force. This regulation establishes the allowance of Certified Emissions Reductions (CERs)—from CDM projects in Mexico—as well as Green Certified Emission Reductions—in the EU ETS—as payment means under the carbon tax (Diario Oficial de la Federación, 2017; World Bank Group and Ecofys, 2018). In the same year, Mexico began a simulation of a voluntary emissions trading system (ETS). A pilot phase was originally programmed to start in 2018, however it has been postponed to 2019 (SEMARNAT, 2017, 2018).

The NewClimate Institute projections for GHG emissions under current policies were based on the BAU values published in the NDC document, adjusted to lower GDP and electricity generation projections from the most recent SENER Energy Outlook. The PBL emissions projections are slightly lower than those in den Elzen et al. (2015), and based on updated calculations using the IMAGE model, including high-impact policies as identified in the CD-LINKS project (CD-LINKS, 2017) (Table S15).

[22] http://www.diputados.gob.mx/LeyesBiblio/pdf/LTE.pdf [Accessed 5 August 2016)

Table S15: Overview of key climate change mitigation-related policies in Mexico (Government of Mexico, 2014b, Cámara de Diputados, 2015, Government of Mexico, 2016, Secretariat of Energy of Mexico, 2014, SEMARNAT, 2001, Secretariat of Energy of Mexico, 2011)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	Special Program on Climate Change (2014–2018) (+)	• Plan to reduce GHG emissions by implementing specific measures in all sectors	• Not included separately	• Not included separately
	Reform to the General Law on Climate Change (LGCC, (+)) (April 2018)	• Addition of NDC GHG emission reduction targets including sectoral targets.	• Not included separately	• Not included separately
Energy supply	Electric Industry Law (LIE, (+)) (2014)	• Law part of the Energy Reform (2014) • Establishes a free competition regime electric power generation and commercialization. It allows for private • Under these Law, market rulebooks exist (e.g. auctioning, interconnections, etc.)	• Not included separately	• Not included separately
	Energy Transition Law (2015)	• Provides a framework for clean energy, energy efficiency and greenhouse gas emissions reductions • 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 (IEA, 2016b)	• Clean energy targets included	• Clean energy targets included as such (assuming they include hydropower); 21.3% reached in 2018, 35% in 2021 and 37.5% in 2024
	National Transition Strategy to Promote the use of clean fuels and technologies	• Policy instrument part of the Energy Transition Law. Planning instrument. • It establishes the "National Strategy to Promote the use of	• Considered in the energy sector projections – Prospectiva	• Not included separately, assumed to support the targets of the Energy Transition Law

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
		clean fuels and technologies", it is a planning document depicting medium and long-term clean energy (incl. efficient cogeneration) goals of 35% by 2024, 37.5% by 2030 and 50% by 2050.	2017-2031 – from the Ministry of Energy 2017.	
	Performance criteria and application for flaring and ventilation of natural gas (CNH.06.001/09)	• Emissions reductions in oil and gas production through decreased venting (73 $MtCO_2e$/year below BAU in 2020 and 92 $MtCO_2e$/year in 2030)	• Not quantified	• Included but not reached (approximately 32 $MtCO_2e$/year below PBL BAU by 2020 and 35 $MtCO_2e$ below BAU by 2030)
Transport	CO_2 emissions standards for light-duty vehicles	• Passenger cars: 135–180 gCO_2/km (depending on vehicle size) • Light-duty trucks: 163–228 gCO_2/km (depending on size)	• Not included as standards only finalized through 2017	• Implemented as 1.68 MJ/pkm from 2016 onwards for light-duty vehicles (1.5 MJ/pkm reached)
Forestry	National Forestry Programme 2025 (2001)	• Protected areas according to the payments for Ecosystem Services (PES) scheme for promoting conservation restoration and sustainable forest use	• Not included	• Not included
	National Forestry Programme - PRONAFOR (2014)	• Reduction of the annual deforestation rate from 0.24% of total forest area in 2010, to 0.2% by 2018	• Included	• Included
	REDD+ National Strategy (2017)	• Continued reduction of LULUCF emissions and achieving 0% net deforestation by 2030.	• Included	• Included

Both PBL and NewClimate calculations were supplemented with the IIASA projections on LULUCF emissions. The IIASA projections of LULUCF emissions and removals were based on the G4M SSP2 projections (Fricko et al., 2016) and were harmonised to the historical data reported on the UNFCCC portal (UNFCCC, 2017a). The current policies scenario includes the fulfillment of the targeted reduction of the annual deforestation from the Sustainable Forestry Management Program, which aims to reduce the yearly deforestation rate from 0.24% of total forest area in 2010 to a yearly loss of 0.2% in 2018. This represents a reduction of the annual deforestation rate by roughly 18%.

15.2 Details of NewClimate calculations

The emissions projections under current policies by NewClimate Institute were based on its analysis for the Climate Action Tracker.[23]

Historical emissions

Historical emissions data was taken from Mexico's National Inventory of Greenhouse Gases and Compounds (INEGyCEI, in Spanish) (INECC, 2018), which is planned to be submitted in 2019 to the UNFCCC. It uses Global Warming Potentials (GWPs) from the IPCC Fifth Assessment Report (AR5).

Emissions projections under current policies

We took the BAU as reported in the documentation accompanying the NDC (Government of Mexico, 2015a) as a starting point for the emissions projections under current policies. We harmonized this scenario to historical data from the inventory and adjusted to a range of lower GDP projections from SENER Energy Outlook (SENER, 2017a).

The BAU range was then used to assess the implementation of the Clean Energy Targets and electricity generation through 2030 from SENER'S Energy Outlook (SENER, 2017a).Two scenario variants were evaluated; the first scenario assumed that the clean energy target will be reached according to the fuel mix provided in the energy forecast by SENER (SENER, 2016)(SENER, 2017b). This includes a 7% share of nuclear in 2030 (which suggest a 250% increase in nuclear power generation compared to current values). In the second scenario variant, we assumed that generation from nuclear would remain constant to 2030 (as it is projected to through 2027), and that the additional electricity would be generated using efficient co-generation, which is likely to include natural gas, which still emits CO_2. According to Mexican regulation, efficient cogeneration can emit up to 100 gCO_2/kWh (Cámara de Diputados, 2015). Mexico includes efficient co-generation in its definition of clean energy, and has projected higher shares of co-generation in the past (SENER, 2015, 2016). For the estimation of emissions from efficient co-generation, we have applied an emissions factor of 100 gCO_2/kWh. However, we could be overestimating emissions reduction impact because it is unclear how this emissions factor relates to an efficient cogeneration plant (Comision Reguladora de Energia, 2011)(Cámara de Diputados, 2015).

15.3 Details of IIASA calculations

IIASA results for Mexico were based on national estimates utilizing the G4M model. In its core, the emissions projections under current policies are based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the National Forestry Programme - PRONAFOR). For this assessment, only forestry related changes in LULUCF carbon pools for Mexico were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to historical data reported on the UNFCCC portal (UNFCCC, 2017a).

[23] https://climateactiontracker.org/countries/mexico/ (update November 2018)

For the projections to reach consistency with policy measured related to the reduction of the annual deforestation rate, a nation-wide carbon price was implemented in G4M, which reduces the deforestation rate and enhances the afforestation/reforestation rate over time. The carbon price was specifically implemented so that the gross deforestation rate would be decreased from 0.24% as of 2010, to 0.2% as of 2018, and 0% as of 2030. The carbon price itself was assumed to be implemented as of 2015 and furthermore increasing on a yearly basis by 2% until 2030. It should be noted that the target of zero deforestation as of 2030 has thereby been assumed to be a target of zero gross deforestation (i.e. annual afforestation minus annual deforestation should be great than zero), not as a net zero deforestation rate (i.e. annual deforestation should be zero).

16 Morocco

16.1 Assessment

NDC

Under its NDC, Morocco aims to limit its GHG emissions including LULUCF emissions by 17% below BAU by 2030 and has an economy-wide sectoral coverage. The NDC covers CO_2, CH_4 and N_2O only. Excluding emissions reduction contributions from agriculture, forestry and other land use (AFOLU), Morocco targets to unconditionally reduce GHG emissions by 13%.

Conditional on international financial support of USD 35 billion, Morocco would decrease GHG emissions including LULUCF emissions further by 42% below BAU by 2030. Excluding emissions reduction contributions from AFOLU, Morocco targets to conditionally decrease GHG emissions by 34%.

Current policies

Table S16 shows an overview of key climate change mitigation-related policies in Morocco and how they were taken into account in deriving emissions projections under current policies. NewClimate Institute calculations were based on its analysis for the Climate Action Tracker, whose analysis has been slightly adapted to better reflect the implementation status of current policies.[24] The projections used the BAU scenario provided by the BUR1 (Kingdom of Morocco, 2016a) and NC3 (Government of Morocco, 2016a) as a basis In addition, it considers several sectoral policies that are currently being implemented. For each of these policies, the BUR1 provides emissions reduction estimates, which were used to model the current policies emissions projections.

The present emissions projections under current policies assumes full implementation of Morocco Solar Plan and Morocco Hydro-Electric Plan based on latest information available. The extension of wind, solar and hydro capacity by 2020 is estimated to reduce emissions 11 $MtCO_2$ annually (Kingdom of Morocco, 2016a).

After administrative restructuring, the Moroccan Agency for Sustainable Energy (MASEN) will take over the lead for the development of all renewable energy technologies in Morocco (Renewables Now, 2016) from the Moroccan Electricity and Water Utility Company (ONEE). This includes the ongoing development of ONEE's solar power programme for 500 MW by 2020, including the three large projects Noor-Tafilalet (120 MW), Noor-Atlas (200 MW) and Noor Argana (100 MW). With the projects already led by MASEN, the final phase of the Noor Ouarzazate complex (70 MW out of 580 MW) and the Noor Laayoune (80 MW) and Noor Boujdour (20 MW) projects were commissioned in 2018 (MASEN, 2018). Finally, MASEN announced the they will award contracts for the 800 MW Noor Midelt project by the end of 2018 (Renewables Now, 2018).

Owing to these recent developments, it is assumed that the Morocco Solar Plan's capacity extension targets until 2020 will be fully implemented. Some of the latest project developments already address capacity extension plans for the post-2020 period to achieve the 2030 capacity extension target. In our CAT assessment we have not quantified these impacts as the developments and successful implementation for the post-2020 period are relatively more uncertain.

The *Morocco Integrated Wind Energy Program* aims to increase the capacity of national wind farms from 797 MW in 2015 to 2,000 MW by 2020 (Government of Morocco, 2016a). This programme is also assumed to be part of the current policy projections since its implementation is on track.

[24] https://climateactiontracker.org/countries/morocco/ (update November 2018)

The Moroccan Electricity and Water Utility Company awarded a tender bid of 850 MW in 2015 that includes five projects: 150 MW in Tangiers, 300 MW in Tiskrad, 200 MW in Jbel Lahdid, 100 MW near Boujdour, and 100 MW at Midelt, all beginning operation between 2017 and 2020 (Oxford Business Group, 2016). At the end of 2017, Morocco had 1,000 MW wind energy installed capacity (IRENA, 2018a) which during the year of 2018 has been expanded with the inauguration of the 120 MW Khalladi windfarm (Climate Home News, 2018).

As an extension of the *Morocco Hydro-Electric Plan*, Morocco plans to install an additional hydro-electric capacity of 775 MW by 2020, on top of the already-installed capacity of about 1,300 MW in 2010. Two projects of 15 MW of small hydropower power in Morocco's Middle Atlas region received approval in 2018 (HydroWorld, 2018) Three plants with a total potential capacity of around 300 MW are further assumed to be developed until 2020, with El Menzel and Station de Transfert d'Energie par Pompage (STEP) Abdelmoumen already under construction. ONEE recently identified numerous sites suitable for locating small or micro hydropower plants (~100 kW to 1,500 kW), with a total potential capacity of around 300 MW(Federal Ministry of Economic Affairs and Energy, 2016).

The Moroccan Climate Change Policy (MCCP) coordinates and aligns various sectoral and cross-sectoral national policies with climate change. Therefore, this policy is not additionally considered in the current policies scenario. Moreover, the current status of eight policies listed as "under implementation" in the NC3 and BUR1 could not be confirmed by external sources (see Section 16.2). For this reason, none of these policies were considered in the current policies analysis by NewClimate Institute.

LULUCF emission projections were also provided by IIASA. Projections of LULUCF emissions and removals under current policies were based on updated G4M estimates and were harmonised to the level of net emissions reported on the UNFCCC portal (UNFCCC, 2017a).

Table S16: Overview of key climate change mitigation policies in Morocco (Kingdom of Morocco, 2016b, Kingdom of Morocco, 2016a, Kingdom of Morocco, 2014, Kingdom of Morocco - Ministry Delegate of the Minister of Energy Mines Water and Environment, 2013, Ministry of Equipment and Transport, 2010, Schinke and Klawitter, 2016)

Sector	**Policies (marked with "(+)" when mentioned in the NDC document)**	**Description**	**NewClimate quantification of impact**
Economy-wide	Moroccan Climate Change Policy (MCCP) (2014)	• Overarching coordination and alignment of various sectoral and cross-sectoral national policies tackling climate change	• Not additionally considered in the current policies scenario as Moroccan Climate Change Policy (MCCP) coordinates and aligns various sectoral and cross-sectoral national policies with climate change
Energy supply	National Energy Strategy (2009, updated 2012) (+) • Morocco Integrated Wind Energy Program (2010) • Morocco Solar Plan (2009) [1)] • Morocco Hydro-Electric Plan (continuation of plan started in the 1970s) [1)]	• Aim for an installed renewable electricity capacity of 42% by 2020 (14% wind, 14% solar and 14% hydro) and 52% by 2030 • Energy savings of 12–15% in 2020 and 20% in 2030 • Supply 10–12% of the country's primary energy demand with renewable energy sources by 2020 and 15–20% by 2030 • Extension of national wind farms to total 2,000 MW by 2020 • Extension of solar power capacity to 2,000 MW (both concentrated solar power plants & photovoltaic systems) • Extension of hydro power capacity with 775 MW by 2020 • Extension of small hydropower projects with total capacity of 100 MW in 2030	• 2020 objectives to install RE capacity under Morocco Integrated Wind Energy Program, Morocco Solar Plan and the extension of the Morocco Hydro-Electric Plan are all considered to be fully implemented in current policies scenario based on latest information. Included based on emissions reduction estimates provided in BUR1.
Transport	Extension of Rabat and Casablanca tramways (2016)	• Extension of Rabat tramway by 20 km by 2019 • Extension of Casablanca tramway by 45 km by 2025	• Included based on emissions reduction estimates provided in BUR1
Industry	Energy efficiency	• Energy efficiency program for industry, buildings and transport	• Included based on emissions reduction

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
	program in the industry sector (2011)	sector (excluding large energy consuming industries)	estimates provided in BUR1
Buildings	Energy efficiency program in the building sector (2009)	• Minimum requirements for new residential and commercial buildings	• Included based on emissions reduction estimates provided in BUR1
	Energy efficiency program for public lighting (2009)	• Instalment of new public lightening technologies	• Included based on emissions reduction estimates provided in BUR1
Forestry	Preservation and Sustainable Forest Management Strategy (+)	• Afforestation and regeneration of approximately 50,000 hectares of forest per year	• IIASA projection
	Morocco Green Plan (PMV) (2008) (+)	• Promotion of natural resources and sustainable management [2)] • Modernization of the agricultural sector [2)]	• Policies not included in IIASA projections

16.2 Details of NewClimate calculations

The emissions projections under current policies by NewClimate Institute were based on its analysis for the Climate Action Tracker.[25]

Historical emissions

National GHG inventory data provided by Morocco's 1st Biennial Update Report for 1994 until 2012 are used for historical emissions (Government of Morocco, 2016b). All reported values are originally based on Global Warming Potentials (GWP) from the IPCC's Second Assessment Report – SAR. For the historic years before 1994, we used a linear backward extrapolation of the trend between 1994 and 2012.

Emissions projections under current policies

The emissions projections under current policies used the BAU scenario provided by the NC3 as a basis. In addition, it considered several sectoral policies that are currently being implemented. For each of these policies, the BUR1 (Kingdom of Morocco, 2016a) provides emissions reduction estimates, which annual emissions reduction impact by 2020 and 2030 were aggregated to model the current policies emissions projections.

[25] https://climateactiontracker.org/countries/morocco/ (update November 2018)

The NDC provides BAU scenario projections including AFOLU for the years 2010, 2020, 2025 and 2030. The NC3 offers LULUCF projections in five years intervals from 2015 until 2040. Total GHG emissions excluding LULUCF are calculated by subtracting LULUCF projections from NC3 from NDC BAU emissions. Furthermore, the BUR1 provides annual emission reduction estimates by 2020 and 2030 for the following policies, which have all been identified as current policies:

- Extension of national wind farms to total capacity of 2,000 MW by 2020
- Solar power capacity of 2,000 MW by 2020 (both concentrated solar power plants & photovoltaic systems)
- Extension of hydro power capacity of 775 MW by 2020
- Energy efficiency program in the building sector (household and tertiary sector)
- Energy efficiency program for public lighting
- Energy efficiency program in the industry sector (excluding large energy consuming industries)
- Extension of Rabat tramway by 20 km by 2019
- Extension of Casablanca tramway by 45 km by 2025
- Extension of small hydropower projects with total capacity of 100 MW in 2030

The following policies have been accounted for to calculate projected LULUCF emissions under currently implemented policies:

- Annual olive tree plantations of additional 44,700 ha
- Annual fruit tree plantations of additional 55,300 ha (excl. citrus and olive trees)
- Plantation of 3 million date palms until 2020

The current status of the following eight policies listed as "under implementation" in the NC3 and BUR1 could not be confirmed by external sources. For this reason, none of these policies were considered in the current policies analysis by NewClimate Institute.

- Programme d'implantation de système DES GEStion de l'énergie et de la productivité (SGEP) et de la norme ISO 50001 dans l'industrie
- Programme Biomasse - Inventaire, organisation et valorisation de la filière
- Programme de remplacement des grands taxis par des véhicules 7 places à faible facteur d'émission (g.CO_2/km)
- Programme de modernisation du parc automobile de l'état vers véhicules électriques
- Valorisation des cendres volantes dans l'industrie des matériaux de construction
- Augmentation du recyclage de PVC
- Valorisation des émanations DES GES en provenance des décharges contrôlées
- Valorisation des émanations DES GES en provenance des stations de traitement des eaux usées

16.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (Preservation and Sustainable Forest Management Strategy). For this assessment, only forestry related changes in LULUCF carbon pools for Morocco were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to data provided by the UNFCCC portal (UNFCCC, 2017a).

For the projections to reach consistency with policy measured related to afforestation and the regeneration of forests, a nation-wide carbon price was implemented in G4M, which enhances the afforestation/reforestation rate over time. The carbon price was specifically implemented so that the afforestation/reforestation target of 50,000 ha/year is already reached as of 2015, after which the carbon price is assumed to remain constant over time.

17 Philippines

17.1 Assessment

INDC

The Philippines' INDC covers the energy, transport, waste, forestry and industry sectors. The INDC does not specify which gases are covered. The INDC includes a conditional GHG reduction target of 70% below BAU levels by 2030. The target covers all emissions from all sectors, including LULUCF. The NDC states that the target is conditional on "the extent of financial resources, including technology development & transfer, and capacity building, that will be made available to the Philippines." The Philippines have not submitted its NDC as of September 2018.

Since the INDC does not specify the BAU pathway, the emission levels under the NDC were based on NewClimate Institute analysis for the Climate Action Tracker analysis that used the range of emissions projections under current policies estimated in 2015 to represent BAU projections.[26]

Current policies

Our projections suggest that the Philippines is not on track to meet its INDC but, given that has not put forward an official BAU scenario to quantify the conditional INDC pledge as well as the uncertainty around the emission reduction in LULUCF and other sectors, the emissions pathway is highly uncertain.

Current policy projections for the Philippines were calculated by the NewClimate Institute based on its analysis for the Climate Action Tracker.[26] Table S17 shows an overview of key climate change mitigation-related policies in the Philippines and how they were taken into account in deriving emissions projections under current policies. Projections for the energy-related CO_2 emissions taken from the BAU scenario of the 2016 APERC Energy Demand and Supply Outlook (APERC, 2016b), which "reflects current policies and trends with in the APEC energy sector; thus, its projections largely extend the past into the future". As for the renewable energy capacity to be installed under the National Renewable Energy Program (NREP), the 2016 APERC BAU scenario considers all committed renewable energy projects and the overall renewable energy historical capacity trends as of the end of 2015. Launched in 2011, the NREP serves as the blueprint for the implementation of the Renewable Energy Act of 2008 by tripling the 2010 renewable energy capacity level from 5.4 GW to 15.3 GW until 2030.

Mandated under the Renewable Energy Act (2008) as one of five policy mechanisms to promote renewables deployment, a feed-in tariff applicable to solar, wind, biomass and run-off river hydropower has been implemented in 2012. As of December 2016, a total of 178 projects with a total capacity of about 3.0 GW have received a certificate of commerciality confirmation or endorsement to ERC, with an additional 22 projects with a total capacity of about 1.6 GW considered for nomination (Department of Energy of the Republic of the Philippines, 2017). Due to delayed implementation of policy instruments under the Renewable Energy Act (2008), the fulfillment of the renewable energy capacity set in the NREP has also been delayed significantly and it remains unclear whether the planned capacity expansion can be achieved (IRENA, 2017c).

[26] https://climateactiontracker.org/countries/philippines/ (update November 2018)

Table S17: Overview of key climate change mitigation policies in The Philippines (APERC, 2017, Department of Energy, 2015b, Department of Energy, 2015a, London School of Economics and Political Science, 2015, Philippine Institute for Development Studies, 2014)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Economy-wide	Energy Efficiency and Conservation Roadmap (EE&C) (2014) and Energy Efficiency and Conservation Action Plan (2016)	• 20.2% energy saving by 2030 compared to BAU, from 2005 levels • 3% per year economy-wide improvement in energy intensity compared to BAU • 21 $MtCO_2$ reduction by 2030, compared to BAU • Savings of c.a. 10,665 ktoe (1/3 of current demand) by 2030	• Most sectoral policies in both policy documents included in 2016 APERC BAU scenario for energy-related CO_2 emissions (see below)
Energy supply	Sitio Electrification Program (SEP) of the National Electrification Administration (2012)	• Aims to energize sitios[1)] through on-grid electrification • 2015 target: 100% sitios energized; covering at least 648,820 households [2)]	• Included in 2016 APERC BAU scenario for energy-related CO_2 emissions
	National Renewable Energy Program (NREP) (2012)	• Increase renewable energy capacity of the country to an estimated 15,304 MW by 2030 (almost triple its 2010 level) • The aimed installed capacity by 2030 is broken down as follows: 3,461 MW from geothermal; 8,724 MW from small hydropower (<50 MW); 316 MW from biomass; 2,378 MW from wind; 285 MW from solar; 71 MW from the ocean.	• Committed renewable energy projects and renewable energy historical capacity trends considered in 2016 APERC BAU scenario
	Renewable Energy Act (2008)	Implementation of several energy policy mechanisms: • Renewable Portfolio Standards (RPS rules drafted and set in force when 35% share of renewable energy in power generation reached) • Renewable energy market (REM) reform • Feed-in Tariff (implemented in 2012, applicable to solar, wind, biomass and run-off river hydropower)	• Policy mechanisms such as feed-in tariff considered in 2016 APERC BAU scenario, however, the overall target of 30% share of renewables in total generation capacity not included

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
		• Green Energy Option (rules not finalized as of March 2017) • Net-metering (implemented in 2013)	
Transport	EE&C Roadmap (2014) and Action Plan (2016)	• 14.3% energy savings in transport sector compared to BAU by 2020 • 25% energy savings compared to BAU by 2030	• Some measures of roadmap and action plan included in 2016 APERC BAU scenario
Industry	EE&C Roadmap (2014) and Action Plan (2016)	8.7% energy savings in industrial sector by 2020 compared to BAU, 15% energy savings by 2030	• Some measures of roadmap and action plan included in 2016 APERC BAU scenario
Buildings	EE&C Roadmap (2014) and Action Plan (2016) • Appliance Standards and Labelling Program • Government Buildings Efficiency Program	• 10% energy savings in commercial buildings by 2020 and 25% by 2030, compared to BAU by 2030 • 6.6% energy savings in residential buildings by 2020 and 20% by 2030, compared to BAU by 2030	• Some measures of roadmap and action plan included in 2016 APERC BAU scenario
F-gases	N/A	• N/A	N/A
Forestry	National Greening Program (2011)	• Plant 1.5 billion trees by 2016 covering 1.5 million hectares	• IIASA projection
	The Philippine National REDD+ Strategy (2010) (+)	• Continued reduction deforestation and forest degradation	• Policy not included in IIASA projection

[1] *A "sitio" is defined as a territorial enclave within a barangay (smallest administrative division in the Philippines, equivalent to town or district) which may be distant from the barangay centre.*

[2] *A sitio is considered energized if it is successfully connected to the grid and at least 20 households are given electricity connections.*

The Department of Energy further approved the Energy Efficiency Roadmap in December 2014 (2014–2030) and its corresponding short-term Energy Efficiency Action Plan in December 2015 (2016–2020), both of which have been prepared with the support of the European Union (Department of Energy of the Republic of the Philippines, 2015). Both aligned policy documents list various measures to be implemented in order to enhance energy efficiency in the buildings, industry, energy supply and transport sector. The Energy Efficiency Action Plan is being implemented, but it remains unclear to what extend the energy efficiency measures have been implemented as of today. For this reason,

NewClimate Institute calculations have not been adjusted from the previous analysis in 2016, but the process of implementation of the NREP and the Energy Efficiency Action Plan will be closely followed.

17.2 Details of NewClimate calculations

Historical emissions

The historical GHG emissions data (in AR4 GWP terms) for non-LULUCF sectors from 1990 to 2015 is taken from the PRIMAP database (Gütschow et al., 2018) and harmonised with UNFCCC gas inventory data for the Philippines. LULUCF emissions are taken from UNFCCC database as officially reported by the country for years 1994 and 2000 (UNFCCC, 2018a). PRIMAP sectoral information was used to split historical UNFCCC emissions into three groups: energy CO_2, other-CO_2, and non-CO_2.

Emissions projections under BAU, Current and Planned Policy Scenarios

Emissions projections were based on NewClimate Institute's analysis for the Climate Action Tracker (CAT).[27] The BAU scenario is based on the current policy projections of the CAT from 2015 as the INDC does not specify a BAU emission pathway.

The projections of total energy-related CO_2 emissions were based on the BAU scenario from the 2016 APERC Energy Demand and Supply Outlook (APERC, 2016b). Projected emission data were provided for the years 2005, 2010, 2013, 2020 and 2030 with linear interpolation added for the time periods in-between. Non-energy CO_2 emissions provided in PRIMAP for 1990–2015 were extrapolated with the historical trend between 2000 and 2015. For the projection of non-CO_2 emissions, series from US EPA (2012) were used.

17.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the National Greening Program). For this assessment, only forestry related changes in LULUCF carbon pools for the Philippines were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to the historical datasets provided by FAO (FAOSTAT, 2017).

For the projections to reach consistency with policy measured related to the planting of trees, a nation-wide carbon price was induced as of 2011 that enhances the national afforestation and reforestation rates, thereby providing additional forests and increasing the numbers of trees planted. The carbon price was assumed to be implemented as of 2011 and increase linearly until 2030 such that a cumulative total of 1.5 million hectares of forest land will be afforested/reforested from 2011 until 2030

[27] http://climateactiontracker.org/countries/philippines/2016.html (update 2 November 2016)

18 Republic of Korea

18.1 Assessment

NDC

In its NDC, the Republic of Korea put forward an economy-wide target to reduce its GHG emissions by 37% from BAU by 2030. The NDC covers energy, industrial processes and product use, agriculture and waste, and states that "[…] a decision will be made at a later stage on whether to include greenhouse gas emissions and sinks of the land sector as well as the method for doing so" (UNFCCC, 2015). The target applies to six GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6).

For 2020, the Republic of Korea's Cancun Pledge is to reduce its GHG emission by 30% from BAU by 2020, but this target has been replaced by the 2030 NDC target in the amended Green Growth Act (Presidential Decree no.27180, 24 May, 2016; The Law National Information Center, 2016). There is, however, no report to date that the Republic of Korea abandoned its 2020 pledge communicated to the UNFCCC.

The Republic of Korea provides an official estimate in its NDC document, which would equate to emission levels of about 535.9 $MtCO_2e$/year in 2030. In June 2018, the NDC implementation roadmap originally developed in 2016 was amended to reduce reliance on overseas credits (from 11.3% to 4.5%) (Ministry of Environment, 2018).

The IIASA projection of the net LULUCF emissions for the Republic of Korea estimates that the net LULUCF sink would remain stable until 2030 under the NDC.

Current policies

Table S18 shows an overview of key climate change mitigation-related policies in the Republic of Korea and how they were taken into account in deriving emissions projections under current policies. The Republic of Korea introduced a green growth strategy to stimulate green technologies and industries. Based on this strategy, Republic of Korea pledged to reduce emissions unconditionally by 30%, compared to BAU levels, by 2020, implying an emission target level of about 545 $MtCO_2e$/year, excluding LULUCF. The green growth strategy is supported by renewable energy targets for 2020 and 2030, specified in the Basic Plan on New and Renewable Energies and 7th Basic Plan for Long-term Electricity Supply and Demand. The Republic of Korea launched a national emissions trading system (ETS) in January 2015.

The renewable electricity targets from the Basic Plan on New and Renewable Energies and 7th Basic Plan for Long-term Electricity Supply and Demand could be achieved by effective implementation of the Renewable Portfolio Standard (RPS). The 10% target by 2024 linked to this policy instrument is implemented in the bottom-up model from NewClimate and the PBL TIMER model. This standard covers around 90% of electricity emissions. The RPS aims to increase the share of new and renewable energy, so also including Integrated Gasification Combined Cycle (IGCC) plants and gas generated as a by-product. We do not consider IGCC as a renewable energy source, and it is unclear whether gas as by-product refers to renewable biogas from waste or agriculture or from non-renewable processes in oil production or industry. Based on the scenario from the Republic of Korea Long-term electricity plan, we determined an upper and lower limit by including and excluding the "gas as by-product" in the renewable target. The Republic of Korea has implemented a subsidy program for renewable electricity in the buildings sector. Therefore, we assumed that together with the RPS, the 10% renewable target by 2024 holds for total electricity production. NewClimate further assumed that the 2030 target for renewable energy share in total primary energy supply would be met through the RPS and other policies.

The new President Moon Jae In recently announced to reduce coal-fired power generation and move towards a nuclear phase-out while increasing renewable electricity (Yonhap News Agency, 2017). A new 15-year "Plan for Electricity Supply and Demand" published in 2017 confirms the government's intention to shift electricity generation away from coal and nuclear towards more renewables (CAT, 2018, Ministry of Trade Industry and Energy, 2018). The government plan would result in an electricity generation mix in 2030 based on 23.9% nuclear, 36.1% coal, 18.8% natural gas and 20% renewable energy. The Climate Action Tracker analysis indicates that these announcements, if fully implemented together with the expected lower level of electricity demand, would lead to 53 to 69 $MtCO_2e$/year (7–9%) reductions below current policies scenario projections in 2030, but not enough to achieve the NDC target (CAT 2018n). In this report, we did not consider them as current policies or planned policies because no relevant official policy document has been published.

The PBL emissions projections were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S18).

The IIASA projections of LULUCF emissions and removals under current policies were based on the scenarios presented in Den Elzen et al. (2015) but were updated taking into account the Act on Sustainable use of Timber and Act on the Management and Improvement of Carbon Sink. Overall, these two policies are expected to lead to a stable development of the net LULUCF sink over time.

18.2 Details of NewClimate calculations

The emissions projections under current policies by NewClimate Institute were based on the Climate Action Tracker analysis.[28]

Historical emissions
Historical GHG emissions data were taken from the national inventories submitted to UNFCCC (UNFCCC, 2019).

Emissions projections under current policies
Emissions projections under current policies were based on the BAU scenario from the 6th Edition of APEC Energy Demand and Supply Outlook (APERC, 2016b), which reflects current policies and trends, for energy-related CO_2 emissions and the US EPA projections until 2030 for non-CO_2 GHG emissions (U.S. EPA, 2012). Non-energy CO_2 emissions were assumed to remain constant at the 2012 level up to 2030, based on the historical trend observed between 1995 and 2012.

For energy-related CO_2 emissions, add-on calculations were carried out for different renewable electricity deployment levels. For the upper end of the projections, renewable electricity generation reaches 3.7% in 2024 and growing further to 4.7% by 2030, as projected by APERC (APERC, 2016b). The lower end of the projections results from our assumptions on the implementation of the Renewable Portfolio Standard (RPS); the share of renewable electricity generation reached 10% by 2024 and was sustained up to 2030.

In the APERC (2016a) it is not fully clear to what extent the vehicle fuel efficiency standards and the support for green homes were considered.

https://climateactiontracker.org/countries/south-korea/ (update April 2018)

Table S18: Overview of key climate change mitigation policies in Republic of Korea (Republic of Korea, 2014, Republic of Korea, 2012, MOTIE, 2015, Hwang, 2014, MOTIE, 2017)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	Emissions Trading System (2015)	• Emission cap is in line with the "37% reduction below baseline" target for 2030	• Included through APERC (2016b) BAU scenario	• Not included
Energy supply	Renewable energy targets (4th Basic Plan on New and Renewable Energies, 7th Basic Plan for Long-term Electricity Supply and Demand) (2014)	• 11% share of NRE in TPES by 2035 (5% by 2020, 9.7% by 2030); • 13.4% of total electricity supplied by NRE by 2035 (4th Basic Plan on NRE), 11.7% by 2029 (7th Basic Plan for Long-term Electricity Supply and Demand); o 1.8 GW hydropower, 0.8 GW onshore wind, 1 GW offshore wind, 16.6 GW solar power, 0.2 GW biomass, and 0.2 GW waste capacity by 2029	• Capacity targets for renewables overachieved for all technologies except for solar in the APERC BAU scenario.	• Included capacity targets (share targets not included separately): 1.8 GW hydropower overachieved in baseline; 0.8 GW onshore wind, 1 GW offshore wind, 16.6 GW solar, 0.2 GW biomass and 0.2 GW waste all implemented for Korea region (based on 0 GW of these sources in 2010 in both Republic of Korea and Democratic People's Republic of Korea) and all overachieved; biomass and waste are grouped in one category in TIMER so implemented as 0.4 GW in that category
	8th Basic Plan for Long-term Electricity Supply and Demand	• Aims to shift electricity generation away from coal and nuclear towards more renewables. • The government plan would result in an electricity	• Not included	• Not included

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
		generation mix in 2030 based on 23.9% nuclear, 36.1% coal, 18.8% natural gas and 20% renewable energy.		
	Renewable portfolio standards (2012)	• 10% supply of NRE in total electricity generation by 2024	• Not explicitly included in the APERC (2016b) BAU scenario	• Not included (after implementation of capacity targets, share of renewables in electricity production reaches 5% by 2020, 6% by 2024, 10% by 2029 and 12% by 2035). Including nuclear, share reaches 31.6% by 2030 (28% by 2024).
Buildings	Renewable energy targets (4th Basic Plan on New and Renewable Energies, 7th Basic Plan for Long-term Electricity Supply and Demand) (2014)	• Budgetary support for one million green homes (which covers various renewable energy resources such as solar PV, solar thermal, geothermal, small wind and bioenergy) by 2020 [1)]	• Not explicitly included in the APERC (2016b) BAU scenario	• Not implemented
Transport	Fuel efficiency standard (2005) (+)	• 140 gCO_2/km (16.7 km/l) by 2015, 97 g CO_2/km (24.1 km/l) by 2020	• Not explicitly included through APERC (2016b) BAU scenario	• Implemented as 0.9 MJ/pkm by 2020 for light-duty vehicles
	Renewable Fuel Standard (2013)	• Biodiesel share in diesel of 3% from 2018 onwards	• Included through APERC (2016b) BAU scenario	• Implemented as 1.3% biofuel share (bioethanol + biodiesel) by 2018 (1% reached)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Forestry	Act on the Sustainable use of Timber (2012)	• The forest harvest level will increase by 2.3 million m^3 by 2020, compared to the 2014 level	• IIASA projection	• IIASA projection
	Act on the Management and Improvement of Carbon Sink (2013)	• Act on the Management and Improvement of Carbon Sink (2013)[2] by 2019, compared to the 2014 level	• Increase the forest carbon stocks by 200 $MtCO_2$ by 2019, compared to the 2014 level	• IIASA projection
	Forest Carbon Offset Program (2013)	• Promote activities and forest management practices that enhance the forest carbon sink, facilitate the use of harvested wood products for construction and enhance the use of forest biomass for energy production.	• Not included in IIASA projection	• Not included in IIASA projection

18.3 Details of PBL calculations

The PBL results were based on calculations for the Korea region (including Republic of Korea and Democratic People's Republic of Korea, see the IMAGE wiki for more details). It was assumed that the Republic of Korea has a constant share of Korea's regional emissions, based on the year 2015 (about 92%). The Democratic People's Republic of Korea is also located in this region, but the current policies scenario only includes Republic of Korea's policies as identified in the CD-LINKS project. These policies were modeled by calculating the effect of Republic of Korea's targets on the Korea region, assuming business-as-usual for the Democratic People's Republic of Korea.

18.4 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with LULUCF related policy measures (the Act on Sustainable use of Timber and the Act on the Management and Improvement of Carbon Sink). For this

assessment, only forestry related changes in LULUCF carbon pools for the Republic of Korea were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and were harmonised to historical datasets provided by the UNFCCC portal (UNFCCC, 2019).

For the projections to reach consistency with policy measures related to the Act on the Sustainable use of Timber, the historical harvest rate was taken from FAOSTAT (FAOSTAT, 2017) for 2014 and assumed to increase linearly until 2020 to reach the targeted increase of 2.3 million m^3 by 2020. After 2020, the national forest harvest level was assumed to remain constant over time. For the Act on the Management and Improvement of Carbon Sinks, a nation-wide carbon price was modelled to be induced as of 2013 that enhanced the storage of carbon in forests through enhanced afforestation, reduced deforestation and a combination of changes in management of forests, including: changes of rotation length for existing managed forests, ratio of thinning versus final felling, harvest intensity, and enhancements in afforestation and reforestation of forests. Overall, the total carbon stored and sequestered in forested areas (i.e. above ground, below ground, and soil) increased through the implementation of the carbon price by 2.3 million m^3 by 2020, compared to the IIASA estimated levels for 2014. After 2020, the carbon price was assumed to remain constant until 2030.

19 Russian Federation

19.1 Assessment

INDC

The Russian Federation submitted its Intended Nationally Determined Contribution (INDC) on the 1st of April, 2015 and states that "limiting anthropogenic greenhouse gases in Russia to 70%–75% of 1990 levels by the year 2030 might be a long-term indicator, subject to the maximum possible account of absorbing capacity of forests". This statement implies a reduction target of 25%–30% below the 1990 level (UNFCCC, 2015).

Russian Federation's INDC states that target is "subject to the maximum possible account of absorbing capacity of forests". We assume that Russia applies a gross-net accounting approach. The NDC range presented is a combination of a minimum amount of land-use (0 $MtCO_2e$) and maximum (800 $MtCO_2e$) amount of land-use credits for the unconditional targets. In our previous report, the maximum credits were estimated to be 690 $MtCO_2$. The difference comes from the GWPs used: last year, data was converted to SAR, while this year, AR4 was used, in line with the NDC.

The Russian Federation officially signed the Paris Agreement on the 22nd of April 2016; however, the agreement's ratification and thus the submission of the definitive Nationally Determined Contribution (NDC) are still pending. The Russian government further has presented a national strategy that may delay ratification until at least 2019 (Government of the Russian Federation, 2016). The strategy lists several planned studies of how ratification of the Paris Agreement would affect the national economy, which would have to be ready before the final decision regarding the ratification is taken. The timeline outlined in the strategy would result in a draft presidential decree for approving the 2030 emissions targets by 2019.

Under the Copenhagen Accord, the Russian Federation pledged an emission reduction of 15%–25%, relative to 1990 levels, by 2020. In September 2013, the Russian Government committed to the higher end of the target. This is projected to be achieved with already implemented policies.

Current policies

Table S19 shows an overview of key climate change mitigation-related policies in the Russian Federation and how they were taken into account in deriving emissions projections under current policies. The Russian State Programme includes targets for energy efficiency and renewable electricity generation. Russia's gas flaring policy could lead to additional emission reductions, but it is unclear whether this policy will be fully implemented.

The PBL projections of emissions under current policies were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S19).

The NewClimate Institute projections were based on the Climate Action Tracker analysis[29], which provides an upper and lower bound projection of emission trajectories under current policies. Energy-related CO_2 emissions projections in the higher bound of the emissions projections are largely based on the *Current Policies Scenario* of the IEA's World Energy Outlook 2017 (IEA, 2017b), which takes account of energy-related policy measures formally adopted as of mid-2017. Additional calculations were performed to account for the impact of the renewable energy target (2.5% by 2020, excluding hydropower larger than 25 MW) and the 5% limit on associated gas flaring. For the calculation of the lower bound of the projections, the growth rates of the "with measures" scenario excluding LULUCF in the Sixth National Communication (NC6) (Government of the Russian Federation, 2013b) were applied

[29] https://climateactiontracker.org/countries/russian-federation/ (update April 2018)

to 2014 national inventory submission data (CRF, 2014). The “with measures” scenario includes both the renewable energy target and the 5% limit on associated gas flaring.

Both NewClimate Institute and PBL projections indicate that Russia would not meet its energy intensity target adopted in the Decree on Certain Measures to Increase Energy and Ecological Efficiency of the Russian Economy of 2008 (UNFCCC, 2012). The Energy Strategy 2030 drafted in 2010 furthermore envisage a 44% reduction by 2030 compared to 2005 level (Government of the Russian Federation, 2010). The upper bound of NewClimate Institute projections indicates that this target value is not met by only achieving 40% below 2005 levels by 2030.

The emissions projections under current policies by IIASA concerning the development of the net LULUCF emissions was based on the National Strategy of Forestry Development. National forest harvest projection levels were based on the SSP2 database (Fricko et al., 2016) from which policies for intensification in forest harvest levels (National Strategy of Forestry Development, 5.8% yearly increase in harvest) were analysed to estimate the impact on net LULUCF emissions. Overall, the intensification in forest management is not expected to lead to a significant change of the net LULUCF emissions, which are expected to remain relatively stable over time.

Table S19: Overview of key climate change mitigation policies in the Russian Federation. Source: (Nachmany et al., 2015)

Sector	**Policies (marked with “(+)” when mentioned in the INDC document)**	**Description**	**NewClimate quantification of impact**	**PBL quantification of impact**
Economy-wide	Energy intensity targets (2008)	• 40% reduction of energy intensity of GDP by 2020, relative to 2007	• Checked after implementation of other policies: 10% decrease achieved between 2007 and 2020	• Checked after implementation of other policies: 29.5% decrease achieved between 2007 and 2020
Energy supply	Renewable energy targets (2013)	• 2.5% renewable energy in the power sector by 2020 (excluding hydro larger than 25 MW) (supported by regulated capacity prices for renewable energy, Government of the Russian Federation, 2013a)supported by regulated capacity prices for renewable energy, Government	• Target is not achieved for upper bound projections	• Target share checked after implementation of capacity targets; 19.8% reached by 2020 • Wind and solar capacity targets included as such; small hydropower is not distinguished from hydropower in the TIMER model, so this

Sector	Policies (marked with "(+)" when mentioned in the INDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
		of the Russian Federation, 2013) • 3.6 GW wind, 1.52 GW solar and 75 MW small hydropower capacity by 2020		target was excluded
Industry	Decrease flaring in oil (2009)	• 5% limit on associated gas flaring for 2012 and subsequent years	• The target is considered in lower bound projections	• Not modeled (-1.3 $MtCO_2e$ between 2012 and 2020 achieved; -36 to -12 $MtCO_2e$ required for the 5% limit)
Buildings	Strategy for development of building materials sector for the period up to 2020 and 2030, adopted by Government Decree №868 from 10.05.2016	• Energy consumption in buildings: 20% reduction in residential heat consumption by 2030, relative to 2014	• Not included.	• Not included (electricity consumption of residential buildings is projected to increase by 52.4% between 2014 and 2030)
Forestry	National Strategy of Forestry Development by 2020 (2008)	• Increase in forest intensification and harvest of wood by 5.8% per year compared to 2007	• IIASA projection	• IIASA projection

19.2 Details of NewClimate calculations

Emissions projections under current policies

The emissions projections under current policies by NewClimate Institute were adapted from the Climate Action Tracker analysis.[30] The projections for GHG emissions under current policies comprise an upper and lower bound projections of emission levels under current policies.

The upper bound of the projections was based on the current policies scenario of the World Energy Outlook 2017 for energy-related CO_2 emissions until 2030 (IEA, 2017b). For other GHG emissions, two different methods were applied:

1. The historical trends of per GDP intensity of all GHG emissions other than energy-related CO_2 emissions between 2007 and 2016 were extrapolated up to 2030, then multiplied by the forecasted GDP in the IEA WEO 2017 (IEA, 2017b). Since 2007 the emission intensity has been stagnant, thus the emissions projections under this method increases at a rate roughly proportional to the GDP growth.
2. Historical emission trends for non-energy CO_2 emissions between 2003 and 2016 were linearly extrapolated for the period 2017–2030, and for non-CO_2 GHGs the growth projections estimated by the US EPA (U.S. EPA, 2012) were applied to the 2016 historical emissions data submitted to the UNFCCC (UNFCCC, 2018b).

This analysis did not assume that the renewable energy target of 2.5% excluding large hydro for 2020, which is referenced in multiple energy national documents such as Resolution No. 512-r on the State Program of Energy Efficiency and the Development of the Energy Sector (IFC Advisory Services, 2013), would be met. We compared the IEA WEO 2017 projection with the recent IRENA study on Russia (IRENA, 2017b)—both the WEO 2017 current policy scenario and the IRENA reference scenario project 1.3% share of RE excl. hydro in 2030. While Russia's target does not define the capacity range for small hydro, IRENA projects the total installed capacity of hydro smaller than 10MW in 2030 to be around 1GW or roughly 4TWh (0.3 to 0.4%, assuming a capacity factor of 4000 hr/yr, p.13) of total power generation. If we assume a definition of small hydro similar to that of IRENA, the 2.5% target would not be reached under our upper bound projections.

We also did not assume the achievement of the associated petroleum gas (APG) flaring limit of 5% of total APG produced, which was implemented by the 2009 Decree on Measures to Stimulate the Reduction of Air Pollution from Associated Gas Flaring Products and entered into force in 2015 (Russian Federation, 2009). While the flaring rate has reduced in the last few years, the progress has been slow and there is scepticism whether this is the result of policy implementation (Korppoo, 2018). Since the IEA WEO 2017 does provide flaring-specific emissions projections and does not refer to this flaring limit policy as one of the policies considered in its Current Policies Scenario development, we assume that the target is not achieved in our upper bound projections.

For the calculation of the *lower bound of the projections*, the growth rates of the "with measures" scenario excluding LULUCF in the NC7 and the BR3 (Government of the Russian Federation, 2017b, Government of the Russian Federation, 2017a) were applied to 2016 historical emissions data submitted to the UNFCCC (UNFCCC, 2018b). The "with measures" scenario includes measures to modernise the Russian economy, increase energy efficiency, reduce emissions, the development of nuclear and renewable energy, and others accepted in recent years. It is implied that the "with measures" scenario includes both the renewable energy target and the APG flaring limit (Government of the Russian Federation, 2013b, pp 89-90). We assumed that the government decree No. 868 for building materials is not considered in the "with measures" scenario projections.

[30] https://climateactiontracker.org/countries/russian-federation/ (update April 2018)

19.3 Details of PBL calculations

The PBL results were based on calculations for the Russia region (including a few additional countries, see the IMAGE wiki for more details). It was assumed that the Russian Federation has a constant share of the region's emissions, based on the year 2015 (approximately 97%).

19.4 Details of IIASA calculations

IIASA results for the Russian Federation were based on national estimates using the G4M model. In its core, the emissions projections under current policies are based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the National Strategy of Forestry Development by 2020). For this assessment, only forestry related changes in LULUCF carbon pools for the Russian Federation were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and were harmonised to historical datasets provided in the 2017 CRF tables reported to the UNFCCC.

For the emissions projections under current policies to be consistent with the National Strategy of Forestry Development, the national forest harvest level was pre-defined and assumed to increase by 5.8% per year, starting from the FAOSTAT (FAOSTAT, 2017) reported harvest level for 2007. The national increase in forest harvest was implemented until 2020 after which it was assumed that the harvest would develop in-line with the assessment for the SSP2 baseline.

The NDC scenarios were based on scenarios presented in den Elzen et al. (2016a) and Forsell et al. (2016), based on the information provided in the NC6 of the Russian Federation (Government of the Russian Federation, 2013b). The projection of net LULUCF emissions was furthermore harmonised to historical 2015 levels of net LULUCF emissions based on reported national GHG inventory data provided in the 2017 CRF tables submitted to the UNFCCC.

20 Saudi Arabia

20.1 Assessment

NDC

The Kingdom of Saudi Arabia submitted its Nationally Determined Contribution (NDC***)*** on the 3rd of November, 2016 and seeks to achieve mitigation co-benefits of up to 130 $MtCO_2e$ avoided annually by 2030 through actions and plans outlined to contribute to economic diversification and adaptation. The country has not yet defined a baseline; however, the NDC states that this will be determined based on differently weighted combinations of two scenarios, which differ by assumptions on the allocation of oil produced for either domestic consumption or export (KSA, 2015). The achievement of this goal is not conditional on international financial support, but is contingent on the continuation of economic growth, and robust contribution from oil export revenues to the national economy". Additionally, the country highlights the important role of technology cooperation and transfer as well as capacity building for NDC implementation arguing technical assistant and sustained capacity building in order to be successful will be required for a successful implementation (KSA, 2015).

As of November 2018, Saudi Arabia has not provided the BAU scenario to quantify its NDC target. For this reason, the present analysis quantifies the target based on two estimates of the BAU.

Current policies

The projections by NewClimate Institute were based on the Climate Action Tracker analysis[31]. The projections take into account Saudi Arabia's "Vision 2030" (Kingdom of Saudi Arabia, 2016), which includes a renewable energy target of 9.5 GW by 2023, and the effect of deregulation in energy prices by a subsidy phase-out. The lower end of the range refers to estimations of downscaling of renewable and nuclear targets based on KAUST (KAUST, 2014).

Since 1970 the government has developed ten 5-year national development (KAUST, 2014) plans to guide the development process. The main focus of these plans is the K.A. CARE policy of economic diversification, designed to diversify the country's sources of national income and reduce dependence on revenues from a single source by increasing the share of other productive sectors in gross domestic product (KSA, 2015). Announced in 2013, the K.A. CARE represents the government's plan to build 54 GW of renewable power and 17 GW of nuclear power by 2032 to cover 40–45% of future electricity production (Al-Ghabban, 2013). In 2015, the government announced that the implementation of this policy has been delayed by eight years.

Further delays in policies have been announced by the government in 2016 but are not quantified in our analysis. In Saudi Arabia's "Vision 2030", the renewable energy target was cut down to an 'initial phase' of 9.5 GW in 2023. No targets post-2023 have been announced. In December 2017, a slowdown of four years of the pace of subsidy cuts for oil and derivatives (*i.e.* gasoline, diesel, liquified petroleum gas, fuel oil, asphalt, jet oil, and natural gas) was announced (Nereim, 2017). This will result in a delay of fossil fuel energy price reform—originally planned for 2021 (IMF, 2016). The plan is now to reach international gasoline parity prices, increase diesel prices up to 90% of international prices, and raise the price for other fuels between 2018 and 2025. In January 2018, a 5% VAT on gasoline was implemented (Toumi, 2017).

[31] https://climateactiontracker.org/countries/saudi-arabia/ (update April 2018)

Table S20: Overview of key climate change mitigation policies in Saudi Arabia. Source: (Kingdom of Saudi Arabia, 2016)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
Economy-wide	King Abdullah City for Atomic and Renewable Energy (K.A. CARE) (+) (2010)	Initially aiming to deploy 54GW of renewable power by 2032 (41GW solar, 9GW wind, 3GW waste-to-energy and 1GW of geothermal), the government first announced an eight-year delay of these plans in 2015 and further revised the targets in 2016. In Saudi Arabia's "Vision 2030", the renewable capacity target is revised downward to 9.5 GW by 2023. No additional targets have been announced for the time after 2023.	• Included through accounting for downward adjustment of planned capacity deployment in K.A. CARE in "Vision 2030"
Energy	National Renewable Energy Plan (NREP)	NREP aims to increase the share of renewable energy in the total energy mix, targeting the generation of 3.45 GW of renewable energy by 2020 under the National Transformation Program and 9.5 GW by 2023 towards Vision 2030	• Included through accounting for downward adjustment of planned capacity deployment in K.A. CARE in "Vision 2030"
	Fossil fuel price reform (December 2016)	Gradual increase over between 2017 and 2012 of fossil fuel prices to international prices	• Included in projection for energy-related CO_2 emissions
	Fossil fuel price reform (December 2017)	Fossil fuel price reform delay announced by the government in December 2017, stating that it would slow down the pace of energy subsidy cuts. The plan is now to reach international gasoline parity prices, increase diesel prices up to 90% of international prices, and raise the price for other fuels between 2018 and 2025.	• Not included
	5% VAT in fuel prices (January 2018)	Starting January 2018, the government has implemented a 5% VAT on fuels.	• Not included
Buildings	Energy efficiency labels for appliances (2008)	Energy efficiency labels for a range of household appliances.	• Included in projection for energy-related CO_2 emissions
	Insulation standards for new buildings (2007)	Insulation standards for some insulation products used in residential buildings	• Included in projection for energy-related CO_2 emissions

Through the National Renewable Energy Plan (NREP), Saudi Arabia aims to ensure the deployment of 9.5 GW in renewable electricity capacity by 2023 as specified in the Saudi Arabia's "Vision 2030" (Saudi-US Trade Group, 2017). Managed by the Renewable Energy Project Develop Office (REPDO), a renewable energy tender programme with a financial volume of $30–50 billion has been launched in February 2017 through which domestic and international companies are invited to bid for renewable energy projects. In the first round, 24 pre-qualified companies are bidding to develop 300 MW of solar energy and 400 MW of wind power projects (Bloomberg, 2017). A second round is expected to be launched in the 4th quarter of 2017 (Latham & Watkins, 2017).

20.2 Details of NewClimate calculations

Historical emissions

Historical emissions up to 2010 were obtained from the IEA (IEA, 2017b) for energy-related CO_2 emissions IEA (IEA, 2017b), and US EPA (2012) for non-CO_2 emissions, with interpolation for the years in between for the data from IEA and from US EPA. LULUCF values for 1990 and 2000 were taken from UNFCCC (UNFCCC, 2018a).

Emissions projections under current policies

The emissions projections under current policies were based on the Climate Action Tracker analysis[32]. The Climate Action Tracker analysis estimates a range of emissions through 2030 based on different assumptions given the uncertainty with regards to additional capacity deployment after 2023, the projections comprise an upper bound scenario (pessimistic scenario) and lower bound scenario (optimistic scenario):

- The ***upper bound scenario (pessimistic scenario)*** assumes that renewable power remains at 9.5 GW post-2023, with no nuclear capacity additions.
  This scenario is based on Saudi Arabia's "Vision 2030", which includes a renewable energy target of 9.5 GW by 2023, and the effect of deregulation in energy prices by a subsidy phase-out. We use projections from US EPA (2012) for non-CO_2 emissions and extrapolation of the historical trend for other CO_2 emissions.
- The ***lower bound scenario (optimistic scenario)*** assumes that renewable power will continue to grow at a similar rate post-2023 and the 17 GW nuclear power target is achieved in 2040.
  This scenario is based on KAUST (KAUST, 2014) projections, which assume that the plan of installing 54 GW of renewables and 17 GW of nuclear is to be executed by 2032. We thus estimate the downscaling of renewable and nuclear targets based on growth rates from KAUST (KAUST, 2014). We use projections from US EPA (2012) for non-CO_2 emissions and extrapolation of the historical trend for other CO_2 emissions.

The underlying assumptions for the recalculation of emission levels accounting for the reduced level of renewable and nuclear energy deployment in both scenarios are that the lowered generation from renewables and nuclear is replaced by fossil power generation. This has been done using the emission factor of fossil power generation from the IEA (2014) and (weighted) full load hours for renewable and nuclear power (taken from the KAUST projections). In general, results show that the additional emissions caused by the lowered renewables downscaled targets to be 73 to 135 $MtCO_2e$/year in 2030.

The effect of deregulation in energy prices by a subsidy phase-out is calculated based on the expected effect on the consumption of diesel oil and gasoline. An IISD report estimated that the effect of subsidy phase-out in Saudi Arabia would result in a reduction in emissions by 30.4% below BAU in 2025 and 27.8% in 2030 if subsidies had been phased out by 2020 (Merrill et al., 2015). Based on this study, we estimate that the delayed phase-out will lead to a reduction of fuel consumption leading to emissions

[32] https://climateactiontracker.org/countries/saudi-arabia/ (update April 2018)

reductions of 53 $MtCO_2e$ in 2030. This assumption leads to an overestimation of the emissions reduction potential from the removal of fossil fuels, as the original government target year was 2021. This target has now been postponed to 2025, and its effects—likely to result in higher emissions by 2030—have not been quantified in our analysis. The effect of the introduced 5% VAT for fuels is not quantified in our assessment since there is no data available on the effect of this policy.

20.3 Details of IIASA calculations

IIASA results for Saudi Arabia were based on national estimates utilizing the G4M model. The G4M projections for Saudi Arabia were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017). For this assessment, only forestry related changes in LULUCF carbon pools for Saudi Arabia were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time according to the levels provided by the UNFCCC portal (UNFCCC, 2019).

21 South Africa

21.1 Assessment

NDC

South Africa ratified the Paris Agreement and submitted its Nationally Determined Contribution (NDC) on the 1st of November 2016 (Government of South Africa, 2016). The NDC submission consists of a peak, plateau and decline (PPD) greenhouse gas emissions trajectory range, thus moving away from a "deviation from business-as-usual". The PPD trajectory gives a range of 398–614 $MtCO_2e$/year by 2025 and 2030, with a peak between 2020 and 2025, a plateau for the following decade, and absolute declines thereafter (Republic of South Africa, 2015, Energy Research Centre, 2015). It includes all sectors and gases. No unconditional target is presented. Uncertainties are noted in relation to AFOLU emissions and trace gases, with the intention of reducing uncertainty over time and moving to a comprehensive accounting approach for land-based emissions and removals.

Current policies

Table S21 shows an overview of key climate change mitigation-related policies in South Africa and how they were taken into account in deriving emissions projections under current policies.

The current policy projections of PBL were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S21). The current policy projections by NewClimate Institute were based on its analysis for the Climate Action Tracker,[33] which used the most recent external scenario for CO_2 emissions projections from WEO2016, whereas last year's country assessment relied on the outdated *Greenhouse Gas Mitigation Potential Analysis Report* (Department of Environmental Affairs, 2014b). Both scenarios significantly differ in absolute emissions because of different underlying assumptions. Most prominently, economic growth is 3.6%/year between 2015 and 2022 and 3.9%/year between 2023 and 2032 in the *Greenhouse Gas Mitigation Potential Analysis Report* of the Department of Environmental Affairs, whereas it is 1.7%/year between 2014 and 2020 and 2.8%/year between 2020 and 2030 in the WEO2016.

The National Development Plan (NDP) of the Republic of South Africa provides a 2030 vision on sustainable development, eliminating poverty and reducing inequalities. The National Climate Change Response Policy (NCCRP) of 2011 further elaborates this 2030 vision. Various sectoral plans exist, of which the Integrated Resource Plan (IRP) for electricity is Republic of South Africa's main policy affecting greenhouse gas emissions (Department of Energy, 2011, Department of Energy, 2013). Introduced in 2010, the IRP is the government's capacity expansion plan for the electricity sector until 2050, which contains targets for all technologies, including renewable energy technologies. The IRP sets an overall emissions constraint of 275 $MtCO_2$/year, which has been relevant for supporting the inclusion of RE capacity targets.

[33] https://climateactiontracker.org/countries/south-africa/ (update November 2018)

Table S21: Overview of key climate change mitigation policies in the Republic of South Africa. Source: (Department of Energy, 2016)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	National Development Plan (2012) (+)	• Among other targets: eliminate poverty, reduce inequality, increase access to water and electricity	• Not included	• Not included
	National Climate Change Response Policy (2011) (+)	• Objectives: effectively manage climate change impacts and make a fair contribution to the global effort to stabilise GHG concentrations	• Not included	• Not included
Energy supply	Integrated Resource Plan for electricity (supported by REIPPPP, Renewable Energy Independent Power Producer Procurement Programme) (2011; draft 2018 update published[1)]) (+)	• Additional renewable electricity generation capacity to be built between 2010 and 2030 in the policy-adjusted plan[2)]: 8.4 GW solar PV, 8.4 GW wind (plus 800 MW already committed), 1 GW CSP; resulting total capacity[3)] 8.4 GW solar PV, 9.2 GW wind, 1 GW CSP	• Included in the projections	• Included as such (assuming wind target is met onshore); solar PV target already achieved in the baseline (9.6 GW by 2030, and 10.5 GW in the current policies scenario), solar CSP target overachieved (1.1 GW reached), wind target overachieved (11.3 GW reached)
Transport	Mandatory blending of biofuels under the Petroleum Products Act (Biofuels Industrial Strategy) (2007)	• Concentration for blending: 2%–10% for bio-ethanol and minimum 5% for biodiesel from 2015 onwards	• Included in the projections	• Included as 5% biofuel blending target (bioethanol + biodiesel) from 2015 onwards
Buildings	National Building Regulation (2011)	• Building codes and standards	• Included in the projections	• Not included

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Forestry	Long-term mitigation scenarios	• Establishment of 760,000 hectares of commercial forest by 2030	• IIASA projection	• IIASA projection
	National Forest Act (1998)	• Securing ecologically sustainable development and use of natural resources while promoting justifiable economic and social development • Facilitate improved timber availability and secure supply of timber to ensure sustainability of entire timber value chain	• Not included	• Not included
	Strategic Plan for the Development of Agriculture, Forestry and Fisheries (2013)	• Promote conservation of forest biological diversity, ecosystems and habitats, while promoting the fair and equitable distribution of their economic, social, health and environmental benefits	• Not included	• Not included

[1] 2018 update not considered in the current policies projection, as it is not formally adopted yet

[2] Based on Table 1 in the IRP update report of 2013 (Department of Energy, 2013). As the 2013 update and 2016 updates of the IRP have not been legally adopted as of August 2017, the adjusted targets were excluded from the current policies scenario.

[3] Based on Table 4 in the promulgated IRP (Department of Energy, 2011, Department of Energy, 2013)

For our analysis, the IRP 2010 remains the official government plan for new generation capacity accounted for in the emissions projections under current policies for the Republic of South Africa. As

part of regular updates and revisions laid down in the 2010 IRP, the IRP's 2013 update "intended to provide insight into critical changes for consideration on key decisions in the interim" (Department of Energy, 2013). Among other things, this included lower electricity demand projections than the IRP 2010, thus requiring less additional generation capacity (see Table 2 in Department of Energy, 2013). However, the 2013 update has never been formally adopted, nor have there been subsequent updates. In October 2016, the Department of Energy further released a 2016 IRP update, which was made available for public comment until the end of March 2017 (Department of Energy, 2016). Updating key assumptions such as technology costs, macroeconomic assumptions and policy constraints, the 2016 IRP update proposes a downward adjustment of additional renewable generation capacity to be installed by 2030 compared to the original 2010 IRP policy. As of 20th of July 2017, however, this 2016 update has not been formally adopted and the IRP 2010 thus remains the official government plan for new generation capacity. The government did publish the draft Integrated Resource Plan 2018, which is open for public comments until November 2018 (as such, it is not considered current policy in this report).

The IRP is supported by the Renewable Energy Independent Power Producer Programme (REIPPPP). As of July 2017, 6.4 GW of renewable energy projects have been procured under the REIPPPP (Independent Power Producers Office, 2017). Besides uncertainties regarding the aforementioned long-term IRP capacity planning, Republic of South Africa's state-owned grid operator and largest utility company Eskom has stalled signings of power purchase agreement (PPAs) with renewable energy independent power producers (IPPs) on procured capacity under the REIPPPP since August 2016 (Le Cordeur, 2017, Mail & Guardian, 2017b, Yolandi Groenewald, 2017). Even as President Jacob Zuma in his 2017 State of the Nation Address expressed the government's commitment to the REIPPPP, including stating that Eskom would sign the outstanding PPAs, Eskom has continued to further delay the process over concerns over the South African grid's ability to absorb the new renewable energy projects (CleanTechnica, 2017). These substantial delays in PPA signings have not further been reflected in the current policies, but the process will be followed closely.

The total capacity targets of the IRP 2010 for solar PV and wind were, therefore, used in the current policies scenario: 8.4 GW solar PV (equal to the additional capacity to be built between 2010 and 2030), and 9.2 GW wind (8.4 GW new-build and 800 MW committed capacity) (Table 4 in Department of Energy, 2011). The IRP 2013 update states that the decision on nuclear capacity might be delayed as "no new nuclear base-load capacity is required until after 2025" (Department of Energy, 2013). In addition, the IRP 2016 update even states that in the base case scenario the "first unit of nuclear appears around the year 2037, but this is sensitive to other technology primary fuel costs and their associated emission assumptions" (Department of Energy, 2016). Therefore, the 11.4 GW nuclear target stated in the 2010 IRP was not used in the emissions projections under current policies. However, the general plan to add new nuclear capacity still seems to be backed by the current South African government and the intended nuclear procurement process has been part of recent South African High Court ruling in April 2017 that found it unconstitutional in nature (Mail & Guardian, 2017a, National Assembly of South Africa, 2017). For CSP, the total planned capacity of 1.2 GW stated in the two ministerial determinations of 2012 and 2015 to be built until 2030 was assumed to be built under current policies (see Table 1 in Department of Energy, 2013, Cliffe et al., 2015). Targets for hydropower were excluded from the current policies scenario, as they concern imports.

Despite lack of enforcement as of July 2017, the mandatory blending of biofuels has been included in our emissions projections under current policies. The Biofuels Industrial Strategy mandates a biofuel blending of 2%–10% for bio-ethanol and minimum 5% for biodiesel from 2015 onwards, which falls under the Petroleum Products Act. Even though this policy on the mandatory blending of biofuels has been legally put into force, it has not been enforced as of July 2017, mainly due to concerns about the impact of large-scale biofuels production on food security and the evaluation of biofuels financial support or subsidy mechanisms (Fundira and Henley, 2017). If the policy targets would not be met, this would

lead to higher emissions of 2.0 $MtCO_2e$/year in 2020 and 2.6 $MtCO_2e$/year and 2030 under NewClimate Institute's emissions projections under current policies.

The carbon tax that is currently under consideration was not included in the current policies scenario because its status remains unclear. The NDC submission mentions that the instrument is under development (Republic of South Africa, 2016). The draft bill indicates a start date of 1st of January 2017, but the implementation has been delayed several times. Originally, 1st of January 2015 was the initial start date, but since then, the start date has been repeatedly delayed (The Carbon Report, 2015). The introduction of the carbon tax has been further postponed with the 2017 Budget Review stating that a revised Carbon Tax Bill will be published for public consultation and tabled in parliament by mid-2017 (National Treasury of the Republic of South Africa, 2017).

Both PBL and NewClimate calculations were supplemented with the IIASA projections on LULUCF emissions. The IIASA projections of LULUCF emissions and removals under current policies were based on updated G4M estimates, particularly taking into account afforestation policies, and were harmonised to historical estimates of net LULUCF emissions from the BUR1 for South Africa (Department of Environmental Affairs, 2014c).

21.2 Details of NewClimate calculations

Historical emissions

For historical data, GHG inventory data submitted to the UNFCCC accessed via the UNFCCC data portal was used for 1990 and 1994 (UNFCCC, 2019) and DEA's GHG Inventory for the Republic of South Africa for 2000 – 2010 (Department of Environmental Affairs, 2014a) with linear interpolation added between 1990–1994 and 1994–2000.

Emissions projections under current policies

The NewClimate Institute projections were based on a combination of the World Energy Outlook 2016 for CO_2 emissions from fuel combustion (IEA, 2016c), non-CO_2 emissions from US EPA (2012), and a linear continuation of historical trends for CO_2 process emissions. The WEO2016 *Current Policies Scenario* for CO_2 emissions from fuel combustion assumes a slightly different energy mix for the electricity supply sector and the transport sector, which has been adjusted to reflect policies considered under implementation by NewClimate Institute. In general, neither the WEO2016 main report nor its annexes specify which of the policies have been included in the current policies scenario. As for the energy supply sector, the renewable energy capacity assumed to be installed in the WEO2016 was adjusted to reflect the 2010 IRP policy as follows:

- Adjusted capacity in 2030 by targeted values as indicated in Table S22. For nuclear, assumed no further increase beyond current levels;
- Calculated difference in electricity generation from renewables and nuclear in 2030 in comparison to WEO data;
- Assumed that the difference is balanced by coal only;
- Applied emission factor of coal to the difference.

Adjusting the assumed capacity to be installed resulted in a further reduction of emissions by 2 $MtCO_2e$/year in 2030. As for the transport sector, the biofuels mandate was reflected as follows:

- Increased projected energy demand from biofuels by 0.7 Mtoe/year in 2020 and by 0.9 Mtoe/year in 2030 so that they contribute 5% to the mix of oil products and biofuels;
- Decreased oil products by the same amount (keeping total consumption at the same level);
- Applied emission factor to change in oil consumption, assuming that biofuels are carbon neutral.

Accounting for the biofuels mandate resulted in a further reduction of emissions by 2.0 $MtCO_2e$/year in 2020 and 2.6 $MtCO_2e$/year in 2030. For the projection of non-CO_2 emissions, US EPA (2012) projections for the years 2015, 2020, 2025 and 2030 were used. For the projection of non-energy CO_2 emissions, historical non-energy CO_2 emissions data for the years 1990, 2000, 2005 and 2010 provided by EDGAR (JRC/PBL, 2012) and linear interpolation for the years in-between was extrapolated by assuming a continuation of historical growth between 1990 and 2010.

21.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) complemented with the LULUCF related policy measures (Long-term mitigation scenarios). For this assessment, only forestry related changes in LULUCF carbon pools for South Africa were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and were harmonised to data provided in the BUR1 for South Africa (Department of Environmental Affairs, 2014c).

For the emissions projections under current policies to reach consistency with policy measures related to the establishment of commercial forests, a nation-wide carbon price was induced that enhances the afforestation/reforestation rate and reduces the deforestation rate over time. The carbon price was assumed to be implemented as of 2015 and increased linearly until 2030 such that a cumulative total of 760,000 hectares of land will be afforested for commercial purposes from 2015 until 2030.

22 Thailand

22.1 Assessment

NDC

Thailand submitted its Nationally Determined Contribution (NDC) on the 21st of September 2016 and it (The Kingdom of Thailand, 2015b) includes an unconditional GHG emissions reduction target of 20% in 2030 compared to BAU levels excluding LULUCF. This percentage reduction is relative to the projected BAU GHG emissions in 2030 of approximately 555 $MtCO_2e$/year, corresponding to emission levels of 444 $MtCO_2e$/year in 2030. Conditional on "adequate and enhanced access to technology development and transfer, available financial resources and capacity building support", Thailand pledges an economy-wide GHG emissions reduction of 25% in 2030 compared to BAU levels excluding LULUCF. This conditional target corresponds to an emission level of 416 $MtCO_2e$/year. Whether LULUCF emissions will be included in Thailand's NDC targets will be decided by the Thai government at a later point in time.

For pre-2020, Thailand pledged a CO_2 emission reduction contribution in the energy and transport sectors of 7%–20% below BAU levels by 2020 as its Copenhagen Pledge. As total BAU emissions in the energy and transport sectors are projected to be 358.6 $MtCO_2$/year by 2020 (The Kingdom of Thailand, 2015a), intended CO_2 emissions in the energy and transport sectors range from 287 to 333 $MtCO_2$/year by 2020.

Current policies

Table S22 shows an overview of key climate change mitigation-related policies in Thailand and how they were taken into account in deriving projections. The current policies scenario considers Thailand's Integrated Energy Blueprint (TIEB), which consists of five pillars:

- Alternative Energy Development Plan (AEDP) (2015–2036)
- Energy Efficiency Plan (EEP) (2015–2036)
- Power Development Plan (PDP) (2015–2036)
- Oil Plan (2015–2036)
- Gas Plan (2015–2036)

Over the course of 2015, the Thai government revised and updated all five pillars of the TIEB and their respective sub-sectoral targets to be achieved by 2036 (Ministry of Energy of Thailand, 2016). Besides the TIEB, the current policies scenario includes the Environmentally Sustainable Transport System Plan of 2012, the Building Energy Code of 2009, the Energy Conservation and Promotion Act of 1992 (updated in 2007) as well as the Minimum Energy Performance Standards (MEPS) and High Energy Performance Standards (HEPS) as currently implemented policies. The new Power Development Plan (PDP) is expected to be published by the end of 2018.

The 2018 report revised the projections on renewable energy deployment based on a recent IRENA study endorsed by the Thai Ministry of Energy (IRENA, 2017a). The share of renewables in total electricity generation in 2030 was revised upward from 14% to 18%, while the total direct use of renewable energy in the end-use sectors was revised slightly downward due to the reduced use of bioenergy in the buildings sector. Overall the revised renewable energy deployment projections led to 22 $MtCO_2e$/yr reductions in 2030 compared to our previous projections.

Thailand's Climate Change Master Plan (2015–2050) is considered an overarching climate change strategy, which critically builds upon the before mentioned sectoral policies for its implementation. Consequently, the Climate Change Master Plan is not separately considered in the current policies analysis to avoid double-counting. Furthermore, the Waste Management Roadmap is not considered in

the current policies scenario as this policy does not provide quantifiable mid- and long-term targets for 2020 and beyond.

In March 2017 the Petroleum Law was amended to provide companies with more options for exploration and production operations in addition to concession agreements (Tharaphan and Gulthawatvichai, 2018). While uncertainty remains around how the amended law would be implemented, it may lead to more investments on oil and gas exploration and extraction. Due to the uncertainty around its impact, this law is not considered in our analysis.

Table S22: Overview of key climate change mitigation policies in Thailand. Source: (The Kingdom of Thailand, 2015a, Ministry of Energy of Thailand, 2015b, Ministry of Energy of Thailand, 2015a, Ministry of Energy of Thailand, 2016, National Economic and Social Development Board of the Kingdom of Thailand, 2012, APERC, 2016a, APERC, 2016c)

Sector	**Policies (marked with "(+)" when mentioned in the NDC document)**	**Description**	**NewClimate quantification of impact**
Economy-wide	Climate Change Master Plan (2015–2050) (2015) (+)	• 7–20% GHG emission reduction by 2020 below BAU in the energy and transport sectors • Share of at least 25% of the total energy consumption from renewable energy sources by 2021 • Reduction of energy intensity by at least 25% compared to BAU by 2030	• Not separately considered an overarching climate change strategy that critically builds upon the before mentioned sectoral policies for its implementation
Energy supply	Thailand Integrated Energy Blueprint (2015)		
	• Alternative Energy Development Plan (2015–36) (2015) (+) and Power Development Plan (2015–36) (+)	• Increase of renewable energy shares by 2036 to 30% of total energy consumption, 20% of power generation (plus additional 15% from imported hydro), 35% of heat generation and 35% of transport fuels • Total domestic power generation mix in 2036 are targeted at: 27% coal, 44% gas, and 24% renewables, respectively.	• BAU scenario from the APEC World Energy Demand and Supply Outlook adjusted by the latest developments and projections reported in IRENA (2017). The share of renewables in domestic power generation is projected to be 18% in 2030. • Shares of coal and gas power in total domestic power generation in 2036 are projected to be 25% and 57%, respectively.
	• Energy Efficiency Plan (2015–36) (+)	• Reduction of energy intensity (in final energy terms) per GDP by 30% by 2036, as compared to	• Not achieved under the APEC scenario (17% reduction by 2035)

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact
		2010 baseline, with total savings of 90 TWh by 2036	
	• Oil Plan (2015–2036)	• Support measures to save fuel in the transportation sector and enhance ethanol and biodiesel consumption	• Included as part of the BAU scenario from the APEC World Energy Demand and Supply Outlook
	• Smart Grid Development Master Plan (2015–36) (+)	• Aims for high penetration of renewable energy, mainly mini-hydro and solar PV	• Included as part of the BAU scenario from the APEC World Energy Demand and Supply Outlook
Transport	Environmentally Sustainable Transport System Plan (2013–30) (2012) (+)	• Improvement of rail infrastructure to reduce annual logistics costs and the annual energy bill by about 2% and 1% of GDP respectively	• Included as part of the BAU scenario from the APEC World Energy Demand and Supply Outlook
Industry	Energy Conservation and Promotion Act (1992, amended 2007)	• Stabilise share of energy demand for the three most energy-intensive sectors at 40% by 2030	• Included as part of the BAU scenario from the APEC World Energy Demand and Supply Outlook
Buildings	Minimum Energy and High Energy Performance Standards (MEPS/HEPS) (2011)	• Mandatory MEPS for air conditioners, refrigerators, self-ballasted compact fluorescent lamps and double-capped fluorescent lamps • HEPS for 28 appliances and types of equipment	• Included as part of the BAU scenario from the APEC World Energy Demand and Supply Outlook
	Building energy code (2009)	• Reduce electricity use for large commercial buildings by more than 50% by 2030 compared with BAU projections	• Included as part of the BAU scenario from the APEC World Energy Demand and Supply Outlook
F-gases	N/A	• N/A	
Forestry	National Economic and Social Development Plan (2012)	• Several, not quantifiable long-term targets to reduce GHG emissions in the agriculture and land transport sector • Expansion of conservation areas to at least 19% of total area, expansion of forest reserves up to 40%, and annual mangrove coastal reforestation of at least 800 hectares [2)]	• Policies not included in the IIASA LULUCF projections

22.2 Details of NewClimate calculations

Historical emissions data

Historical GHG emissions data, reported in AR4 GWP terms, was taken from the UNFCCC reported as part of the BUR2 (The Kingdom of Thailand, 2017) for years 1994 and 2000–2013.

Emissions projections under current policies

As in the 2016 and 2017 reports, we used the BAU scenario from the APEC World Energy Demand and Supply Outlook 6th edition (APERC, 2016c) as point of departure for the projections of energy-related CO_2 emissions. The BAU scenario from the APEC accounts for energy-related policy measures in the Thai energy, buildings, industry and transport sectors formally adopted by the end of 2015 (APERC, 2016b).

The 2018 report revised the projections on renewable energy deployment based on a recent IRENA study endorsed by the Thai Ministry of Energy (IRENA, 2017a); we referred to the "Reference Case", which was defined as representing "a view on energy supply and demand based on current or planned policies", and "is based on energy demand and supply forecasts submitted by Thailand in a data questionnaire and then refined through a series of consultations and workshops"; the resulting projection" is roughly in line with the expected developments under the Alternative Energy Development Plan.

The calculation steps have been the following:

- *APEC World Energy Demand and Supply Outlook 6th edition* provides input data for energy-related CO_2 emissions for 2000, 2010, 2013, 2020, and 2030.
- The APEC Outlook projections for renewable electricity generation and direct use of renewable energy in the end-use sectors were replaced by the IRENA report's Reference Case. Since the IRENA study only reports 2025 and 2036 projections, we estimated the 2020 and 2030 values by linear interpolation. The total electricity generation and total final energy use in the end-use sectors were assumed not to change from the original APEC scenario for revising the non-renewable electricity generation and energy use. To revise the APEC Outlook projections for energy-related CO_2 emissions for 2020 and 2030, it was assumed that the emissions are proportional to total fossil fuel-fired power generation for the power sector and to total direct energy use of fossil fuels for the end-use sectors.
- APEC-based energy-related CO_2 emissions projections were harmonised to the 2013 historical emissions data by multiplying it by the growth rates of APEC-based projections between 2013 and 2030.

The projections of non-energy CO_2 emissions were based on the latest official inventory data for 2000–2013 reported to the UNFCCC as part of the BUR2 (The Kingdom of Thailand, 2017). Thailand's non-energy CO_2 emissions in 2013 predominantly stemmed from the cement manufacturing process which is assumed to remain so up to 2030; the future emissions up to 2030 were assumed to grow proportionally to the clinker production as projected in the 2015 Power Development Plan, as reported in Sairatanathongkham and Wangjiraniran (Sairatanathongkham and Wangjiraniran, 2017).

In a similar approach as for the non-energy CO_2 emissions, the projections of non-CO_2 GHG emissions build on the latest official inventory data for non-CO_2 GHG emissions in 2013 as reported to the UNFCCC as part of the BUR2 (The Kingdom of Thailand, 2017), which were extrapolated with the projected growth rates of non-CO_2 GHG emissions provided by USEPA (2012).

22.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017). For this assessment, only forestry related changes in LULUCF carbon pools being were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time according to the historical estimates reported on the UNFCCC portal (UNFCCC, 2019).

23 Turkey

23.1 Assessment

INDC

Turkey submitted its Intended Nationally Determined Contribution (INDC) on the 30th of September, 2015 and established an economy-wide greenhouse gas reduction target of up to 21% below business as usual (BAU) in 2030. The INDC covers 5 sectors (energy, industrial processes and product use, agriculture, waste and land use, land-use change and forestry), and applies to seven gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3). The country provides a BAU scenario in the INDC, against which the target is estimated to result in a reduction of 246 $MtCO_2e$. NewClimate Institute estimates of the emissions under the INDC are based on the Climate Action Tracker analysis[34], which is based on adjusted INDC numbers to exclude the LULUCF sector.

Current policies

Table S23 shows an overview of key climate change mitigation-related policies in Turkey and how they were taken into account in deriving emissions projections under current policies. Although Turkey has not made a 2020 pledge, it has a renewable electricity share target and an energy intensity target. Turkey further has renewable capacity targets, outlined in the Renewable Energy Action Plan (Ministry of Energy and Natural Resources of Turkey, 2014). The renewable capacity targets for 2023 are 34 GW hydropower, 20 GW wind, 5 GW solar, 1 GW geothermal, and 1 GW biomass (in total 61 GW).

The actual emission level resulting from the energy intensity target strongly depends on the future development of GDP and is thus subject to large uncertainty.

The emissions projections under current policies by NewClimate Institute were based on a government-published reference scenario, which assumes a strong economic growth of 4% from 2020 onwards compared to a current rate of 2%, resulting in rapidly increasing GHG emissions up to 2030.

The emissions projections under current policies by PBL were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S23). The projections by NewClimate Institute take the BAU from Turkey's NC6 as a starting point and create a policy scenario based on renewable energy targets. However, an external study found that the Turkish government may overestimate its electricity demand under BAU by 25% in 2030 (WWF and BNEF, 2014).

The National Climate Change Action Plan (Ministry of Environment and Urbanization, 2011) additionally contains various targets for the transport sector. In the PBL TIMER model, the target to decrease the share of highways in freight transportation was already met in the baseline.

[34] https://climateactiontracker.org/countries/turkey/ (update April 2018)

Table S23: Overview of key climate change mitigation policies in Turkey. Source: (Ministry of Energy and Natural Resources of Turkey, 2014, Ministry of Environment and Urbanization, 2011, Ministry of Environment and Urbanization, 2010, Ministry of Energy and Natural Resources of Turkey, 2009)

Sector	Policies (marked with "(+)" when mentioned in the INDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Economy-wide	Energy intensity target (Energy Efficiency Law) (2012)	• Reduce primary energy intensity by 20% by 2023, compared to the 2008 level	• Not included	• Achieved without specific policy implementation (19% reached)
	Energy Efficiency Action Plan (2018)	• Reduce primary energy consumption by 14 % compared to the base usual scenario in 2023 3)	• Not included	• Not included
Energy supply	Renewable energy target (Law for the Utilisation of the Renewable Energy Resources for the Electricity Energy Production) (2005)	• 13% to 30% share of renewable energy resources in electricity production by 2023	• Not included, target reached under BAU scenario	• Checked after implementation of capacity targets: 50.3% reached
	Renewable capacity target (Renewable Energy Action Plan) (2014)	• 61 GW renewable capacity by 2023: 34 GW of hydro, 20 GW wind, 5 GW solar, 1 GW geothermal, 1 GW biomass 1)	• Included in additional calculations	• Included as such
Forestry	National Climate Change Action Plan (2011)	• Decreasing deforestation by 20% by 2020, compared to the 2007 level • Increasing carbon sequestered in forested areas by 15% until 2020, compared with 2007	• Not included	• IIASA projection

1) *No information available on implementation status. For the current analysis, we have assumed full implementation.*

23.2 Details of NewClimate calculations

This report critically examined the reference scenarios from the sixth national communication (NC6) submitted to the UNFCCC used to develop current policies scenario projections in the Climate Action Tracker analysis.[35] Based on the information provided in the NC6 and the World Development Indicators database, we quantified the GDP (constant 2010 USD) elasticity of GHG emissions from energy and industrial processes sectors as per GHG inventories submitted to the UNFCCC (2018); in 2016 these two sectors account for 99% of national total CO_2 emissions (excluding LULUCF), and CO_2 emissions account for 95% of total GHG emissions from these two sectors (UNFCCC, 2018b).

The GDP elasticity values were calculated for "with measures" and "without measures" scenarios between 2012 (modelling base year) and 2030 as well as for historical years 1990–2016, 2002–2016 and 2006–2016. The elasticity values were estimated to be 1.25 for "with measures" scenario projections and 1.55 for "without measures" scenario projections, both of which were considerably higher than the historical trends between 1990 and 2016 (0.88), between 2002 and 2016 (0.75) and between 2006 and 2016 (0.54). Based on these findings, we conclude that both government scenarios are grossly overestimating the future emissions growth.

Therefore, we used the GDP elasticity value historically observed for the 2002–2016 period (0.75) to project GHG emissions from energy and industrial processes sectors. The following calculation steps were taken:

4. The GDP projections for 2018–2030 were revised by applying the compound annual growth rate estimated from the NC6 data to the 2017 historical GDP data (in constant 2010 USD) from the World Development Indicators database ((World Bank, 2018).
5. The GHG emissions projections for energy and industrial processes sectors were recalculated by applying the GDP elasticity values historically observed for the 2002–2016 period (0.75) to the revised GDP projections in the first step.

GHG emissions projections from other sectors (agriculture, waste and others) were based on the NC6's "with measures" scenario; the projections were harmonised to the 2016 historical data.

23.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the National Climate Change Action plan). For this assessment, only forestry related changes in LULUCF carbon pools for Turkey were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and were harmonised to the historical dataset provided in Turkey's 2017 National Inventory Reporting to the UNFCCC (Turkish Statistical Institute, 2017).

For the emissions projections under current policies to reach consistency with policy measures related to decreasing the annual deforestation rate and increasing carbon sequestration in forested areas, a nation-wide carbon price was induced that reduces the deforestation rate, enhances the afforestation rate, and incentivizes the build-up of the forest carbon stock. The carbon price was assumed to be implemented as of 2015 and increase linearly until 2020 such that the annual net deforestation rate decreased by 20% by 2020, compared to the 2007 level provided by FAO FRA 2015. The carbon price

[35] https://climateactiontracker.org/countries/turkey/ (update April 2018)

also enhanced the storage of carbon in forests through a combination of changes of rotation length for existing managed forests, ratio of thinning versus final felling, harvest intensity, and enhancements in afforestation and reforestation of forests. Overall, the total carbon stored and sequestered in forested areas (i.e. above ground, below ground, and soil) increased through the implementation of the carbon price by 15% as of 2020, compared to the IIASA estimated levels for 2007.

24 Ukraine

24.1 Assessment

NDC

Ukraine ratified the Paris Agreement and submitted its Nationally Determined Contribution (NDC) on the 19th of September, 2016 and aims to limit its GHG emissions to less than 60% of the 1990 GHG emissions level by 2030. The NDC covers the sectors energy, industrial processes and product use, agriculture, LULUCF, and waste, and the six Kyoto GHGs plus NF_3. The approach to LULUCF is not clarified, stating that "the land use, land-use and forestry in the climate change mitigation structure will be defined as soon as technical opportunities emerge, but no later than 2020". In our analysis, it was assumed that the NDC target includes LULUCF.

Current policies

The emissions projections under current policies by PBL were based on the IMAGE SSP2 baseline for Ukraine, which is at the lower end of the range of emission projections in the main report. No current policies were included because of the political circumstances as well as administrative and bureaucratic barriers in the country, leading to uncertainties about the policy implementation status. The SSP2 projection is based on the UN medium population projection, showing a decreasing population for the period 2000–2100, and the GDP growth projections from the SSP2 scenario. The IMAGE SSP2 emission projection is lower compared to the "with measures" scenario from Ukraine's NC6. This could be the result of the decreasing population projections, and/or the lower GDP growth projection. It is unclear which population and GDP projections have been assumed in the "with measures" scenario.

The emissions projections under current policies by NewClimate Institute were partly based on the Climate Action Tracker analysis.[36] The projections are based on the extrapolation of historical trends of the GDP elasticity of GHG emissions and thus do not explicitly account for the impact of any individual policy described in the report.

The IIASA emissions projections under current policies of net LULUCF emissions was based on the policy for enhancement of forest cover. The share of forest area was 16.5% in 2010 (FAO, 2015), and was set to increase through afforestation projects to reach 17% by 2020. Based on these policies, the national net LULUCF sink is expected to remain relatively stable until 2030.

24.2 Details of NewClimate calculations

Emissions projections under current policies

The projections were based on the "with measures" scenario from Ukraine's NC6 (Government of Ukraine, 2013). The "with measures" scenario from the NC6 was considered to be the most realistic scenario, taking into account the likely changes in technical and economic indicators of production technology and resource consumption, and includes all commercially reasonable measures. The "with measures" scenario also implies that the development of wind and solar energy is economically and environmentally unjustified for Ukraine, thus resulting in increased consumption of gas for power generation. Moreover, the "with measures" scenario was used as the baseline for GHG emissions projection in Ukraine's draft INDC.

Unlike the CAT analysis, the assessment did not consider the "without measures" scenarios as a baseline (i.e., the upper bound of the projections). This is because the assumption of a frozen emission intensity per GDP up to 2030 is considered unrealistic. While it is uncertain whether Ukraine will

[36] http://climateactiontracker.org/countries/ukraine (update April 2018)

implement all the policy measures included in the “with measures” scenario due to the current political instability, it is also considered unlikely that the emission intensity remains constant under the assumed economic growth (on average 3.7% per year between 2010 and 2030).

Since the modelling base year is 2011 for these government scenario projections, they deviate considerably from the actual historical emissions already by 2016 partly due to economic circumstances. We therefore adapted the projections for GHG emissions from energy and industrial processes sectors as per GHG inventories submitted to the UNFCCC (2018); in 2016 these two sectors accounted for 99% of national total CO_2 emissions (excluding LULUCF), and CO_2 emissions accounted for 82% of total GHG emissions from these two sectors (UNFCCC, 2018b). The calculation steps were as follows:

1. The GDP (constant 2010 USD) elasticity of GHG emissions from energy and industrial processes sectors were calculated for “with measures” scenario between 2011 and 2030 based on the data provided in the sixth national communication (NC6). The elasticity values observed were 0.55 for 2011-2020 and 0.42 for 2020-2030.
2. The GDP projections for 2018–2030 were revised by applying the compound annual growth rate estimated from the NC6 data to the 2017 historical data from the World Development Indicators database ((World Bank, 2018).
3. The GHG emissions projections for energy and industrial processes sectors were recalculated by applying the GDP elasticity values quantified in the first step to the revised GDP projections in the second step.

GHG emissions projections from other sectors (agriculture, waste and others) from “with measures” and “without measures” scenarios were used as reported.

24.3 Details of PBL calculations

PBL results for Ukraine were based on calculations for the Ukraine region (including other countries, see IMAGE wiki for more details). It was assumed that Ukraine has a constant share of the region’s emissions, based on the year 2015 (about 74%).

24.4 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017) augmented with the LULUCF related policy measures (the Enhancement of forest cover and State Programme “Forest of Ukraine”). For this assessment, only forestry related changes in LULUCF carbon pools for Ukraine were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and were harmonised to historical datasets provided in the 2017 National Inventory Reporting submitted to the UNFCCC (Ministry of Ecology and Natural Resources of Ukraine, 2017).

For the emissions projections under current policies to reach consistency with policy measures related to afforestation, reforestation and increases of the national forest area, a nation-wide carbon price was induced that enhances the afforestation/reforestation rate and reduces the deforestation rate over time. The carbon price was assumed to be implemented as of 2015 and increase linearly until 2020 such that the total forest area accounts for 17% of total land cover by 2020. The assessment that the total forest area accounted for 17% of the total land cover was performed using CORINE land cover assessment of the total land cover area of Ukraine. After 2020, the carbon price was set to increase linearly such that a total of 660,000 hectares of afforestation and reforestation would cumulatively occur from 2015 until 2030.

25 United States of America

25.1 Assessment

NDC

On June 1st, 2017, President Donald Trump announced that the US would withdraw from the Paris Agreement and cease implementation of the NDC. On August 4th, 2017, the US notified the UN Secretary General that it intends to "exercise its right to withdraw" from the Paris Agreement. The US will first be eligible to withdraw from the Paris Agreement on November 4th, 2019, three years after the agreement entered into force for the US. Legally, the US NDC is still in place until that time, although the Trump Administration has made clear that the target will not be implemented at the federal level.

The US NDC set a target to reduce net GHG emissions by 26%–28 % from 2005 by 2025, including LULUCF. The target covers all IPCC sectors and seven GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3). The US will account for the land sector using a net-net approach and apply 100-year Global Warming Potentials from the IPCC Fourth Assessment Report.

Current policies

Current policies in the US considered in the analysis are presented in Table S24. Emissions projections do not include the Clean Power Plan, which was never fully implemented, and which the US EPA proposed to replace with a less stringent standard in August 2018 (U.S. EPA, 2018a).

In 2018, the Trump Administration has made significant changes to a number of federal level policies as part of a deregulatory agenda. In the power sector, the EPA has proposed a replacement for the Clean Power Plan that would allow states to set their own standards, require modest emissions reductions, and affect only individual power plants, for example through efficiency measures or CCS technologies (U.S. EPA, 2018a). In contrast, the CPP set emissions reductions targets for entire states, which could have been achieved, for example, through changing the electricity generation fuel mix. In industry, the EPA has indicated that it will not enforce measures to reduce HFC use that were implemented under the Significant New Alternatives Program (U.S. EPA, 2018c). In transportation, the EPA and National Highway Transportation Safety Administration have proposed new standards for passenger cars and trucks that will replace the standards implemented under the Obama Administration after 2021. The former standards increased in stringency over time, whereas the new standards will freeze fuel efficiencies at 2021 levels (U.S. EPA and U.S. NHSA, 2016). The state of California has announced that it will maintain the standards set by the Obama Administration. In oil and gas production, the EPA has proposed a change in the way that it regulates the industry, which could affect the amount of methane that is released through fugitive emissions (U.S. EPA, 2018b).

Full implementation of all additional planned policies covered by the Obama Administration's Climate Action Plan was expected to reduce emissions close to the level needed to achieve the pledge by 2020. These additional policies will now not be implemented under the Trump Administration, as the Climate Action Plan has been rescinded. Instead, the US will likely miss both its 2020 pledge and 2025 NDC target.

The emissions projections under current policies by NewClimate Institute were based on its analysis for the Climate Action Tracker analysis.[37] The projections consider not only federal policies but also state-level policies as presented in Table S25. The emissions projections under current policies by PBL were based on updated IMAGE model calculations, including high impact policies identified in the CD-LINKS project (Table S24). The PBL estimated the impact of current policies including and excluding CPP.

[37] http://climateactiontracker.org/countries/usa (updated November 2018)

Both PBL and NewClimate calculations were supplemented with the IIASA projections on LULUCF emissions. IIASA projections of LULUCF emissions and removals are the same as in Den Elzen et al. (2015) but were harmonised for the year 2015 to the 2018 National Inventory Reporting submitted to the UNFCCC (UNFCCC, 2018b).

Table S24: Overview of key climate change mitigation policies in the United States. Source: (N.C. Clean Energy Technology Centre, 2016, United States of America, 2015, United States of America, 2014, NewClimate Institute, 2016, Executive Office of the President, 2013)(IEA, 2017)

Sector	**Policies (marked with "(+)" when mentioned in the NDC document)**	**Description**	**NewClimate quantification of impact**	**PBL quantification of impact**
Economy-wide	Clean Air Act (1963) (+)	Act governed by the EPA that is implemented through actions such as the Clean Power Plan (CPP)	Included through AEO reference scenario	Not included separately
Energy supply	Clean Power Plan (CPP) (2014) (+) [1)]	• As of August 2018, the EPA has proposed to replace the CPP with less stringent standards for power plants • Formerly, the CPP aimed to reduce emissions from the power sector by 32% below 2005 levels by 2030	Not included in current policies scenario	Not included
	Reduce CH_4 emissions from oil and gas production	40 – 45% from 2012 levels by 2025 Specific standards for oil and gas production As of September 2018, the US EPA has proposed a revision of standards for methane from oil and gas production	Specific emissions standards included through CH4 emissions projections from 2nd BR	Not included Implemented as end-of-pipe measure, assuming total gas production remains the same as in reference scenario.
	Blueprint for a Secure Energy Future	Reduce oil imports 50% by 2020	Not included	• Included by adjusting Net Import Dependency target (21% reduction reached)
Transport	Efficiency standards light-	• 34.1 mpg (14.9 km/l) by 2016, 41 mpg (17.4 km/l)	• Former standards	• Included as such

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
	duty vehicles (CAFE) (+)	by 2021. The EPA has proposed new standards after 2021 that will maintain fleet efficiency at 2021 levels.	through 2025 included through AEO reference scenario	(maintaining standards at 2021 levels after 2021, i.e. 1.11 MJ/pkm)
	Efficiency standards heavy-duty vehicles	• Differentiated standards per truck type	• Included through AEO reference scenario	• Included as 0.83 MJ/tkm for heavy trucks from 2027 onward
	Renewable fuel standard (2015)	• Volume of renewable fuel required to be blended into transportation fuel from 9 billion gallons in 2008 to 36 billion gallons by 2022	• Included through AEO reference scenario	• Included as 10.1% biofuel share (bioethanol + biodiesel) from 2014 onward (target is reached in 2017)
Buildings	Better buildings Challenge (commercial buildings)	• Help American commercial and industrial buildings become at least 20% more energy efficient by 2020[2)]	• Not included	• Not included
	Energy Star Tax credits for buildings		• Included in AEO reference scenario	• Not included
	Building Energy Codes Program	• Efficiency codes are adopted at a state level	• Included in AEO reference scenario	• Included as building codes for new buildings
Industry	Curbing emissions of hydrofluorocarbons (HFCs) (+)	• As of April 2018, the US EPA has announced that it will not enforce HFC regulations under the Significant New Alternatives Policy Program • Mix of actions to reduce HFCs use and encouraging the use of alternatives	• Included in HFCs projections from 2nd BR	• Not included

Sector	Policies (marked with "(+)" when mentioned in the NDC document)	Description	NewClimate quantification of impact	PBL quantification of impact
Forestry	Forest Ecosystem Restoration and Hazardous Fuels Reduction Programs (2000)	• Mix of actions to increase forest resilience, reduce wildfire, and increase the area of set aside forests	• Not included	• Not included

1) *The analysis did not consider the impact of the Clean Power Plan under current policies because the EPA has proposed to replace it with a less stringent standard.*

Table S25: Main state-level policies implemented in the United States.

Sector	Policies (marked with "(+)" when mentioned in the INDC document)	Description
State-level policies	• State renewable energy targets (REN) • State renewable portfolio standards (29 states) • California ETS • Regional Greenhouse Gas Initiative (RGGI) (9 states) • Energy Efficiency resources standards (26 states) • California's Advanced Clean Cars Program • California Low Carbon Fuel Standard • State Motor Fuels Taxes	• Aggregate 16% REN share in electricity generation by 2020 • Aims to reduce to 1990 levels by 2020 • RGGI is a market based regulatory program that caps emissions until 2015 for 9 US states • Includes Zero Emission Vehicle and Low Emission Vehicle Programs

25.2 Details of NewClimate calculations

Emissions projections under current policies with and without Clean Power Plan

The emissions projections under current policies were done in four steps. First, energy-related CO_2 emissions projections were taken from EIA's Annual Energy Outlook 2018 (EIA, 2018). We use two scenarios from the Annual Energy Outlook – the reference scenario and the low economic growth scenario – to create a range of emissions projections. The economic growth assumptions in the reference scenario are higher than those projected by the Congressional Budget office (Congressional Budget Office, 2017), whereas the low economic growth scenario assumptions are slightly lower. We therefore use both scenarios to better capture the range of possible economic growth scenarios. Second, industrial process CO2 emissions were projected by applying the historical ratio (2000-2015)

of industrial process CO2 emissions to industrial energy-related emissions to projections of industrial energy related emissions from the Annual Energy Outlook 2018 Reference Case. Third, other GHG emission projections were taken from the BR2, based on the Current Measures scenario, which includes policies that were implemented through mid-2015 (U.S. Department of State, 2016). Fourth, all the aforementioned emissions were aggregated and then harmonised to historical data.

25.3 Details of IIASA calculations

The LULUCF emissions and removals under current policies were projected using the G4M model. In its core, the emissions projections were based on the MESSAGE-GLOBIOM SSP2 baseline development (Fricko et al., 2017). For this assessment, only forestry related changes in LULUCF carbon pools being were accounted for (i.e. Afforestation, Deforestation, and Forest Management). All non-forest related LULUCF emissions and removals were assumed to remain constant over time and have been harmonised to historical datasets provided in the 2017 National Inventory Reporting submitted to the UNFCCC (U.S. EPA, 2017).

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