PBL Netherlands Environmental Assessment Agency

TRACKING CLIMATE POLICY PROGRESS

Analysing the effect of current climate policies on the drivers of CO_2 emissions of 12 major emitting economies

Note

Robin van der Bles, Heleen van Soest and Michel den Elzen

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Corresponding author
Heleen.vansoest@pbl.nl

Authors
Robin van der Bles (Rijkstrainee)
Heleen van Soest (PBL)
Michel den Elzen (PBL)

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Remark:
This study is the result of a Government traineeship conducted at PBL in 2019.

PBL Netherlands Environmental Assessment Agency is the national institute for strategic policy analysis in the fields of the environment, nature and spatial planning. We contribute to improving the quality of political and administrative decision-making by conducting outlook studies, analyses and evaluations in which an integrated approach is considered paramount. Policy relevance is the prime concern in all of our studies. We conduct solicited and unsolicited research that is both independent and scientifically sound.

Contents

Main Findings

This research investigates the progress of current mitigation actions undertaken by major emitting economies worldwide. It provides an in-depth analysis of the projected impact of currently implemented policies and compares this to the targets set by the countries in their Nationally Determined Contributions (NDCs). This research shows the effect of climate policies on indicators beyond emissions, thereby presenting a more elaborate check of progress toward meeting climate targets in twelve major emitting economies: Argentina, Australia, Brazil, Canada, China, the European Union, India, Indonesia, Japan, Kazakhstan, Russia and the United States. It should be noted that this research does not discuss the level of ambition of such actions and targets.

For this research, a methodology was developed that builds further on Kuramochi *et al.* (2018) and earlier editions. These authors produce yearly country profiles with an analysis of current climate policies and mitigation commitments, focusing on the projected emissions of countries as compared to countries' emission reduction targets. New about this research methodology is that it considers the *drivers* of these emissions projections. Inspired by the fundamental 'Kaya-identity', four indicators were established, which are products of total CO_2-emissions. For these four plus two additional indicators, we show the development for the 12 countries between 1971 and 2015, using historical data, and between 2015 and 2035, using current policy projections of two Integrated Assessment Models (IAMs) (IMAGE & POLES), based on implemented policies until mid-2018.

The report presents the historical development paths and the projections under currently implemented policies for the six indicators, for the twelve individual countries. For each indicator, we also present national targets, if they are available, so that the current policies projections and targets can be compared. However, as countries have formulated their targets on energy and climate change using different definitions, this research 'universalized' the targets, meaning targets were recalculated (translated) to the same indicator definition. In the remainder, these translated domestic targets will be referred to as 'universalized targets'. Thus, this research enables a comparison between countries' climate policy actions and their *domestic* targets, and a comparison of developments between different countries, with the aim to provide additional insights into the countries' current climate policy progress.

Kuramochi *et al.* (2018) already found that countries have made progress toward their 2020 pledges and 2030 NDC targets to varying degrees. This report finds that countries' level of progress regarding their targets on the driving factors of these emissions (the six indicators) is also quite diverse. Four out of the twelve analysed countries (China, India, Japan and the Russian Federation) are on track to meet their 2030 pledges with implemented policies and are projected to meet most of the indicator targets, which means that most of the analysed countries are *not* on track. More specifically:

- For energy intensity (final energy consumption per GDP), four out of six countries or regions for which we were able to find or derive national targets are on track to meet their targets for 2020 or 2030 with current policies *(China, Japan, Kazakhstan and Russia)*. One country is not on track to meet its target for 2030 (*Australia*), and one region is on track to meet its target for 2020, but progress towards the 2030 target is uncertain (*EU*).
- For the final energy consumption per capita, two out of three countries or regions are on track to meet their national targets for 2020 or 2030 (*China and Japan*), and one is not on track (*EU*).

- For the share of fossil fuels and traditional biomass in final energy consumption, one out of four countries is on track (*Indonesia*).
- For the share of renewables in total electricity generation, seven out of eight countries are on track to meet their targets for 2020, 2025 or 2030 (*Argentina*, *Australia, Brazil, China, India, Japan, and Russia*), and one country is on track for 2020, but not for 2030 (*Kazakhstan*).
- For the CO_2 intensity of fossil fuels (fossil fuel and traditional biomass CO_2 emissions per final energy consumption), two out of twelve countries are on track to meet both their 2020 and 2030 targets (*India and Russia*), two are on track to meet only their 2020 targets (*Brazil and EU*), seven are not on track, and for one country, progress is uncertain (*China*).

Regarding the findings of this study, a country being on track to meet its target does not necessarily mean that it is undertaking more stringent action on mitigation than a country that is not on track. We identified one main reason for this. The NDCs differ in their ambition levels. A country that is not on track to meet its target may have set itself a very ambitious target and a country being on track to meet its target may indicate that it set a relatively unambitious target. The Paris Agreement demands participating regions to set their *own* targets in their submissions, reflecting 'the highest possible ambition' (Article 4 of the Paris Agreement). This study does not assess the level of ambition and fairness of the targets; a number of recent studies assessed them in the light of equity principles (such as Höhne et al., 2018; van den Berg et al., 2019).

However, it is useful to keep tracking the individual progress of countries, as compared to their own targets, which is the main focus here. For each of the countries, a country profile was produced, which provides an in-depth interpretation of the developments of the six indicators and the policy environment and attitude toward climate change. This should lead to a broad insight into the progress of countries towards achieving the mitigation components of the 2025/2030 targets (NDCs and INDCs) presented in the context of the Paris Agreement. The added value of the methodology developed here is that it provides deeper insight into progress of countries on indicators they can directly affect with climate and energy policy, going beyond total greenhouse gas emissions, presented in a way that allows a comparison between countries.

It should be noted that the current policy scenario projections presented in this study were based on Kuramochi et al. (2018), which only account for existing policies through 2018. The 2019 update (Kuramochi et al., 2019) takes into account policy developments since the 2018 report, and shows that some countries and regions, i.e. Argentina, the EU, and Japan are now projected to meet their NDC targets. This also implies that their projections for some energy indicators may now meet their national targets.

1 Introduction

1.1 Background

Climate change is a complex environmental, social and political phenomenon, for which response strategies are difficult to formulate. Nonetheless, at the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015, representatives of 196 Parties to the convention adopted the Paris Agreement to hold the increase in global average temperature to well below 2 °C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. In the lead-up to COP21, countries were asked to put forward proposals to reduce their greenhouse gas (GHG) emissions; these are the so-called 'intended nationally determined contributions (INDCs). Nearly 190 countries submitted their INDCs before the COP21, which turned into NDCs upon ratification of the agreement.

Based on this information, one may expect that nationally determined climate targets and actions would be aligned with the intentions expressed in the Paris Agreement. At least, one would expect that governments *that ratified the agreement* would plan to do so. However, research shows that both the aggregated impact of the full implementation of targets and current policies is expected to be insufficient to limit global average temperature increase below either 2 °C or 1.5 °C (Rogelj *et al*., 2016). Further, many countries are expected to not achieve their NDCs, unless they implement additional policies (Kuramochi *et al.*, 2018; den Elzen et al, 2019). The G20 countries collectively are not on track for meeting the unconditional NDCs, with about half of G20 countries' GHG emissions trajectories individually falling short of achieving their unconditional NDCs, also known as the 'implementation gap' (den Elzen *et al.*, 2019). Recently, the urgency for enhanced climate action has become even more evident. This is mostly the effect of the IPCC 1.5 °C special report. The report shows that global CO_2 emissions need to reach net zero by around 2050, in order to limit warming to 1.5 °C with no or limited overshoot (IPCC, 2018).

To meet the climate goal, the Parties to the Paris Agreement need to update their NDCs regularly: each five years they have to submit new NDCs with a new or updated pledge. These submissions should reflect 'the highest possible ambition' (Article 4 of the Paris Agreement), preferably being more ambitious than the previous submission, as the aim is to "ratchet up" ambitions. Still, there is no obligation to do so. Every country can define its own mitigation target. The effect of this large degree of freedom is that a broad range of mitigation targets types exist: from rather quantitative to relatively qualitative ones[1]. Some targets aim to reduce emissions relative to base years, but there are also fixed-level targets, baseline scenario targets, intensity targets, and trajectory targets (Fransen *et al.*, 2017; den Elzen et al., 2016)[2]. The different types of targets per country are shown in *Figure 1*.

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[1] Nachmany and Mangan (2018) argue that 'measurable' and therefore quantified national targets are crucial to the credibility of climate change policies – for design, implementation, tracking and revision
[2] An overview of these targets can be found in the UNFCCC Portal (UNFCCC, 2018)

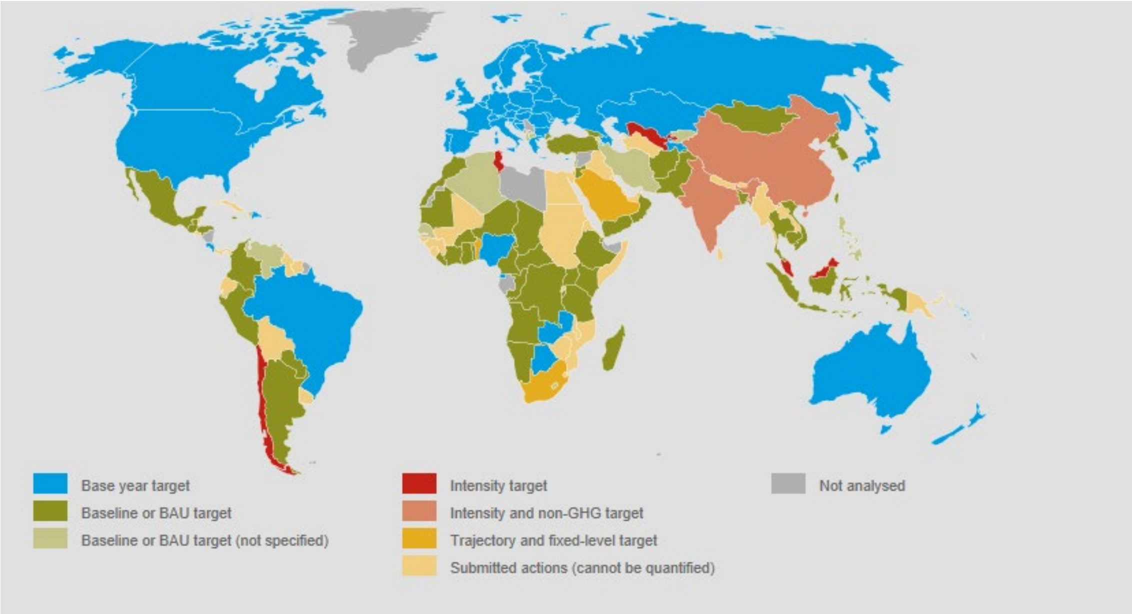

Figure 1. Overview of the several types of mitigation targets of NDCs, www.pbl.nl/indc (obtained from PBL, 2019)

However, countries do not solely express their targets in their NDCs. Countries have also set targets in their national energy and climate policies, which are not always communicated to an international audience, or in other official documents submitted by countries to the UNFCCC (e.g. national communications, biennial reports and biennial update reports). These targets that are expressed solely in the national policies are not always targets on emission reductions but could also be on the *drivers* of emission reduction. For instance, a target on the share of renewables in the country´s power mix or a cap on the total energy demand in a specific year. These targets could be set for the economy as a whole, but they could also be sector-specific. There are differences in the degree of 'embeddedness' of these targets: some targets have been adopted in legislative decisions, executive orders, or their equivalent, while some targets are publicly announced plans or strategies by a Minister or Secretary of State[3].

1.2 Objectives

This research focuses on the progress of current mitigation actions being undertaken by major emitting economies worldwide. Therefore, this research does not discuss the level of ambition of such actions and targets (see for example Höhne *et al.*, 2018), but instead provides an in-depth analysis of the projected impact of currently implemented policies as compared to the targets that have been set by the countries themselves. This research shows the effect of climate policies on indicators beyond emissions, thereby presenting a more elaborate check of progress toward meeting climate targets in twelve major emitting economies, i.e.: Argentina, Australia, Brazil, Canada, China, the European Union, India, Indonesia, Japan, Kazakhstan, Russia and the United States.

Every year, NewClimate Institute, PBL Netherlands Environmental Assessment Agency and IIASA present an up-to-date assessment of progress by 25 countries toward the achievement of the mitigation components of the 2025/2030 targets of the (I)NDCs (from

[3] Except for the EU which has no Ministers of State, because the EU is not a country but a region consisting of multiple countries. For the EU we consider the communications of the European Commission.

now on referred to as Kuramochi *et al.*, 2018). However, they restrict themselves to the projected emission reductions under current policy scenarios[4]. The report does not provide an in-depth overview of the *drivers* of these emission reductions and which (sub)targets have been set with respect to these underlying drivers. The aim of this research is to present high-level decarbonisation indicators to enhance understanding of the progress of 12 countries toward their NDCs and national energy and climate policy targets. This is done by examining development in six indicators.

1.3 Quantitative analysis

The indicators selected for the progress tracking[5] are representative proxies of GHG emissions: they are the sum of the major drivers of emissions. The basis for the set of indicators is inspired by the so-called "Kaya identity". This is an identity that is used to decompose the total greenhouse gas emissions as product into four factors: size of human population, GDP per capita, economy's energy intensity (per unit of GDP) and the economy's carbon intensity (emissions per unit of energy consumed) (Perman *et al.*, 2003; Peters *et al.*, 2017). The projections of the latter two indicators are influenced by many factors. Per capita GDP and population growth results in an increase in emissions, other things being equal, while energy intensity improvements in the global economy and reductions of carbon intensity in energy use results in a decrease in emissions. Inspired by the recent paper of Le Quéré *et al.* (2019), in which emission reductions over time were analysed, a 'renewed' set of four Kaya-indicators was developed[6]:
(a) Final energy intensity of GDP.
(b) Fossil-fuel based (and traditional biomass) final energy share in total final energy use.
(c) Fossil-fuel based (and traditional biomass) primary energy CO_2 intensity.
(d) Fossil Utilization rate[7].

There are multiple merits of this set of indicators as used in this research, which will be discussed here. First of all, it is rather easy to identify concrete policy actions associated with these particular indicators. Secondly, the set of indicators takes into account the emissions associated with the use of traditional biomass[8]. Thirdly, as the indicators are based on the fundaments of the Kaya-identity, we use an approach that is strongly embedded in scientific literature. And finally, and perhaps the most important argument; many countries have expressed (sub)targets in their climate policies in terms of these indicators or in terms which are closely related to the definition of the indictors. The Kaya Identity is discussed in more details in the *methodology* section.

In addition to the four Kaya indicators we discussed already, two additional "non-Kaya" indicators were used in the research. Many countries have also expressed (sub)targets for these indicators in their climate policies. Although these indicators are no Kaya-indicators, they are still important drivers of emissions, which allow us to enhance our full understanding of the progress of 12 economies toward their NDCs and national energy and climate policy targets. These additional non-kaya indicators are:
(e) Final energy use per capita.
(f) Renewable share in the electricity mix (either including or excluding hydropower).

[4] Similar to this research, they consider existing and, in some cases, planned climate and energy policies.
[5] More information about this methodology is found in the next chapter.
[6] Le Quéré *et al.* (2019) do not explicitly refer to Kaya-related literature.
[7] Fossil-fuels based primary energy divided by fossil-fuels based final energy.
[8] Le Quéré et al. (2019) did not include these emissions, probably because they focused on developed countries.

For these six main indicators, both historical data and projections of current policies scenarios from the integrated assessment models IMAGE and POLES were used, in order to analyse the drivers of CO_2 emissions in 12 major economies[9]. Similar to the yearly report of Kuramochi *et al.* (2018), the current policies scenario assumes that no additional mitigation action is taken beyond currently implemented climate policies as of a cut-off date[10]. In addition to the projections, also historical data were used for comparison. For each indicator, the historical development is shown from 1971 to 2015. From 2015 onwards, projections are shown for both IMAGE and POLES through 2035.

The historical development paths and the projections under currently implemented policies were used for comparison with *targets* of the individual countries on the six indicators. However, as countries have formulated their targets on energy and climate change using different definitions, this research 'universalized' the targets, meaning targets were recalculated (translated) to the same indicator definition. In the remainder, these translated domestic targets will be referred to as 'universalized targets'. Thus, this research enables a comparison between countries' climate policy actions and their *domestic* targets, and a comparison of developments between different countries.

1.4 Scope

In this research, the targets and developments of twelve major emitting regions were analysed[11]. These regions were selected based on their relatively large impact on worldwide emissions. These twelve countries accounted for about 75% of total global GHG emissions in 2015. Another criterion was the geographical location of the region – we intended to have a diverse geographical coverage. Furthermore, this analysis is restricted to energy- and industry related CO_2-emissions only, because CO_2 emissions from fossil fuels, industry and cement dominate total GHG emissions (Olivier *et al*., 2018) and these emissions are directly coupled to the selected Kaya-indicators related to energy consumption, whereas non-CO_2 greenhouse gas emissions and land-use related CO_2 emissions also have agricultural and land-use related sources.

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[9] In some cases, only either IMAGE or POLES data was available for the projection purposes. In such a case, solely he results for that integrated assessment models (IAMs) are shown as a 'flat line', instead of a range *between* the two lines for the two separate IAMs. The flat line may suggest that there is no uncertainty involved in the projection data. This is not the case. The uncertainty of the IAMs and the implications of those uncertainty is discussed in Kuramochi *et al.* (2018).

[10] Policy developments since the 2017 report have been taken into account in the emissions projections. The cut-off date of 1 July 2018 is used in this report. Herewith the approach of Kuramochi *et al.* (2018) is followed. They base they yearly policy-updates on their April policy update document (e.g. Kuramochi *et al.*, 2019) and the periodical updates under the European CD-LINKS project (CDLINKS, 2018). Although the April update for 2019 was already available before the publication date of this report, these policies have not been taken in account yet, as those have not been quantified and implemented yet in the current scenarios of the integrated assessment models IMAGE and POLES.

[11] These countries are Argentina, Australia, Brazil, Canada, China, the European Union, India, Indonesia, Japan, Kazakhstan, Russia and the United States

2 Methodology

2.1 General

This research mostly consists of a quantitative desk research: indicators were developed and analysed based on data from a scenario database and from output of integrated assessment models. In this chapter, we explain the sources of the historical data (2.2), the use of integrated assessment models IMAGE and POLES (2.3), and the development of universalized targets (2.4).

This research was supervised by the PBL Netherlands Environmental Assessment Agency and was performed by a Dutch National Governmental trainee in the first half of 2019. No other parties were involved in this research. The methodology of this first check of progress toward climate targets could be evaluated and adapted, for future use by PBL (also for the preparation of products under contract to the European Commission).

2.2 Historical data

For each of the six indicators, the historical development from 1971 to 2015 is reported. Various sources were used to calculate the indicators. For most of the energy data, an IEA dataset was used (Extended World Energy Balances). Furthermore, for data on GDP (in PPP) and population, another IEA dataset (World Energy Indicators) was used, which contains data of the OECD/IEA World Energy Statistics and Balances (World Energy balances statistics and world development indicators).[12] Finally, for *fossil fuels and industrial processes CO_2-emissions,* EDGAR data was used (V5.0). The latter also includes the emissions of traditional use of primary solid biofuels, if applicable.

Table 1: Elements obtained or calculated in this research, used for indicators

E1: Total final energy consumption (in ktoe) (IEA)
E2: Gross domestic product based on purchasing power parity (in 2010 US dollars) (IEA/OECD)
E3: Total population (in billions of people) (IEA/OECD)
E4: Fossil-based (and traditional biomass) Final Energy (in ktoe) (IEA)
E5: Electricity production generated from renewable sources including hydropower (in GWh) (IEA)
E6: Electricity production generated from renewable sources excluding hydropower (in GWh) (IEA)
E7: Electricity production generated from total of sources (in GWh) (IEA)
E8: Fossil CO_2 emissions, originating from fossil fuel use (combustion/flaring), industrial processes (cement, steel, chemicals, urea) and product use (EDGAR)
E9: Fossil fuels-based (and traditional biomass) Primary Energy (IEA)

The *indicators* were created by combining different *elements* (see Figure 2). For instance, for indicator *(b) fossil fuels-based (and traditional biomass) final energy share in total final energy use*, the following two elements were used: "Fossil fuels-based (and traditional

[12] https://www.oecd-ilibrary.org/energy/data/iea-world-energy-statistics-and-balances_enestats-data-en

biomass) final energy" and "Total final energy consumption". A graphical overview of the data used for calculating this indicator, is shown in *Figure 2*. It was possible to derive the second element of the indicator from the IEA 'raw' dataset. However, the first element could not be obtained directly from a database, so it was calculated based on various sub-elements. The element "Fossil fuels-based (and traditional biomass) final energy" was calculated by using data on Total Final Energy (TFE) and subtracting various types of final energy from renewable sources and final energy from nuclear sources. Please note that the renewable sources consist of solar, wind and biomass, which we all subtracted from the TFE. However, we *did not* subtract traditional used primary solid biofuels, as this is not considered as low-carbon in this research. For Nuclear Final Energy, we subtracted energy used for electricity purposes and energy used for heating purposes (only a minor part).

In *table 1* an overview is presented for all the elements that were calculated in order to calculate the six indicators. Appendix A describes which steps were taken to calculate these elements, based on raw data.

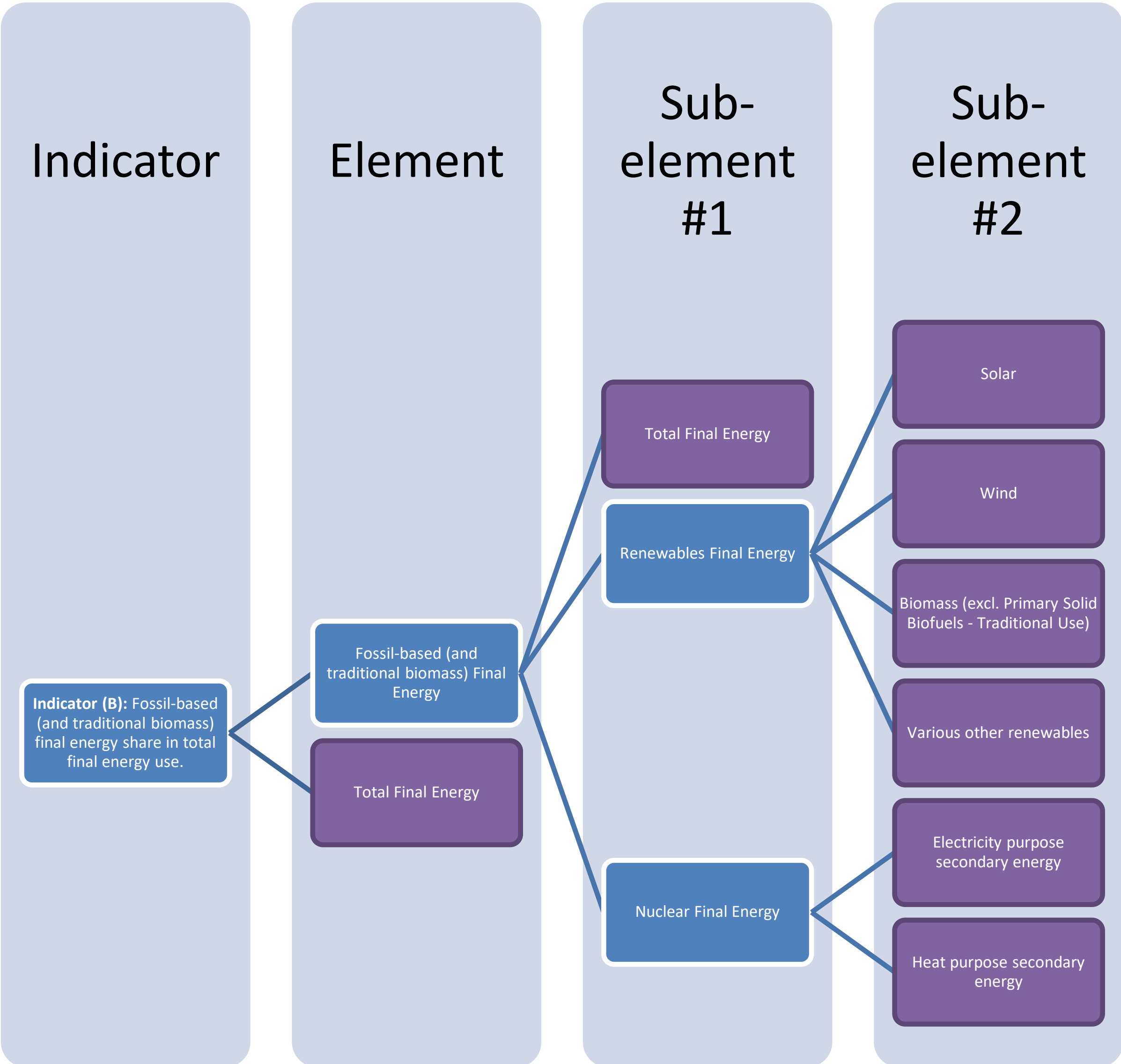


Figure 2: Example of how an indicator (B) is calculated, using elements and sub-elements. The figure shows that multiple levels of data are involved. In every step, an adequate unit of data is required before calculation takes place. The data in purple are 'raw' data that can be obtained from the original dataset.

Kaya-indicators

The set of indicators was inspired by the so-called "Kaya identity". This is an identity that is used to decompose the total greenhouse gas emissions as product into four factors: size of human population, GDP per capita, economy's energy intensity (per unit of GDP) and the economy's carbon intensity (emissions per unit of energy consumed) (Kaya, 1997). it is a specific application of a frequently used approach to organize discussion of the drivers of emissions through the so-called IPAT identity (see e.g. Perman *et al.,* 2003). The identity is used in several IPCC-publications (e.g. Blanco *et al*., 2014) in order to describe developments in emissions and is described in the following way[13]:

$$CO_2 = \frac{CO_2}{E} * \frac{E}{GDP} * \frac{GDP}{P} * P$$

where E represents energy consumption, GDP the global domestic product (or global value added) and P population. Changes in CO_2 emissions can be described by changes in these four factors. Le Quéré *et al.* (2019) used a formula that is rather similar to the Kaya-identity:

$$CO_2 = FE * \frac{FE_{ff}}{FE} * \frac{PE_{ff}}{FE_{ff}} * \frac{C}{PE_{ff}}$$

And $FE = GDP * \frac{FE}{GDP}$

Such that it can be rewritten as:

$$CO_2 = GDP * \frac{FE}{GDP} * \frac{FE_{ff}}{FE} * \frac{PE_{ff}}{FE_{ff}} * \frac{CO_2}{PE_{ff}}$$

FE is Final Energy Consumption, FE_{ff} is Final Energy from fossil fuels, PE is Primary Energy consumption, PE_{ff} is Primary Energy from Fossil fuels. In addition to the paper of Le Quéré *et al.* (2019), final and primary energy from fossil fuels here includes the energy originating from traditional use of primary solid biofuels, as this use of biomass has associated carbon emissions. Then the equation becomes:

$$CO_2 = GDP * \frac{FE}{GDP} * \frac{FE_{ff+trad}}{FE} * \frac{PE_{ff+trad}}{FE_{ff+trad}} * \frac{CO_2}{PE_{ff+trad}}$$

This equation consists of five driving factors of energy- and industry related CO_2 emissions, which can be measured and projected using data. However, GDP as such is *not* included in the tracking of progress toward climate targets, as this study focuses on the effects of energy- and climate policy. Energy- and climate policy only has an indirect effect on GDP. Furthermore, none of the 12 countries that are discussed in this analysis aims for changes in GDP in order to reduce emissions (which would imply a reduction of the GDP).

Four factors remain, which policy makers can target to bring down emissions: final energy intensity, fossil share of final energy, carbon utilization ratio and fossil-based (and traditional biomass) primary energy CO_2 intensity. Le Quéré *et al.* (2019) present various examples of policy actions that can help to direct the indicators, such that lower GHG emissions will be attained.

[13] For instance, IPCC (2000)

2.3 Projections

For this research, data from Integrated Assessment Models (IAMs) was used. The models used here are IMAGE and POLES, which were both developed in the European Union. IAMs are tools to understand the complex interactions between energy, economy, land use, water and climate systems (Gidden *et al.*, 2018). Their output has been reported in scientific literature, usually with the aim to project developments in climate change and energy. For this analysis, the integrated assessment models IMAGE 3.0 (Stehfest et al. 2014) and POLES-JRC (see Keramidas *et al.*, 2018 and Keramidas *et al.* (2017) were used to assess the impact of current national policies on the development of emissions and energy factors.

The IMAGE and POLES model are well suited for such an assessment, given the relatively high degree of detail with which they represent the activity levels in different sectors and their focus on a physical description of activities (allowing a rather straightforward interpretation of the implemented policies). The current policy scenarios have been described more extensively in Kuramochi *et al*. (2018). In this subsection, a small summary is provided.

IMAGE
IMAGE 3.0 is a comprehensive ecological-environmental model framework that simulates the environmental consequences of human activities worldwide (Stehfest *et al*., 2014; van Vuuren *et al*., 2017; van Vuuren *et al.,* 2018). For this research, it is relevant that IMAGE is able to simulate the impact of currently implemented climate policies, which affect various drivers of emissions.
IMAGE divides the world in 26 regions. Therefore, not every country is an IMAGE region. In many cases, individual countries are part of a larger IMAGE region. For countries that are part of a larger IMAGE region (in this research Australia, Kazakhstan and the Russian Federation), elements of the indicators were downscaled using the country's share in the region for 2015 historical data on that element (e.g. emissions) as a constant scaling factor.

POLES
The POLES-JRC (Prospective Outlook on Long-term Energy Systems) model is a global partial equilibrium simulation model of the energy sector, with complete modelling from upstream production through to final user demand (Keramidas *et al.*, 2017; Vandyck et al., 2016). The POLES-JRC model follows a year-by-year recursive modelling. As it is a global partial equilibrium model, prices are determined endogenously. These prices trigger various technical mechanisms in several sectors. POLES covers 39 regions over the world. With POLES, it is also possible to project the impacts of currently implemented policies (called the "Reference scenario").

First, all implemented policies in the analysed countries were gathered using the periodical updates from the CD-LINKS project (McCollum *et al.*, 2018 & CD-LINKS, 2018), literature research, and expert knowledge. PBL, NewClimate Institute and IIASA update this list on a yearly basis, as new policies arise. Policies through July 2018 were considered in the emissions projections. Current policy trajectories reflect *all* adopted and implemented policies until 2018, which for the purpose of this report are defined as legislative decisions, executive orders, or their equivalent. This implies that publicly announced plans or strategies alone would not qualify as implemented policies, while individual executive orders to implement such plans or strategies would. With respect to current policy trajectories, this research follows the approach used in Kuramochi *et al.*, (2018).

The starting point for the calculations of the impact of these climate policies was the latest SSP2 (no climate policy) baseline as implemented in the IMAGE model (van Vuuren *et al.,* 2017) and the POLES model (Keramidas *et al.,* 2018). The SSP2 scenario describes a middle-of-the-road scenario in terms of economic and population growth and other long-term trends, such as in technology development. The main drivers for the energy and industrial sectors are population, gross domestic product (GDP), lifestyle and technology change.

The following step consisted of introducing the explicit policy measures to the SSP2 baseline. For IMAGE, this process is reported in detail in Roelfsema *et al.* (2018), Van Soest *et al*. (2017) and Kuramochi *et al.* (2017). The so called 'current policy scenario' assumes that current policies are implemented up to 2030. For the 2030–2100 period, the scenario assumes no new policies. Policies may have a long-term effect through the induced technology learning effects (e.g. by additionally installed renewable energy technologies compared to the SSP2 baseline). For calculations of the impact of individual policies in different subsectors, modules of IMAGE were used, such as the global climate policy model (FAIR) and the detailed energy-system model (TIMER).

The POLES current policies scenario is based on the GECO2018 Reference scenario (Keramidas *et al*., 2018). It includes adopted energy and climate policies worldwide, for 2020, and the extension of the EU ETS to 2050 (with a constantly decreasing cap at -1.74%/year); after 2020, CO_2 and other greenhouse gas emissions are driven by income growth, energy prices and expected technological development with no supplementary incentives for low-carbon technologies (Keramidas *et al.*, 2018). A full list of the policies considered in the GECO2018 Reference scenario and their implementation is provided in Annex 5 of the GECO2018 report (Keramidas et al., 2018).

The current policy scenarios of both IMAGE and POLES consider a wide range of implemented national climate and energy policies but do not provide a complete assessment of *all* policies. This has the risk of underestimating or overestimating the total impact of a country's policies on GHG emissions. Another side note is that many assumptions are needed before one can estimate the impact of a policy: sometimes, there is a lack of information about the policy, sometimes one needs to simplify. Altogether, there are many uncertainties around the current policy projections. More information about the uncertainty and limitations of the scenarios is provided in Kuramochi *et al*. (2018).

For this research, output-data of IMAGE and POLES was used, for their current policy scenarios. It consists of data for energy- and emissions projections, organized in different categories. An approach similar to the one described for the historical data was taken, such that indicators were calculated using similar defined elements and various sub-elements (Table 1). Appendix A describes the steps in calculating these elements.

The indicators based on the model projections did not immediately match the selected historical time series. Literature on IAMs shows that this phenomenon is not unique: Rogelj et al. (2011) show that usually, historical emission levels from data officially reported to the UNFCCC are lower than independent global emission levels used in models. Gidden *et al.* (2018) argue that although historical data is used as both starting point for the creation of IAMs and instrument to calibrate the model afterwards, still discrepancies can exist. In order to deal with these discrepancies, model teams use the approach of harmonization. Gidden *et al.* (2018) write: "*Harmonization refers to the process of adjusting model results to match a selected historical time series such that the resulting future trajectories are consistent with the original modelled results and provide a smooth transition from the common historical data. In emissions context, this means that each individual combination of model region, model sector, and emissions species must be harmonized*". Furthermore Gidden *et al.* (2018)

refer to various authors using this technique, showing that its application is "common practice".

For this research, harmonization was also done. Different from the example of Gidden *et al.* (2018) and the application in Kuramochi *et al.* (2018), we did not only apply the technique on the emissions, but also on the *drivers* of emissions. More specifically: the elements used for the calculations of the indicators (e.g. "Final Energy" and "GDP (PPP)", for the energy efficiency indicator) were harmonized. There are different techniques for harmonization. Which technique is favoured depends on various factors (Gidden *et al*., 2018; Rogelj *et al.*, 2011). As we observe the unharmonized data for the indicators (consisting of one line for the projections and another one for the historical data), we find that the lines have, in general, similar shapes. However, the two separate lines are "shifted from each other" on the vertical axis. It may be that, although we tried to match the definitions of elements for calculating the indictors for both the historical data and the projections, there is still some small discrepancy in the way (sub)elements of the indicators were formulated. Therefore, based on the logics of Rogelj *et al.* (2011), we chose to use the *offset-method* for the energy and emissions indicators. Basically, the offset harmonization methodology offsets the entire emission pathway with the difference in emissions observed in the reference year[14]. For GDP (PPP), we chose to use the uniform scaling harmonization methodology, which looks at the relative difference between the 2000 GDP levels from a given pathway and the reference values of the IEA (World Bank), and scales the entire pathway for all years to get the harmonized GDP data. In this research, both the harmonized and the unharmonized, original, projections are shown.

2.4 Targets

The historical development paths and the (harmonized) projections under currently implemented policies were used in a comparison with the universalized targets of the individual countries. The transformation of targets in their original form and definition (i.e. as mentioned by the government in official communication) towards the universalized target's definition is a rather complex process. *Appendix B* provides more details on the calculations of all individual targets for each of the 12 regions analysed here. Each of the transformations (from explicit 'original' target to implicit 'universalized' target) is unique, as every country described their targets using different definitions, units and exceptions[15]. Still, there are always elements in the transformation process that are somewhat similar.

In *Appendix B*, every individual type of the six indicators has its own section in which the transformation processes for the countries' targets are discussed. At the start of every section, a graphical impression is provided in which the interconnections between the calculations are shown. a Metro Mapping Design is used in each of these figures. *Figure 3* shows an example for the energy efficiency indicator (Final energy per GDP (PPP)). In *Appendix B,* this figure is discussed more extensively.

[14] In the Python script that was created for this analysis, we did not use one reference year, but instead a combination of three reference years for which we have both projections and historical data: 2005, 2010 and 2015. For each of the three years, we checked where the absolute difference between projections and historical data is the smallest. We refer to this as the 'structural deviation' between projections and historical data, and this deviation was used as an offset factor. The deviation (either positive or negative) was structurally added to the projections from 2015 onwards until 2035 (final time period in this analysis). In order to have a smooth transition from the historical data to the adjusted projections, the data between 2015 and 2030 was adjusted, by applying a diminishing factor.
[15] For example: one country sets a maximum level (cap) on final energy in 2030, while another country sets a cap on primary energy in 2025. Yet another country aims to reduce the energy per capita with a certain percentage, as compared to business as usual projections.

A Metro Mapping Design has a universally understood logic and, therefore, helps us to represent and comprehend process flows and the connections between those. The identical routes followed for multiple countries and the intersections with partly divergent routes for other countries, represent the parallels between the universalized target calculations. For example, it is shown in *Figure 3* that Kazakhstan (KAZ), Russia (RUS) and China (CHN) formulated their targets in similar ways (regardless of their level of ambition). Therefore, there are parallels in the approaches of transforming these countries' explicit original targets into implicit universalized targets. The countries first follow the green line towards the intersection with the magenta-coloured line. Then they follow the vertical trajectory of the magenta-coloured line in the southern direction, ending at the universally defined implicit target. The target of Australia (AUS) is rather unique in its formulation, but also has similarities to the KAZ, RUS and CHN targets. Therefore, its transformation process towards a universalized target takes a *partly* different route, as compared to the other three countries we discussed. Its transformation process first follows a unique trajectory. However, as the trajectory hits the intersection with the green line, it follows the *joined* calculation trajectory on the same magenta-coloured line, together with Kazakhstan, Russia and China. Again, ending at the universally defined implicit target.

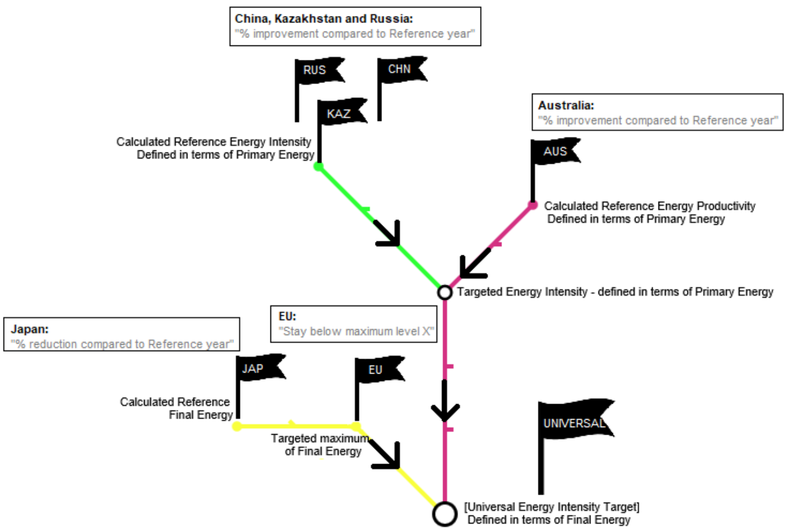
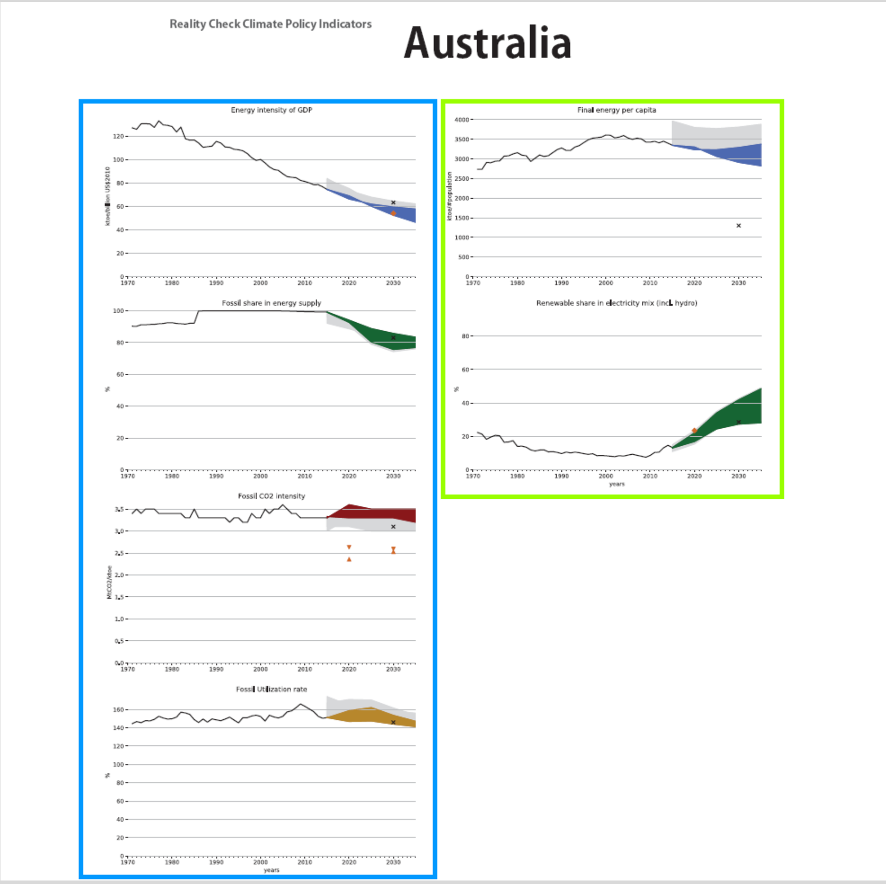


Figure 3: Example of the transformation (calculation) process, for the energy efficiency indicator (FE / GDP (PPP)). Starting at a small flag, representing the explicit 'original' target of an individual country, several trajectories lead to the larger flag (there is only a one-way road; multiple routes are not possible). This larger flag represents the implicit 'universalized' target.

How to interpret the country profile graphs?

In the next chapter, country profiles are provided for the 12 selected countries. Here, we explain how to read those profiles. The profiles first start with an overview of six graphs for the country, one for each of the six indicators. Four Kaya-indicators in the left column (see blue box) and two additional indicators in the right column (see green box). *Final energy use per capita* is an additional graph to the *Energy intensity* Kaya-graph. *Renewable share in electricity mix* is an additional graph to the *fossil share in energy use Kaya-graph*.



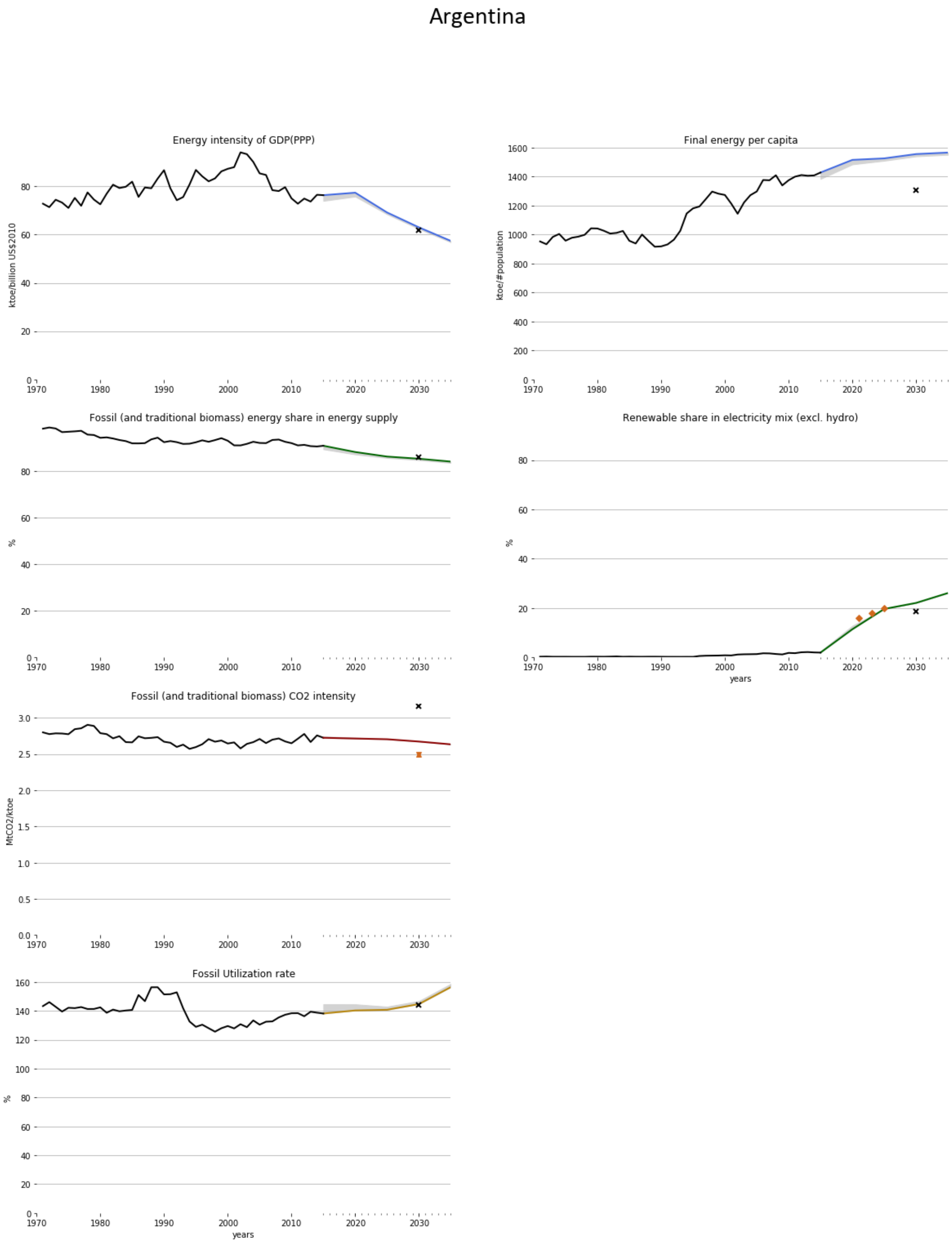
- Projections of IMAGE and POLES are shown as the coloured ranges between 2015 and 2035.
- These coloured ranges represent harmonized projections (see 2.3), while the grey ranges represent the unharmonized, original, projections.
- The bold black lines, usually between 1971 and 2015, represent the historical data.
- The world-average of the indicator in 2030 (using harmonized data) is shown as a black 'X' in 2030.
  - The estimates for the world are the same across countries, except for the share of renewable energy, which depends on the definition including or excluding hydropower.
- The universalized 'implicit' targets are shown as a brown-coloured diamond.
- If the target was not transformed (i.e. if the target was already defined in terms of the universal definition), then the 'explicit' target is shown as a gold-coloured diamond.
- The targets for fossil-based (and traditional biomass) primary energy CO_2 intensity are an exception; those are shown as arrows: one upward pointing arrow for the minimum estimate of the target and one downward pointing arrow for the maximum estimate of the target.
- Each of the indicators and how they are defined are similar for all country profiles. However, there is one exception: the *Renewable share in electricity mix* graph is

generally shown *including hydropower as renewable source*. However, if the specific country has defined its original renewable target *excluding hydropower*, then the graph is shown without this source of energy. For every country, the graph states whether hydropower is included or not.

- Additional background information on climate policies in the twelve countries and a further explanation of trends observed in the indicators can be found in Appendix C.
- An overview of countries’ progress on the six indicators is presented in Table 2.

3 Country profiles

3.1 Argentina



Indicator targets

- **Renewable share in electricity mix (explicit targets):**
  - 16% renewable electricity share by 2021.
  - 18% renewable electricity share by 2023.
  - 20% renewable electricity share by 2025.

  Important remark: renewable energy targets are excluding large hydropower and including small hydropower. As no reliable data on small hydropower generation is available, this source is not included in the historical data and projections.

  Source: Law 27191 on renewable energy (Reference in Appendix B).

  > The 2025 **target is projected to be met** under the current policy scenario of POLES.

  > The 2021 and 2023 **targets are projected *not* to be met** under current policy scenario.

- **Fossil and traditional biomass CO_2 intensity (implicit target)**: 2.49 $MtCO_2$/Mtoe by 2030.
  Based on explicit target: Limiting GHG emissions to 483 $MtCO_2e$ by 2030.
  Source: NDC.

  > The target **is projected *not* to be met** under the current policy scenario.

Overall GHG emissions target

"*Argentina is not yet on track to meet its unconditional NDC, and further mitigation actions are needed*" (Kuramochi *et al.*, 2018).

> The overall GHG emission target **is projected *not* to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Energy demand and savings

Argentina's energy use per capita has increased at a similar pace as the G20 average. Still, the absolute levels remain below the G20 average. The current policy scenarios show a continuation of this upward trend, such that in 2030, the energy per capita is higher (1550 ktoe/million persons) than the world average (1300 ktoe/million persons).

Argentina's energy intensity dropped by 21% (1990–2017), at a slower pace than the G20 average, but remains slightly below the G20 average (Climate Transparency, 2018). It is expected that the energy intensity will decrease more strongly in future, driven by for instance the *National Program for Rational and Efficient Use of Energy* and the *Energy Efficiency Project*. If the plans of the National Cabinet for Climate Change on transport are further developed and implemented, energy savings may be larger than in the current policies projections shown here.

Also the new carbon tax (not yet quantified in the projections), which mainly focuses on higher prices of liquid fuels, is expected to have an impact on the amount of energy used, due to its negative income effect

Implemented contributing policies

- National Program for Rational and Efficient Use of Energy (PRONUREE) (2007)
- Energy Efficiency Project (2009)
- Program for Rational and Efficient use of Energy in Public Buildings.

Renewable input and fossil phase-out

Argentina does not have a very carbon-intensive energy mix, when compared to other G20-countries. In 2017, 4.2% of the primary energy consisted of hydropower, 4.2% was from 'New Renewables', 1.9% from nuclear sources and 51.9% came from natural gas. The rest of the energy mix (37%) consisted mostly of oil and coal. The carbon intensity of the Argentinian power sector is only slightly below the G20 average (Climate Transparency, 2018).

New renewables (excluding large hydropower and traditional biomass), however, are not that abundant compared to other G20 countries. The Brown to Green report's country profile for Argentina shows that only 4.23% of the primary energy supply was generated from those renewable energy sources in 2017 (ClimateTransparency, 2018). The authors are more optimistic about the recent policy developments: Argentina's bio-economy is developing itself quickly, partly because of the impact of the *PROBIOMASA Program* (2013) (via Ministry of the Environment, 2015). Biomass is the main source and driver of the 20% increase in renewable energy supply between 2012 and 2017 in Argentina. Furthermore, the RenovAr auctions are promising. It is expected that the auctions will reach their goal of increasing the generation capacity of various renewable energy sources (Climate Action Tracker, 2019).

It is projected that Argentina's explicit renewable energy target for 2025 will be met. However, this is not the case for the earlier targets of 2021 and 2023. Marcelo Álvarez, President of Cámara Argentina de Energías Renovables (CADER), states in an article: *"Argentina will achieve its goal of 20 percent renewable energy in its electricity matrix by 2025. It will probably not achieve the first two-year goals because there are many projects being built. The main barriers right now are: financial support (high interest or short-term paybacks), the macroeconomic state of Argentina and the lack of infrastructure to reduce cost and time for building solar and wind plants"* (TheDialogue, 2018).

Implemented contributing policies

- Renewable Energy Programme in Rural Markets (2000)
- Renewable Energy Law 27191.
- National Development Scheme for the Use of Renewable Energy Sources (RenovAr) (2016)
- PROBIOMASA: Promotion of biomass energy (2013)

Carbon intensity and utilization

When the forestry sector is excluded from the emissions data, something noteworthy is found: Argentina's emissions increased by 43% between 1990 and 2014. The forestry sector would have a large compensating effect on the emissions. An important driver of those overall 'unmasked' emissions is the agriculture sector. The sector is capital-intensive compared to other countries' agricultural sectors. The agricultural emission intensity is 1.73 tCO_2 per thousand US$2015 in Argentina, compared to 0.95 for the average over all G20 countries (Climate Transparency, 2018). If we would also take into account the emissions related to forest clearance for agricultural land, the carbon footprint of the agriculture sector would be even larger.

Overall, the carbon intensity of Argentina is projected to remain rather stable in the coming 20 years, remaining well below the world average carbon intensity. Still, the aggregate of the Argentinean climate policy actions is not sufficient to make them meet the implicit carbon intensity target. This target is based on Argentina's own NDC ambitions. It will depend on the new and most recent (unquantified) plans of the Cabinet for Climate Change whether Argentina will be able to decrease its carbon intensity and therefore will be able to attain its NDC emission reduction target.

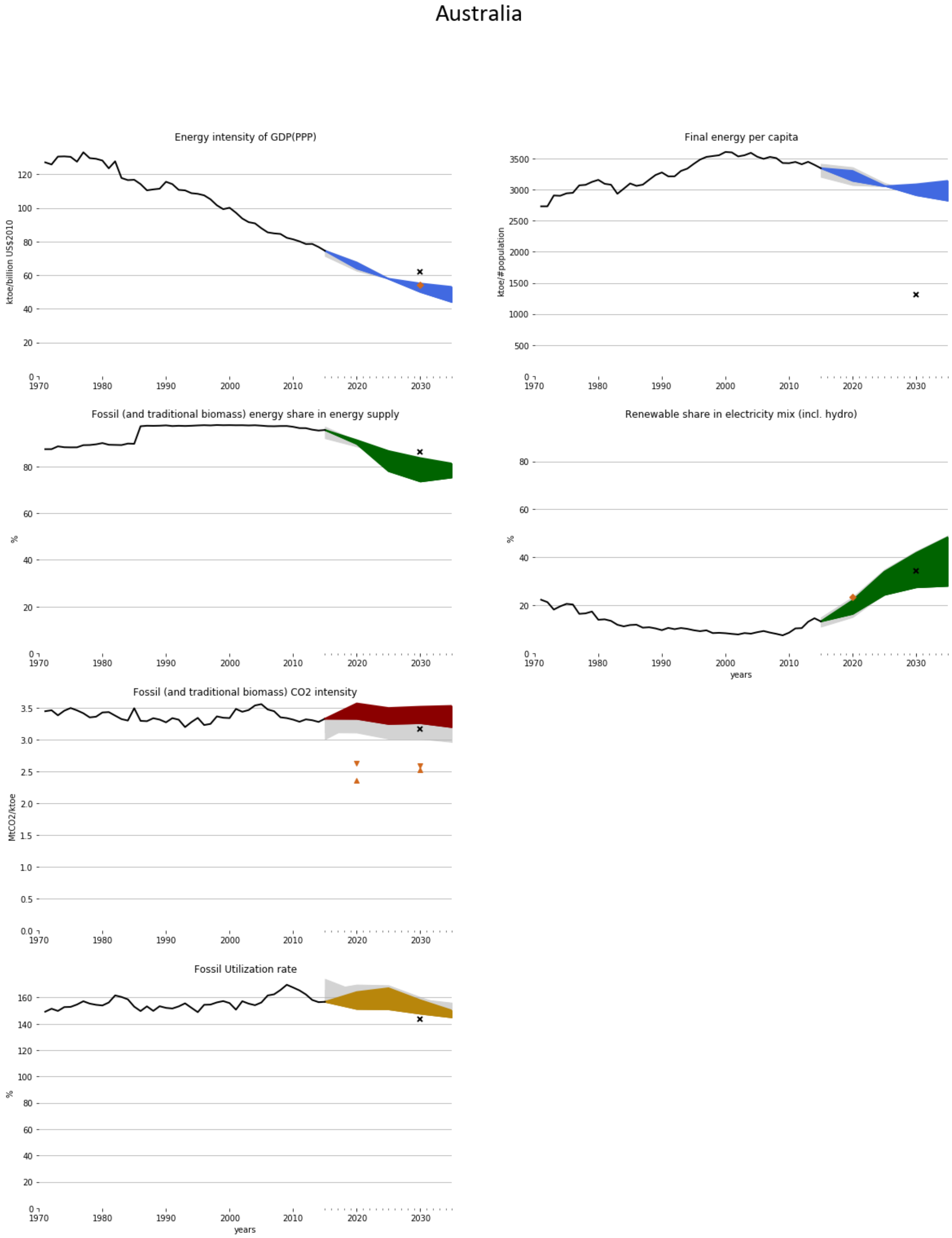
Implemented contributing policies

- Carbon tax on energy (2017)
- Biofuels law (2016)

Sources of implemented contributing policies:

- Kuramochi *et al.*, 2018
- Ministry of the Environment, 2015

3.2 Australia



Indicator targets

- **Energy Intensity of GDP (implicit target):** 53.22 ktoe/billion US$2010 by 2030.
  Based on explicit target: 40% improvement of energy productivity between 2015 and 2030.
  Source: The National Energy Productivity Plan (NEPP) (Reference in Appendix B).
  > The target **is projected to be met** under the current policy scenarios of IMAGE and POLES.
- **Renewable share in electricity mix (implicit target)**: 23.5% of Australia's electricity generation by 2020.
  Based on explicit target: realizing 33,000 GWh capacity of large-scale electricity generation by 2020.
  In a government report, this is equated to 23.5% of Australia's electricity generation in 2020.
  Source: The Renewable Energy Target (RET) scheme (impacted by amendment act 2015).
  > The target **is projected to be met** under the current policy scenarios.
- **Fossil and traditional biomass CO_2 intensity (implicit target)**: between 2.36 and 2.63 $MtCO_2$/Mtoe by 2020 and 2.52 to 2.59 $MtCO_2$/Mtoe by 2030
  Based on explicit targets: unconditional 2020 pledge of 5% GHG emissions reduction from the 2000 level and unconditional target of 26% to 28% GHG emissions reduction by 2030 from 2005 level.
  Source: NDC.
  > The targets **are projected *not* to be met** under the current policy scenarios.

Overall GHG emissions target

"Our current policies scenario projections for 2030 (5% to 11% below 2010 levels) are about 10 percentage points lower compared to our projections in the 2017 report due to higher renewable energy targets and enhanced forestry policy, but still show a significant difference with the NDC emission levels in 2030 (20% to 23% below 2010 levels). We therefore conclude that Australia is not on track to meet its NDC." (Kuramochi *et al.*, 2018).

> The overall GHG emission target **is projected *not* to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Energy demand and savings

Australia's energy use per capita is with 220 GJ/capita more than twice the G20 average (97 GJ/capita) (ClimateTransparency, 2018). In particular, Australia performs weak with regard to energy efficiency in both the industry and the transport sector, as compared with other developed countries (EEC, 2018). The Energy Efficiency Council (EEC) writes that Australia can rather easily increase their performance, by for instance implementing minimum standards for efficiency for more appliances (EEC, 2019). They point to the many best practices worldwide, from which Australia may learn some lessons if they would like to improve their efficiency rates.

In spite of this status quo, the energy efficiency policies which are implemented over the past years currently turn out to be fruitful: Australia is making a continuous improvement in its energy savings over the years and is projected to do so over the years to come. Based on current policy projections it even seems like Australia is going to attain the target of 40% improvement of energy productivity between 2015 and 2030. Yet, the final energy per capita will remain relatively high compared to the world average.

There is an important reason for Australia to continue their job on improving energy efficiency: The potential to save a lot on the household expenditures throughout the entire country. The EEC has found that in case Australia would adopt the German efficiency standards of today, it could save the average Australian households €500 a year on power bills (EEC, 2019).

Implemented contributing policies

- Greenhouse and Energy Minimum Standards Act 2012
- Energy Productivity Plan

Renewable input and fossil phase-out

Australia has the G20's second lowest share of zero-carbon fuels in the energy mix (ClimateTransparency, 2018). The graphs in this report show clearly that Australia is slowly but steadily about to escape from their fossil 'lock-in'. While previous decades the fossil share of Australia was approaching the 100%, Australia has shown a strong increase of 27% of zero-carbon fuels between 2012 and 2017. The current policy projections show that Australia is expected to continue this trend of fossil fuel decline.

This is especially driven by the strong increase of new renewables (e.g. solar and wind) in Australia. "New renewable" sources (excl. large hydro and traditional biomass use) supply 4.5% of energy in Australia (ClimateTransparency, 2018). This is somewhat similar to the G20 average. Supply from new renewables increased by 42% (2012–2017). Australia has one of the highest rooftop solar rates in the world: a fifth of all households has it installed, providing around 4% of Australia's electricity (Carbon Brief, 2019a). Altogether, Australia is well on track to meet the renewable electricity target of 23.5% in 2020. However, the beyond-2020 ambitions of the government are still unclear, as the national targets for 2030 and 2050 (set by previous coalitions) have been abolished.

Implemented contributing policies

- Renewable Energy Target (see previous page)

Carbon intensity and utilization

Australia is currently in a large transition from focusing on primarily coal exports to also focusing on LNG exports. Although LNG is less carbon intensive compared to coal, it is not sure whether exporting the cheap LNG to Asia will actually lead to a lower overall emission level. This is because it is expected that the LNG will not only compete with coal, but especially with the much cheaper renewable and nuclear Asian energy and also with gas from Qatar. Each of those are less emission intensive than the Australian LNG. This is partly due to the fact that there is expected an increase of fugitive methane gases, from increasing the activity level at various Australian mines (Guardian, 2019b). This leads to concerns that *actual* emissions and therefore intensities might be higher than presently reported (Hare *et al.*, 2018).

In 2017 the Australian carbon intensity was 76 tCO_2/TJ compared to a G20 average of 59 tCO_2/TJ (ClimateTransparency, 2018). Specifically, Australia's energy sector has even the G20's *highest* carbon intensity, due to Australia's high share of fossil fuels in the energy mix. Also the transport sector is relatively 'high-carbon' compared to other G20 countries: The Australian transport emissions account for 4.04 tCO_2 per capita, compared to a G20 average of 1.13 tCO_2 per capita. Now that Australia is working on the implementation and specification of the National Electric Vehicle Strategy, the government has the opportunity to counteract these high-carbon-statistics.

The graph on the projections of emission intensity show that Australia is expected to retain similar levels of carbon intensity over the years to come. This makes it hard to meet the implicit emission intensity target for 2030, which is critical to pursue their explicit NDC-emission-target.

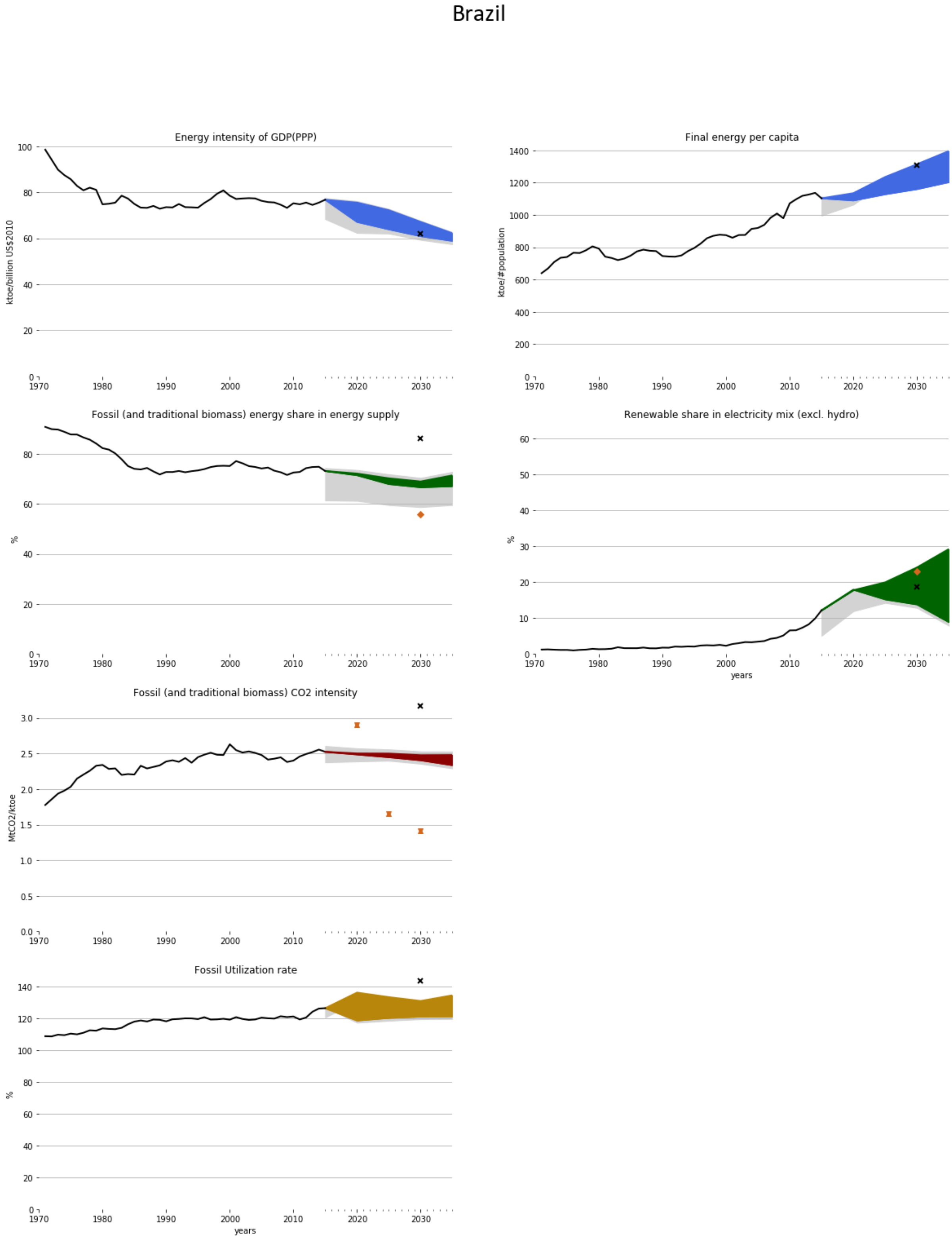
Implemented contributing policies

- Fuel tax for diesel and gasoline is set at AUD 0.3814 per litre
- CCS Flagships Programme Australia 2009
- Fuel Quality Standards Act 2000

Sources of implemented contributing policies:

- Kuramochi *et al.,* 2018
- Australian Government, 2015
- Australian Government, 2017

3.3 Brazil



Brazil
Energy intensity of GDP(PPP)
ktoe/billion US$2010
Final energy per capita
ktoe/#population
Fossil (and traditional biomass) energy share in energy supply
%
Renewable share in electricity mix (excl. hydro)
%
years
Fossil (and traditional biomass) CO2 intensity
MtCO2/ktoe
Fossil Utilization rate
%
years

Indicator targets

- **Renewable share in electricity mix (excluding hydropower) (explicit target)**:
  Share of renewables in power supply at least 23% (excluding hydro) by 2030.
  Source: NDC (References in Appendix B).
  > The target **is projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Fossil and traditional biomass share in energy supply (implicit target)**:
  56% fossil and traditional biomass share in total final energy by 2030.
  Based on explicit targets: 45% of renewables in the primary energy mix by 2030.
  Source: NDC.
  > The target **is projected *not* to be met** under the current policy scenarios.

- **Fossil and traditional CO_2 intensity (implicit targets)**:
  - For 2020, the calculated implicit target is 2.90 $MtCO_2$/Mtoe.
  - For 2025 the calculated implicit target is 1.65 $MtCO_2$/Mtoe.
  - For 2030 the calculated implicit target is 1.42 $MtCO_2$/Mtoe.

  Based on explicit targets:
  - Unconditional pledge: Between 36.1% and 38.9% reduction from a baseline scenario by 2020.
  - Unconditional NDC: 37% GHG emissions reduction by 2025 from 2005 level and indicative contribution of 43% GHG emissions reduction by 2030 from 2005 level (equivalent to 4% to 8% below 2010 levels by 2030).

  Source: NDC and other pledges (see Kuramochi *et al.*, 2018).
  > The targets for 2030 and 2025 **are projected *not* to be met** under the current policy scenarios.
  > The target for 2020 is **projected to be met** under the current policy scenarios.

Overall GHG emissions target

"Our latest assessment shows that Brazil is not on track to meet its NDC with existing policies, which contrasts with the finding of the 2017 report that Brazil is likely on track to meet its NDC target. The main reason for our conclusion is due to the increasing deforestation emissions over recent years. The newly elected president of Brazil has indicated he wants to limit environmental constraints on agriculture (Associated Press, 2018)" (Kuramochi *et al.*, 2018).

> The overall GHG emission reduction target **is projected *not* to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Energy demand and savings

The energy efficiency of Brazil shows a stabilization over the past 40 years and is projected to decrease slightly over the coming 25 years. Here we find a large contrast with the other G20 countries, of which the majority shows a clear decreasing trend. Nevertheless, Brazil is still below the G20 average.

When we look at the energy use per capita, we see an increasing trend. Energy use per capita in Brazil has increased by 48% since 1990, but started to decrease in 2014. The projections show that this decrease is only temporarily. Under current policies, energy use per capita is projected to increase again.

There are not many policies in Brazil that are specifically aimed at decreasing the country's energy use. One of the energy efficiency policies is the *Inovar-Auto* policy from 2012. This policy demands a 30% tax on cars sold between 2013 and 2017 (Kuramochi *et al.*, 2018). However, it should be recognized that many other climate change policies will have lower energy demand as a co-benefit.

Implemented contributing policies

- Inovar-Auto (2012)

Renewable input and fossil phase-out

From the indictors discussed in this country profile, Brazil scores best on the indicators related to renewable energy generation. Brazil is endowed with many favourable characteristics and natural resources which allow them to make a rapid transition from fossil to low carbon energy. In 2017, already 80% of the power generation came from renewables (incl. hydro), while the G20 average was only 24% in the same year Hydropower and bioenergy were important constituents of the renewable power mix. The sustainability of large-scale hydropower and first-generation biomass is debated. Therefore, these numbers should be interpreted with care. If we exclude hydropower from the power generation statistics for 2017, it turns out that only 25% of power generation is from a renewable source (Climate Transparency, 2018).

Brazil generates 29% of its energy supply from *new* renewable energy sources in 2017 (the G20 average is 5%). 'New renewable sources' include solar, wind, geothermal and (non-traditional) biomass. The growth in these sources has been mainly driven by biomass, which represented almost 97% of the new renewable energy supply (Climate Transparency, 2018).

This does not mean that Brazil focusses entirely on biomass; recent electricity auctions have targeted solar energy specifically, signalling a potential increase in solar capacity in the country in the coming years. The UN Emission gap report states that currently, contracts exist for the construction of around 4GW nominal capacity. Climate Transparency (2018) states that the Brazilian government announced plans to increase solar power, by installing 13 GW generation capacity by 2026.

Altogether, Brazil is projected to meet its renewable power target by 2030 under current policy projections (Share of renewables in power supply at least 23% (excluding hydro) by 2030). Yet, there is quite a large uncertainty range around the projections for the Brazilian fossil fuel share. Still, even in the most conservative case, Brazil is projected to meet the target.

However, the implicit target of 56% fossil and traditional biomass share in total final energy by 2030 is *not* projected to be met under the current policy scenarios (please note that the implicit target is based on the explicit target of 45% of renewables in the primary energy mix by 2030). Under current policy projections Brazil will only perform slightly better than the world average, with regard to their fossil share.

Implemented contributing policies

- 10-year National Energy Expansion Plan (2011)
- National Plan on Climate Change (2008)

Carbon intensity and utilization

The carbon intensity of the Brazilian energy sector is well below the G20 average (Climate Transparency, 2018). This would reflect the relatively high share of renewables in the primary energy mix. In other sectors, the emission intensity would be much higher: for instance, the transport emissions are 1.13 tCO_2 per capita in Brazil, while the G20 average is 0.96. COMMIT (2018) suggests that GHG emissions in Brazil may be reduced even further by a decarbonization and electrification of the transport sector. Here also bioenergy can play a crucial role. They also point to the option of deployment of Bioenergy with Carbon Capture and Sequestration (BECCS) in liquid biofuels production.

Another sector with a particular high carbon intensity is the agricultural sector. With 2.80 tCO_2 per thousand US$2015 (sectoral GDP), Brazil's agriculture is

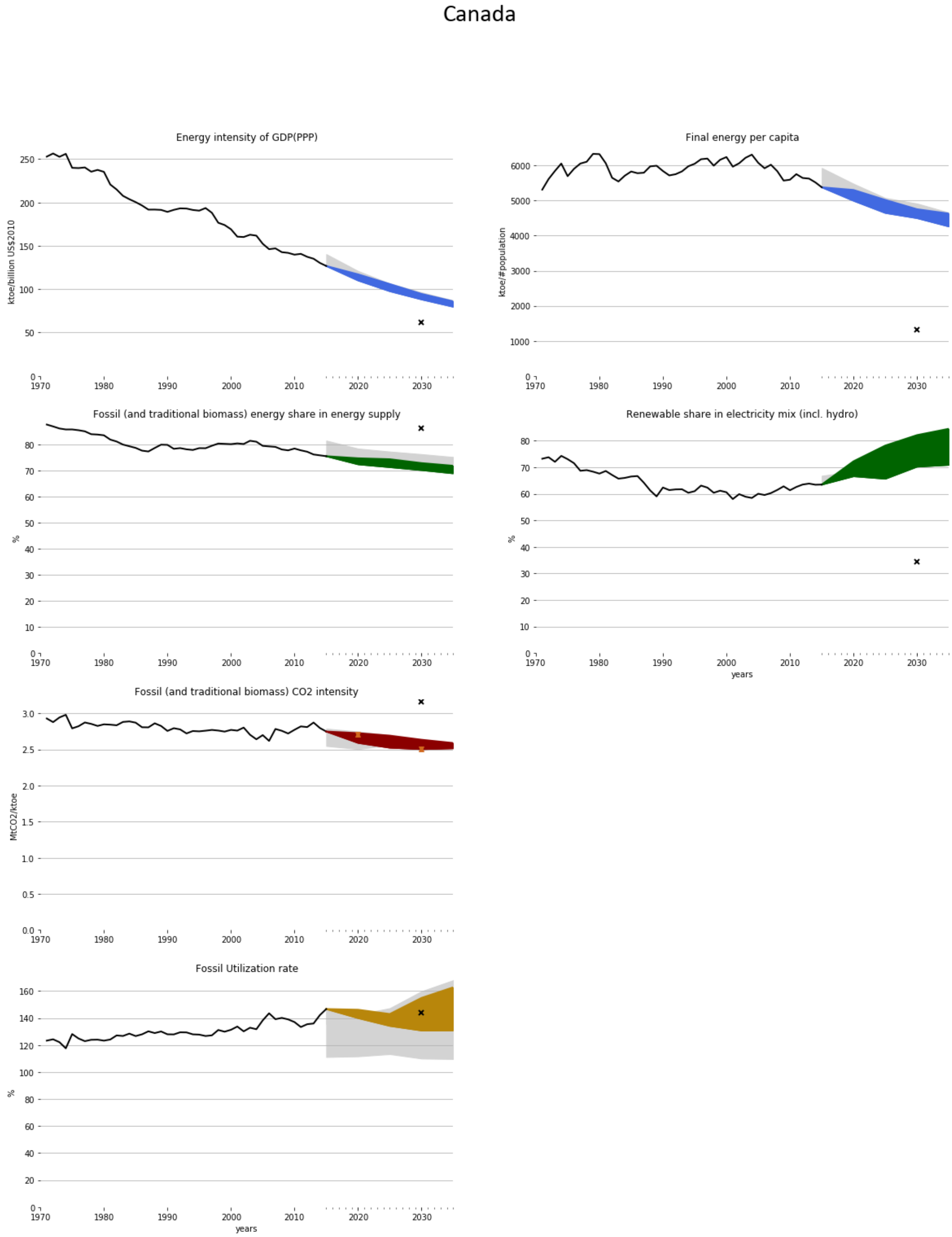
Implemented contributing policies

- Carbon tax on energy (2017)
- Biofuels law (2016)

Sources of implemented contributing policies:

more carbon-intensive than the G20 countries' average (0.95 tCO_2 per thousand US$2015 (Climate Transparency, 2018). Agriculture is an important pillar of the Brazilian economy. The agri-food chain is responsible for about 18% of the total economic output (OECD, 2015). Many products with a relatively high carbon footprint are exported: soybeans, sugar, coffee, beef and chicken. There is large mitigation potential in the agricultural sector, which is currently unexploited: half of the 200 million hectares of pasturelands are considered to be degraded. Recuperation of the soils may lead to higher sequestration rates, argues COMMIT (2018). There would be various options to intensify Brazil's agriculture production in a sustainable way; thereby, the production per square meter of land increases and the emissions decrease. None of the overall implicit intensity targets will be met under current policy projections.	• Kuramochi *et al.,* 2018 • Government of Brazil, 2008 • Ministry of Mines and Energy, 2012 • Presidência da República Brasil, 2017

3.4 Canada



Canada
Energy intensity of GDP(PPP)
ktoe/billion US$2010
Final energy per capita
ktoe/#population
Fossil (and traditional biomass) energy share in energy supply
%
Renewable share in electricity mix (incl. hydro)
%
years
Fossil (and traditional biomass) CO2 intensity
MtCO2/ktoe
Fossil Utilization rate
%
years

Indicator targets

- **Fossil and traditional biomass CO_2 intensity (implicit targets)**:
  - For 2020, the calculated implicit target is 2.71 $MtCO_2$/Mtoe.
  - For 2030, the calculated implicit target is 2.51 $MtCO_2$/Mtoe.

  Based on explicit targets:
  - Unconditional: 17% GHG reduction by 2020 from 2005 level.
  - Unconditional: 30% GHG reduction by 2030 from 2005 level.

  Source: NDC (References in Appendix B), and other pledges (see Kuramochi *et al.,* 2018)

  > The targets for 2020 and 2030 are **projected to be met** under the current policy scenarios of IMAGE and POLES.

Overall GHG emissions target

"*Under current policies, Canada is projected to emit about 635 to 770 $MtCO_2e$/year by 2030 excluding LULUCF (9% below 2010 levels to 11% above 2010 levels) and therefore, not meet its NDC (17% below 2005 level, or 25% below 2010 levels)*" (Kuramochi *et al.*, 2018).

> The overall GHG emission target **is projected *not* to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Important: Please note that only major policies were quantified in this research that have been implemented *before* June 2018. However, it is important to mention here that since June 2018, there have been some major policy changes in Canada. Newly introduced policies include the Greenhouse Gas Pollution pricing act, the Phase-out of traditional coal power, regulations for limiting carbon dioxide from natural gas fired generation of electricity and altered clean fuel standards.

Energy demand and savings

Canada has the G20's highest energy use per capita. In 2017, the Canadians used almost 328 GJ per capita, while the G20 average is approximately 100 GJ per capita (Climate Transparency, 2018). The relatively large energy use in Canada can be explained by a couple of factors: Canada has a relatively small population, which is scattered over a large landmass. The average Canadian is, therefore, using relatively much energy on transport. Another factor is that a large part of the population lives in the northern half of the northern hemisphere, requiring quite some energy for heating purposes.
Also the energy intensity of the economy is well above the G20 average. While other G20 countries show a steep decline in energy intensity (-11% between 2012 and 2017), Canada is not showing that much progress: the decline is only 3% in the same period (Climate Transparency, 2018). The projections show a continuation of this decreasing intensity trend.
Canada has implemented various efficiency standards for passenger and freight transport, fuel regulations, energy efficiency standards and there are initiatives to advance environmentally sustainable agriculture (Government of Canada, 2017). However, these measures have not been sufficient to be able to stop the increase of the absolute energy demand. One of the pathways in the Mid-Century Scenario aims at the electrification of final energy in combination with non-emitting electricity generation (Minister of the Environment, 2016). This pathway could be one of the possible solutions in order to bring down the Canadian major demand for energy, as electrification of heat engines leads to an overall net improvement in energy efficiency (Le Quéré *et al.*, 2019).

Implemented contributing policies

- CO_2 standards for new power plants (2012)
- Efficiency standards heavy-duty trucks (2013)
- Efficiency standards light commercial vehicles (2004)
- EcoENERGY efficiency (2011)

Renewable input and fossil phase-out

Some Canadian provinces show strong support for renewables and fossil-phase-out (Climate Action Tracker, 2019). Alberta has, for instance, adopted a carbon levy, which aims for a 2030 phase-out of coal-fired electricity. Ontario is another example, being the leader among provinces in wind and solar power capacity and having phased out coal since 2014. Currently, the majority of the Ontarian population is using biomass energy.

On a national level, the share of renewables in power generation is 65%, compared to a G20 average of 24% (Climate Transparency, 2018). However, if we look at the sources of total final energy consumption, it is shown that only 5% is from a non-fossil origin. Wind and solar only contribute 0.1% and 1.1%, respectively to the final energy consumption. Biomass is somewhat higher, with around 3.3% of the total share. The fossil and traditional biomass share graph shows that Canada is projected to reduce their fossil share to approximately 85% by 2030, under current policies projections.

Canada has no target on maximum allowed fossil shares or minimum targets on renewables in the power mix. They do have, however, announced a full coal phase-out by 2030. Although this may sound very ambitious, it should be recognized that Canada’s current energy mix already contains a relatively small share of coal: only 6% in 2017. At the same time, gas is responsible for a 35% share and oil for 34% share in the energy mix (Climate Transparency, 2018). There are no signs that the demand for oil or gas will be specifically targeted by restrictive policy. Recently, the Government of Canada decided to purchase the Kinder Trans Mountain Expansion Project and related pipeline and terminal assets, despite strong opposition from civic governments, indigenous peoples and other concerned citizens (Guardian, 2018b).

Implemented contributing policies

- Renewable fuel regulations (incl. biofuel bill – amendment to the Canadian Environmental Protection act)
- Forest Bio-economy Framework for Canada

Carbon intensity and utilization

Canada is among the small amount of major economies which is about to meet their implicit carbon intensity target. This calculated target is based on their explicit emission reduction NDC target for 2030. Still, one should be careful before drawing any conclusion about the ambitions of Canada as compared to other G20 countries. In nearly every sector, except for the power sector (146 tCO_2 per capita, compared to 490 tCO_2 per capita for average G20 country (2017)), they show above-average emission intensity statistics. Because the power sector is such a large sector in Canada, the net *overall* economy's emissions intensity is still relatively low compared to other G20 countries in 2017 (Climate Transparency, 2018).

According to the Brown-to-Green Canadian country profile (Climate Transparency, 2018), transport emissions per capita were 4.76 tCO_2 per capita, while the G20 average is 1.13 tCO_2 per capita (2017). Building emissions per capita are even 2.02 tCO_2 per capita, while the G20 average is 0.48 tCO_2 per capita (2016). And finally, agriculture emissions are 3.32 tCO_2 per capita, while the G20 average is 0.95 tCO_2 per capita (2015). The rather low carbon intensity of the power sector is a clear exception, reflecting the relatively low share of coal in the energy mix.

Although Canada is projected to meet their implicit carbon intensity target under IMAGE and POLES current policy projections, they still lack sufficient high-impact policies to meet their *overall* emission reduction target for 2030. An additional research would be required to explain this casus, as there is a strong connection between the emission intensity target and the overall emission target. Furthermore, an updated research should take in account the impact of the new set of policies that have been introduced in the previous year, as these policies are expected to have a large impact on the carbon intensity of Canada, which are not quantified here.

Implemented contributing policies

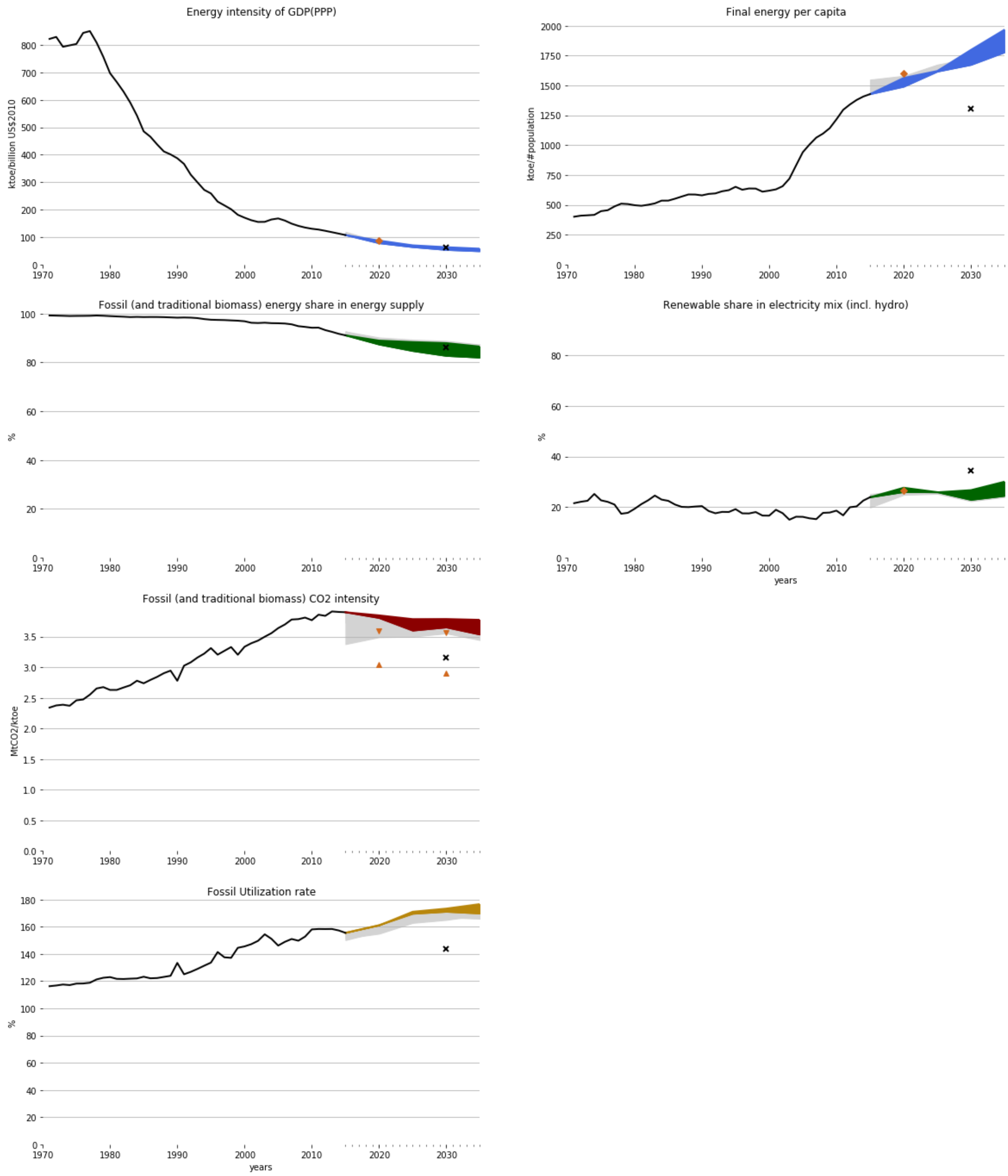
- CO_2 standard for new power plants (2012)
- Regulations to address methane in the oil and gas sector (2018)

Sources of implemented contributing policies:

- Kuramochi *et al.,* 2018
- Government of Canada, 2016
- Government of Canada, 2017

3.5 China

China



Indicator targets

- **Energy Intensity of GDP (implicit target)**:
  For 2020, the calculated implicit target is: 86.43 ktoe/billion US$2010.
  Based on explicit target: Decrease energy intensity (TPES/GDP) by 15% by 2020, relative to 2015.
  Source: 13th Five Year Plan (2016-2020) (References in Appendix B)
  > The target for 2020 is **projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Final energy per capita (implicit target)**:
  For 2020, the calculated implicit target is: 1603.30 ktoe/million people
  Based on explicit targets:
  - Cap on primary energy consumption – 165 EJ in 2020.
  - Government will modify family planning to keep the national population around 1.42 bn people based on one couple and a maximum of two children.

  Source: 13th Five Year Plan (2016-2020)
  > The target for 2020 is **projected to be met** under the current policy scenarios.

- **Renewable share in the electricity mix (implicit target)**:
  For 2020, the calculated implicit target is: 26.5% share of renewables in electricity mix (including hydropower).
  Based on explicit targets:
  - realizing 340 GW Hydro-electricity capacity, 210 GW Wind, 15 GW biomass, 105 GW solar PV and 5 GW Solar thermal in 2020.

  Source: 13th Five Year Plan (2016-2020).
  > The target for 2020 is **projected to be met** under the current policy scenarios.

- **Fossil and traditional CO_2 intensity (implicit target)**:
  For 2020, the calculated implicit target is between 3.05 and 3.59 $MtCO_2/Mtoe$.
  For 2030, the calculated implicit target is between 2.90 and 3.57 $MtCO_2/Mtoe$.
  Based on explicit targets:
  - 40-45% CO_2 emission intensity reduction by 2020, compared to 2005 levels.
  - 60-65% CO_2 emission intensity reduction by 2030, compared to 2005 levels.

  Source: 13th Five Year Plan (2016-2020).
  > The implicit targets for 2020 and 2030 are *not* projected to be met under the current policy scenarios, using the methodology of this research.
  > **However:** This research has calculated a universalized implicit target, such that the target can be easily compared with targets of other countries. The explicit 'original' targets are underlying the implicit 'universalized' targets. It is shown by Kuramochi *et al*. (2018) that China's current policies **are more or less in line with their *explicit* target**.

Overall GHG emissions target:

Different from many other countries, China does not have a base year-, baseline- or BAU target for their emissions. Instead, they have formulated an intensity target that depends on the level of GDP; furthermore, they have set some additional targets.

"*China has pledged to peak CO_2 emissions around 2030, to achieve a 20% share of non-fossil fuel energy sources in total primary energy consumption by 2030, and to reduce the carbon intensity of its GDP by 60-65% compared to 2005 levels. Our current policies scenario, which takes the latest renewable capacity targets into account as well as a cap on coal consumption, projects that China's policies are more or less in line with what the NDC targets would mean for overall emissions*" (Kuramochi *et al.*, 2018).

> The overall GHG emission target **is projected to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Energy demand and savings

The energy intensity has decreased by a factor 8 over 40 years, and is now slightly above the G20 average. Current policy scenarios project that by 2030, the Chinese energy intensity will stabilize at approximately 80 Ktoe/billion US$2010. Under this projection, China is expected to meet their target on energy savings in 2020 and will reach the world average energy intensity by 2030 (Climate Transparency, 2018).

As a developing country, the energy use per capita is still projected to increase over the years to come. The current trend is expected to continue until at least 2030. However, the energy per capita projection is slightly lower than what is targeted by the Chinese government. Also for this indicator, the implicit target is met under current policy scenarios.

Controlling and decreasing coal consumption has been one of the important policy objectives in China's National Action Plan on Climate Change (China Government, 2014a), Energy Development Strategy Action Plan (2014–2020) (China Government, 2014b), and Action Plan for Upgrading of Coal Power Energy Conservation and Emission Reduction (Climate Policy Database, 2014). The 13th Five Year Plan (2016–2020) introduced even more coal-related targets, such as a ban on new coal-fired power plants (which was subsequently raised in 2018), and a cut in production capacity of coal (Enerdata, 2016). An important motivation for saving on energy, is China's energy security. China used to be a net energy exporter, but over the years it became a net importer as its industrial production was subject to massive growth in the 90s. Leung *et al.* (2014) argue that the growing import dependence, especially on oil, became a concern for national policy leaders.

Implemented contributing policies

- Cap on total primary energy use in 2020 (13th Five Year Plan)
- The Thirteenth Five Year Energy Development plan
- Energy Development Strategy action plan
- Vehicle fuel economy standards
- "Made in China 2025" standards for auto industry
- Green industry development plan (2016-2020)
- Various appliance standards and labelling programme for buildings

Renewable input and fossil phase-out

On the one hand, China is still the world's largest consumer of coal (64% of coal in the energy mix; G20 average being 32%); on the other hand, they are also the world's largest solar technology manufacturer and, next to that, have seen the largest increase in share of "new renewables" in the energy mix; Energy production from wind, biomass, solar and geothermal energy increased by 170% (2012-2017; Climate Transparency, 2018).

The IPCC Special Report on 1.5 °C found that it is required to phase out coal from the global power sector by 2050, in order to be able to limit temperature levels to at most +1.5 °C and therefore stick to the Paris ambitions (IPCC, 2018). The efforts of China, as largest GHG-emitter, are therefore critical for the successful realization of the IPCC-report ambition.

So far China is not on track to reduce the use of coal in power generation to a bare minimum in 2050. In the current policy projections of Climate Action Tracker (2018), it is calculated that coal's share in China's total primary energy demand decreases from 58% in 2017 to between 39 and 48% in 2030. The COMMIT (2018) country-profile shows that not only China's domestic action should be considered, but special attention is required for China's foreign investments: *"China's actions abroad will also have an important impact on future global greenhouse gas emissions, and China is financing and building both fossil-fuel and renewables infrastructure worldwide. Of all coal plants under development outside of China, one quarter, or 102 GW of capacity, have committed or proposed funding from Chinese financial institutions and companies. That's roughly double Germany's current coal capacity"* (COMMIT, 2018).

Implemented contributing policies

- Energy Development Strategy Action Plan 2014-2020
- Biofuel targets

The capacity target that China has set for itself is projected to be met. In 2025 the country is about to reach the 26.5% share of renewables in electricity mix (including hydropower), which is due to its successful feed-in tariff system.

Carbon intensity and utilization

China's overall carbon intensity target has been discussed earlier in this country profile. In 2017, China announced the launch in 2020 of an emissions trading scheme for its power sector in order to reduce the country's carbon intensity, as the power sector is the most important contributor to emissions (53%) (Climate Transparency, 2018). The system's overall impact on emissions is unclear, as not many operation details have been shared (Kuramochi *et al.*, 2018). Therefore, the emission trading system is not quantified in the current policy scenario.

If we zoom in to China's sectors emission intensity statistics, using data from Climate Transparency (2018). As for many major economies, the energy sector is the major source of emissions in China; Nearly 10.000 MtCO_2e of GHG emissions is directly related to the energy sector, from the 12,700 MtCO_2e of GHG emissions in total. From 2000 through 2012 there was a strong increase in absolute energy emissions. However, in the recent years the energy emissions and therefore the carbon intensity of China's energy sector has decreased slightly. This could be explained by a decreasing share of fossil fuels in the energy mix, which is discussed earlier. Yet, at 72 tCO2/TJ, it remains well above the G20 average (59 tCO2/TJ).

Most of the other sectors perform 'better' than the G20-average, with regard to their intensity indicators in the report of Climate Transparency (2018). This is currently true for the Agriculture, Built environment and Transport sector in China. However, as the average Chinese citizens standard of living keeps improving rapidly, it may not take very long until production and therefore emission intensities in these particular sectors will increase to a level above the G20-averages.

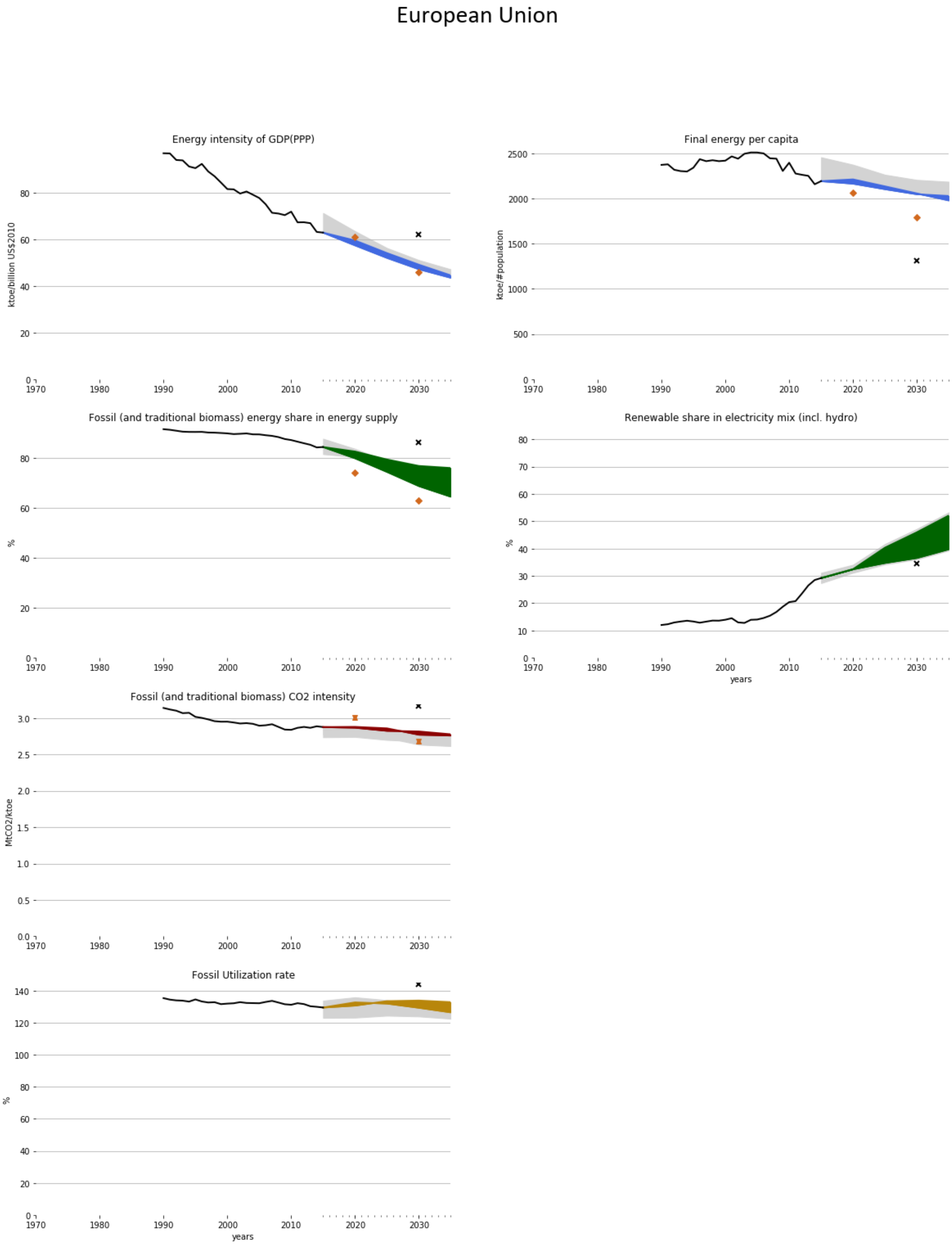
Implemented contributing policies

- Action Plan for Upgrading of Coal Power Energy Conservation (2014)

Sources of implemented contributing policies:

- Various sources via Kuramochi *et al.,* 2018

3.6 European Union



Indicator targets

- **Energy Intensity of GDP (implicit target)**:

  For 2020, the calculated implicit target is: 61.01 Ktoe/billion US$2010.

  For 2030, the calculated implicit target is: 45.90 Ktoe/billion US$2010.

  Based on explicit targets:
  - 20% energy reduction by 2020, compared to business as usual ("maximum 1078 Mtoe of final energy in 2020") (See appendix B for references)
  - 32.5% energy reduction by 2030, compared to business as usual ("maximum 956 Mtoe final energy by 2030").

  Source:
  - 2020 target: Climate and Energy Package European Union 2009.
  - 2030 target: Climate & energy framework (2014; amended in 2018).

  > The target for 2020 is **projected to be met** under the current policy scenarios of IMAGE and POLES.

  > It is **uncertain** that the target for 2030 is **projected to be met** under the current policy scenarios. The current policies scenario shows that it is close to be met. However, the 2030 target is met under the most recent calculations with the current policies scenario (Kuramochi et al., 2019), assuming a full implementation of directives, regulations and legislation adopted in 2018 and 2019 that comprise the Clean Planet for all Europeans policy package.

- **Final energy per capita (implicit target)**:

  For 2020, the calculated implicit target is: 2064.60 Ktoe/million people.

  For 2030, the calculated implicit target is: 1793.43 Ktoe/million people

  Based on explicit targets & Source: See *Energy Intensity of GDP*

  > The targets for 2020 and 2030 are **projected *not* to be met** under the current policy scenarios.

- **Fossil and traditional biomass share in energy supply (implicit target)**:

  For 2020, the calculated implicit target is: 74%. For 2030, the calculated implicit target is: 63%.

  Based on explicit targets:
  - 20% of Final energy from renewable sources by 2020.
  - 32% of Final energy from renewable sources by 2030.

  Source:
  - 2020 target: Renewable Energy Directive.
  - 2030 target: Renewable Energy Directive.

  > The targets for 2020 and 2030 are **projected *not* to be met** under the current policy scenarios.

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**:

  For 2020, the calculated implicit target is 3.01 $MtCO_2$/Mtoe.

  For 2030, the calculated implicit target is 2.68 $MtCO_2$/Mtoe.

  Based on explicit targets:
  - 20% GHG reduction by 2020 from 1990 level.
  - At least 40% greenhouse gas reduction by 2030 from 1990 level.

  Source: Kyoto-pledge and NDC.

  > The target for 2020 is **projected to be met** under the current policy scenarios.

  > The target for 2030 is **projected *not* to be met** under the current policy scenarios.

Overall GHG emissions target

"*Under current policies, now including the effort sharing regulation and F-gas regulations, the EU is likely to overachieve its unconditional 2020 pledge. For 2030, the EU is projected to be short of its NDC target in the NewClimate Institute projections but is projected to overachieve its NDC target in the PBL projections (reaching about 43% below 1990 levels).*" (Kuramochi *et al.*, 2018).

> The overall GHG emission target for 2020 **is projected to be met** under the current policy scenarios of PBL and NewClimate Calculations.

> It is **uncertain** whether the EU will meet the NDC target in 2030, due to policies taken into account in the current policy scenarios of PBL and NewClimate Institute. The NDC target in 2030 is met under the current policies scenario (Kuramochi et al., 2019), assuming a full implementation of directives, regulations and legislation adopted in 2018 and 2019 that comprise the Clean Planet for all Europeans policy package.

Energy demand and savings

The EU Parliament agreed upon new Energy efficiency measures as part of the EU Clean Energy Package. This policy mentions a binding target of 32.5% EU-wide energy efficiency improvement. Member States are currently implementing *additional* policies in order to meet this recent and more stringent target (as compared to the 2020 target). In order to meet the 2020 target, many policies were already in place in Member States, such that projections show a continuation of their declining energy efficiency. The UK (still an EU Member State as of July 2019) has for instance implemented the UK Clean Growth Strategy, featuring a target of 20% efficiency improvement in business and industry by 2030, next to energy efficiency obligations for utilities as well as funds for innovation in low-carbon heating and public sector efficiency improvements. Italy has a target of 10 Mtoe reduction in final energy consumption by 2030, and proposes tax breaks and loan guarantees for residential energy efficiency investments (IEA, 2018)

The built environment represent almost 40% of total final energy consumption in the European Union, transport accounting for 28% of the final energy consumption and industry 23%. The amount of energy consumed by the built environment in the EU is relatively large compared with other G20 regions. That is why the EU has implemented the Building Energy Efficiency Directive in 2012, aiming at near zero energy buildings by 2020 (residential). The transport sector is another large consumer of energy. In order to save on energy consumption, performance standards for light- and heavy-duty vehicles have been adopted (Kuramochi *et al.*, 2018).

Given the currently implemented policies (prior to June 2018), the energy efficiency target for 2020 is projected to be met, while the one for 2030 is not projected to be met.

Implemented contributing policies

- Eco-design Framework Directive (Directive 2009/125/EC)
- Energy Efficiency Directive (2012/27/EC)
- Building Energy Efficiency Directive (2012)
- *Individual Member States' policies*

Renewable input and fossil phase-out

Next to more ambitious energy efficiency targets, the EU agreed on more ambitious renewable energy targets as well. These targets are even higher than initially proposed by the Commission (Kuramochi *et al.*, 2019).

Currently, the share of renewables in the power mix is around 30%, slightly higher than the G20 average (24% in 2017). This share is projected to be between 40% and 50% by 2030. The EU did not set an explicit target for the share of renewables in the power mix, but instead they set a target on the share of renewable resources in the final energy mix (20% by 2020). This explicit target has been used to calculate the universalized implicit target on the maximum allowed fossil share presented here. In 2018, the fossil share was between the 85% and 90%, while in 2020, it should be 74% to attain the target. It is not likely that the EU will reach both the implicit targets under current policies (implemented prior to 2018).

The EU institutions send mixed signals about the likeliness that the EU is to reach the *actual* explicit target of 20% final energy from renewable energy. On the one hand Climate Commissioner Miguel Arias Canete says in 2019:

Implemented contributing policies

- Renewable Energy Roadmap/ Directive (2009/28/EC)
- Directive 2009/28/EC Biofuel target
- *Individual Member States' policies*

“The EU is on track to meet its 2020 renewable target, with 11 member states already above their national targets” (Reuters, 2019). On the other hand, the European court of auditors have published a special report on the 2020 renewable targets in 2019 stating that “significant action [is] needed if EU targets to be met” (Reuters, 2019). Based on their statistics, the share of energy from renewable sources in the EU’s gross final energy consumption reached 17.5%, compared with the overall 2020 target of 20%.

Carbon intensity and utilization

The EU’s emission intensity is somewhat lower than the world average. ‘Electricity, heat and other’ make up the largest share of energy related CO_2 emissions in the EU (36% in 2017). The second largest sector is the transport sector (27%). If we compare those two sectors with similar sectors in other G20 countries, we find that emission intensity of the power sector in Europe is relatively low (289 gCO_2/KWh in EU vs. 490 gCO_2/KWh G20 average). The transport emissions per capita, however, are relatively high in Europe (1.8 tCO_2/capita in EU vs. 1.13 tCO_2/capita G20 average) (ClimateTransparency, 2018).

Given the currently implemented policies (prior to June 2018), the carbon intensity targets for 2020 and 2030 are projected not to be met. The projections show a carbon intensity that is expected to stabilize at slightly lower than today’s levels. In order to meet the EU’s ambitious NDC target, a strong decline in emission intensity is crucial.

Implemented contributing policies

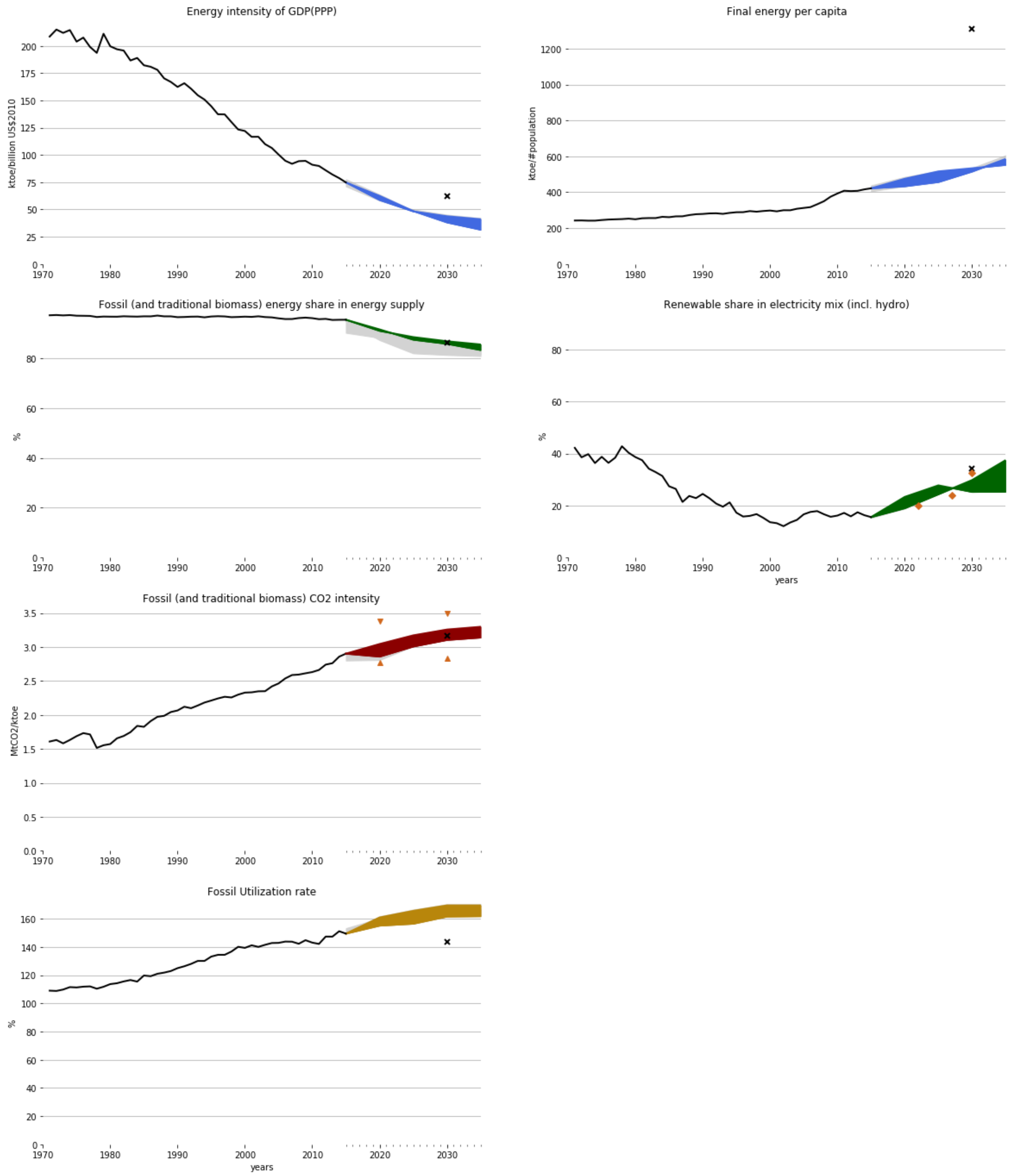
- EU ETS Directive (2003/87/EC revised by Directive 2018/410/EU)
- Regulation of CO_2 emissions from passenger vehicles (443/2009)
- *Individual Member States’ policies*

Sources of implemented contributing policies:

- Kuramochi *et al.,* 2018
- EU, 2019f (overview of strategies & policies)

3.7 India

India



Indicator targets

- **Renewable share in electricity mix (implicit target)**:
  - 20% share of renewables in the electricity mix (including hydropower) in 2022.
  - 24% share of renewables in the electricity mix (including hydropower) in 2027.

  Based on: realizing capacity additions.

  Source of calculations: CD-LINKS (References in Appendix B)

  > The target for 2022 and 2027 are **projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**

  For 2020, the calculated implicit target is in the range 2.77-3.38 $MtCO_2$/Mtoe.

  For 2030, the calculated implicit target is in the range 2.83-3.50 $MtCO_2$/Mtoe.

  Based on explicit targets:
  - 20% GHG emissions reduction by 2020 from 1990 level.
  - Reduce emissions per unit of GDP by 20% to 25% below 2005 level by 2030 (excluding agricultural emissions).

  Source: NDC and 2020 emission reduction pledge.

  > The targets for 2020 and 2030 are **projected to be met** under the current policy scenarios.

Overall GHG emissions target

Different from many other countries, India does not have a base year-, baseline- or BAU target for their emissions. Instead, they have formulated an intensity target that depends on the level of GDP. This means that their targeted absolute emission reduction depends on the future development of GDP. That is why Kuramochi *et al.* (2018) draw the following conclusion:

"We project that India will overachieve its 2020 pledge and most of the elements of its NDC under current policies. These projected emission levels depend heavily on the assumptions on future economic growth".

> The overall GHG emission target for 2020 **is projected to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Energy demand and savings

India has one of the G20's highest growth rates in energy use per capita (+15%, 2012-2017), writes Climate Transparency in its Brown to Green report (2018). Still, compared to the other G20 countries India has the lowest absolute energy use per capita. The rapidly increasing energy demand also received the attention of the Indian Government, which in 2001 established the "Bureau of Energy Efficiency". So far, the government's approach with regard to energy efficiency has been fruitful – the energy efficiency of the economy has decreased with 13%. This is even faster than the average G20-country in the same period (-11%). This trend is projected to continue under continuation of current policies, if we consider the indicator graphs.

India has implemented quite some policies aimed at reducing energy-use. Combined, the several fuel standards may be the most effective policies in the country. The main and most eminent policy, however, is the *market-based Perform, Achieve and Trade (PAT) scheme* (Government of India, 2008). This scheme limits the consumption of energy-intensive industries, including thermal power plants, iron and steel, and cement. Companies that achieve even more reductions than required, can sell their energy saving certificates to those that have fallen short. The Indian Government writes that its first cycle led to savings of 31 $MtCO_2e$ (1% of the total annual emissions) between 2012 and 2015. The scheme has been extended several times and the government even extended its scope (COMMIT, 2018).

Implemented contributing policies

- Fuel economy standards
- Energy efficiency in industry (PAT scheme) (2011)

A new and promising policy plan is the *India Cooling Action Plan* (Government of India, 2019), which aims to cut cooling demand by 20% to 25% by 2037 – curbing a large part of electricity demand throughout the nation. This and other policies, being *implemented* after June 2018, were not yet quantified in the current policy-based projections of the indicators shown in this report.

Renewable input and fossil phase-out

India is the world's second largest coal consumer after China, having overtaken the US earlier this decade (IEA, 2018b). Climate Transparency (2018) refers to the analysts who expect the rapid growth in India to lead the increase in global coal demand over the next few years. Easily-available and cheap coal would have been the main cause of the fast-increasing electrification rate of India. Climate Transparency shows that in 2017 76% of India's electricity was generated by coal.

These facts explain why the largest driver for overall GHG emissions in India are CO_2 emissions from the energy sector. This sector's emissions are about to reach the G20 average this year. Climate Transparency (2018) argues that the increase of fossil fuels over the previous years has been offset (only partially) by a shift away from traditional biomass use, which is a rather positive development from an environment- and public health perspective. One of the policy measures that are meant to counter this increase in coal use, is the *Clean Energy Cess* from 2010 (*via* Government of India, 2015). It consists of a tax, levied on use of coal, lignite and peat. Despite this and other policies, the current policy projections show a continuation of India's emission intensity for the coming decades.

India's transition story is noteworthy for its rapid expansion of renewables in recent years. In 2017, renewable investment and new capacity topped fossil fuels for the first time. However, meeting various voluntary targets on renewables (see graphs) is seemingly not sufficient to stabilize India's energy-driven overall emission intensity growth. COMMIT (2018) provides an adequate summary on India's current fossil status quo: *"The biggest challenge that India faces right now is to efficiently manage the existing fossil fleet and carbon-intensive infrastructure; the large-scale shift to renewables is likely to generate stranded assets (of coal-based power plants), thereby increasing the social cost of renewable electricity. The transition needs to be carefully planned to maximize the use of current assets and minimize further lock-ins"* (COMMIT, 2018).

Implemented contributing policies

- Clean energy cess (coal tax) (2010)
- Renewable energy targets and support schemes (12th Five Year Plan (2012 to 2017), National Solar and Wind Missions (2010))
- Government Assistance for Small Hydropower Stations (2003), National Solar and Wind Missions (2010)
- 12th Five Year Plan (2012 to 2017): supercritical power generation
- National Electricity Plan (2018)

Carbon intensity and utilization

As mentioned in the previous section, the main cause of India's increasing emission intensity is the energy sector. Other sectors are performing relatively better (lower emission intensity rates), compared to similar sectors in G20 countries. Most of the sectors also show a declining trend; the industry sector even shows a rather steeply decreasing intensity rate (Climate Transparency, 2018).

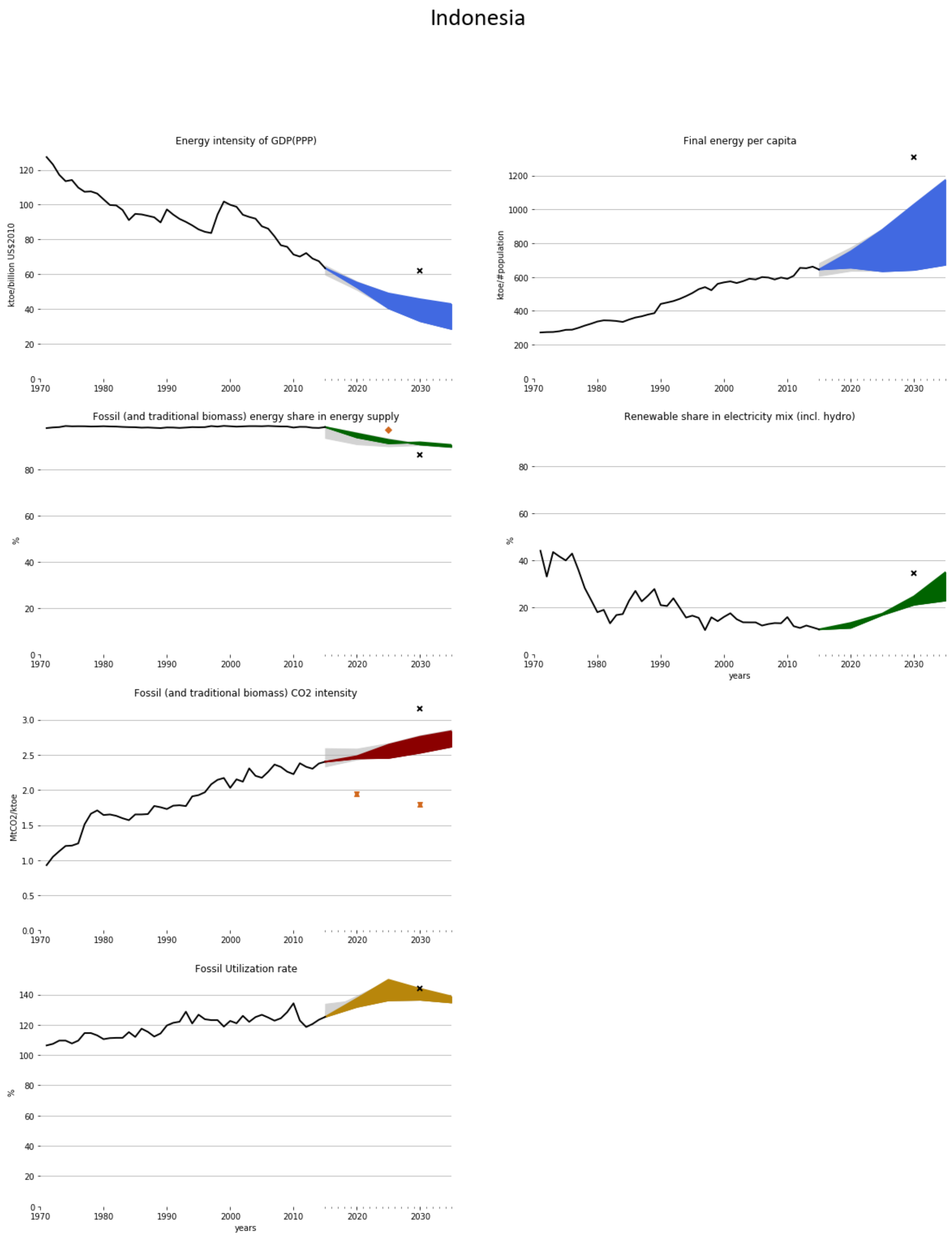
The transport sector is emitting 0.21 tCO_2 per capita in India (compared to 1.13 tCO_2 per capita G20 average). In the future this sector will face major challenges, due to rising incomes and rapid urbanization. Oil demand will increase to high levels if the government does not promote (or even obligate) electric and/or hydrogen vehicles as a realistic alternative for fossil

Implemented contributing policies

- Electric vehicle target (2018), Faster Adoption and Manufacturing of Hybrid and Electric vehicles I (FAME I) (2015)
- Support for biofuels (2007), National Policy on Biofuels

fuels. In 2011, India set up its *National Mission for Electric Mobility*, which aimed to promote electric vehicle (EV) and hybrid manufacturing (*via* Government of India, 2015). In 2017, then-power minister Piyush Goyal said petrol and diesel car sales should end by 2030. However, the government has since rowed back on this aim, now targeting a 30% share of sales for EVs by 2030. India also aims for all new urban buses to be fully electric by 2030 (COMMIT, 2018). The implicit universalized carbon intensity targets for 2020 and 2030 are projected to be met under the current policy scenarios.	(2018) (incl. blending target) **Sources of implemented contributing policies:** • Kuramochi *et al.,* 2018 • Government of India, 2015

3.8 Indonesia



Indicator targets

- **Fossil fuels and traditional biomass share in energy supply (implicit target)**:
  For 2025, the calculated implicit target is 97%.
  Based on explicit target: 23% TPES new and renewable energy (including nuclear).
  Source: National Energy Policy (Government Regulation No. 79/2014) (References in Appendix B).
  > The target for 2025 is **projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**
  For 2020, the calculated implicit target is 1.94 $MtCO_2$/Mtoe.
  For 2030, the calculated implicit target is 1.80 $MtCO_2$/Mtoe.
  Based on explicit targets:
  - Unconditional: 26% GHG reduction by 2020 from baseline scenario.
  - Unconditional: 29% GHG reduction by 2030 from baseline scenario.

  Source: NDC and 2020 emission reduction pledge.
  > The targets for both 2020 and 2030 are **projected *not* to be met** under the current policy scenarios.

Overall GHG emissions target

"Indonesia would likely fall short of meeting its unconditional NDC target under current policies, with overall emission levels ranging from 2,690 to 3,080 $MtCO_2e$/year by 2030 (including LULUCF, including historical peat fires)" (Kuramochi *et al.*, 2018).

> The overall GHG emission target for 2030 **is projected *not* to be met** under the current policy scenarios of PBL and NewClimate Calculations.

Energy demand and savings

Indonesia is showing a steep decrease in energy efficiency for the past decades. It was able to offset 23% of the impact of growing activity thanks to energy efficiency improvements between 2000 and 2017, argues IEA in the *World Energy Outlook* (2018a). Economic activity moved from energy-intensive industry sectors to less-intensive manufacturing and service sectors, which is common for many emerging middle-income counties that tend to catch up on developed countries. Projections of POLES and IMAGE differ from each other, with regard to energy efficiency projections. It should be recognized that both POLES and IMAGE did not identify high-impact policies aimed *specifically* at improving energy efficiency or energy savings, using the CD-LINKS database for current policies. This does not mean that Indonesia has no efficiency standards implemented at all in practice.

There is a strong surge in energy demand in Indonesia; the net effect is that the amount of energy per capita is still increasing (7% growth between 2012–2017, compared to 1% of the average G20 country) (Climate Transparency, 2018). It will continue to do so in the following years, according the indicator graphs. This trend can be best explained by the electrification of mainly rural areas. Data at the Energy and Mineral Resources Ministry in Indonesia showed that in the past eight years, the electrification ratio has risen from 67.2 percent to 98.05 percent (Tempo, 2018). On the one hand this development is leading to a significant higher standard of living of the Indonesian population, but on the other hand, from an environmental perspective, it is a pity that the additional electricity is generated mainly from such a relatively large share of fossil sources.

Implemented contributing policies:

There have not been identified high-impact policies which focus in particular on improving energy efficiency or energy savings.

Renewable input and fossil phase-out

One of the important policies in the energy sector that supports climate change mitigation and that would eventually put Indonesia on the path to decarbonisation is the *Indonesia National Energy Policy* of 2014 (*via* IEA, 2014). This regulation sets out the targets to transform the primary energy supply mix. It demands, for instance, that new and renewable energy should reach at least 23% by 2025 and 31% by 2050. It is not clear whether Indonesia will reach these targets.

The Indonesian government announced in 2017 that no new coal power plants would be built on Java, the largest island, in order to remain on track to the 2025-target. Recently, Indonesia also adopted the so called *RUPTL regulation* (Republic of Indonesia, 2019; *via* Kuramochi *et al.*, 2019). The regulation consists of various plans to help them meet the targets: plans to increase renewable capacity (e.g. rooftop PV), implement smart grids, and invest in an electric vehicles infrastructure. As this policy was only recently adopted, it was not taken into account in the current policy projections (only high-impact policies adopted before June 2018 were quantified).

What makes it especially difficult to assess whether Indonesia will reach its target, is the fact that it is unclear whether the country qualifies traditional biomass-use as a 'renewable' source. In 2014, still 38% of the Indonesian population depended on traditional biomass use, according to Climate Transparency (2018). Various established institutes, such as OECD, include this particular source in their calculations of renewable energy. However, there are in the academic literature various reasons *not* to consider this source a sustainable fuel. When considering the Indonesian renewables target it is *assumed* that Indonesia will qualify traditional biomass as renewable. This information is used in order to calculate the universalized implicit target (Fossil fuels and traditional biomass share in energy supply should be 97% in 2025). Calculated as such, it is projected that Indonesia will meet its target under current policy projections, even without taking the impact of the new RUPTL-policy into account.

Implemented contributing policies

- Renewable energy targets (2014)
- National Electricity Plan (2018)
- Electricity Supply Business Plan (2018)

Carbon intensity and utilization

Indonesia's emission intensity has been increasing over the past years to 2.4 $MtCO_2$/Ktoe in 2015. Compared to other countries worldwide this is not very high; the average worldwide intensity level is 3.0 $MtCO_2$/Ktoe in the same year.

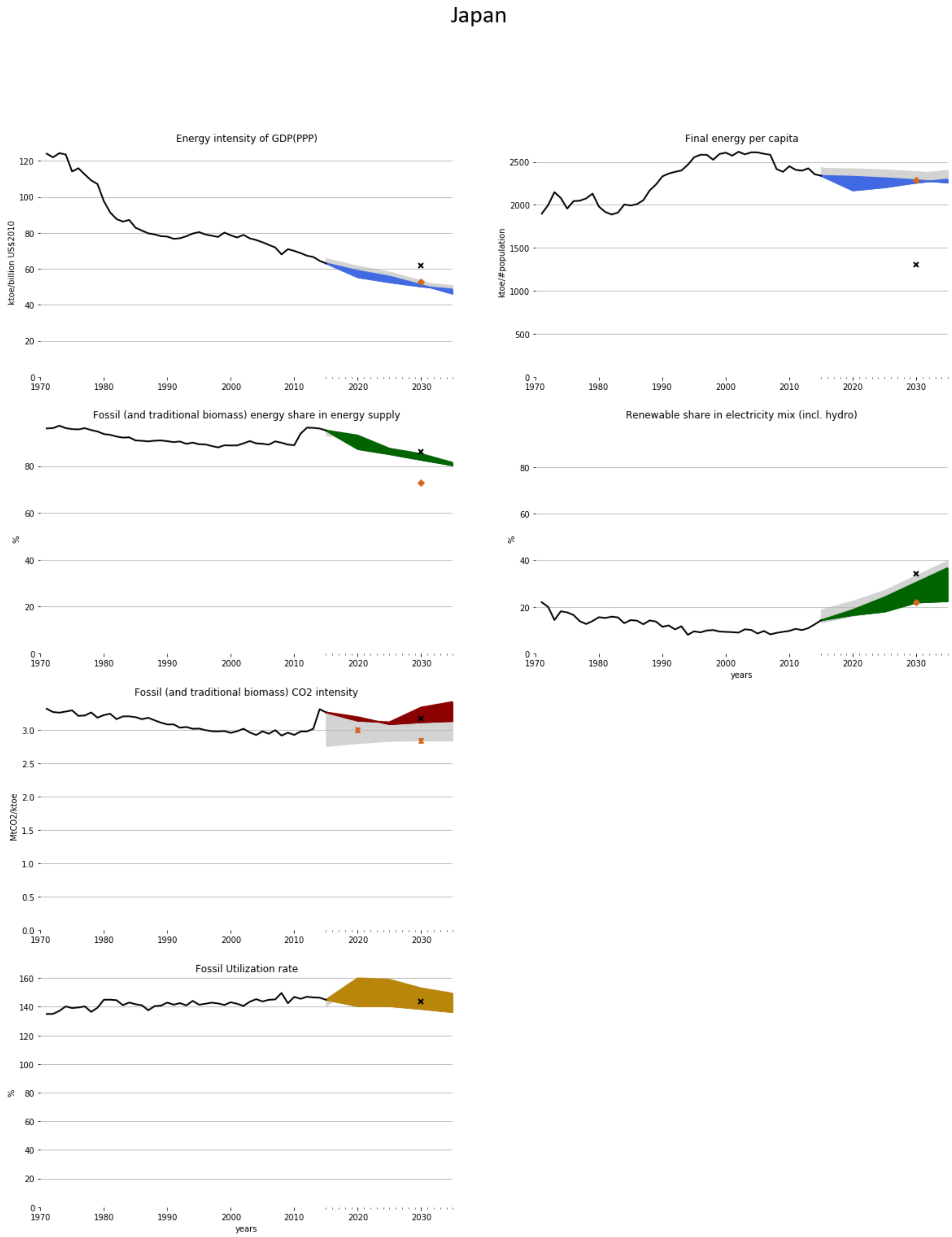
The largest contributor to overall GHG emissions are CO_2 emissions stemming from the energy sector. The overall emissions have increased by 18% (2012–2017). This growth is largely driven by increasing emissions from power generation, industries and transport (Climate Transparency, 2018). Still, *absolute* emission intensity rates in those sectors are still well below G20 averages. The carbon intensity of Indonesia's energy sector, for

Implemented contributing policies

- Biofuel targets (2013)

instance, increased by 4% (2012–2017) to 48 tCO_2/capita – but remains below the G20 average of 60 tCO_2/capita. Their 'performance' as compared to average energy-sector intensity statistics could be explained by the high share of (nearly) zero-carbon geothermal energy in the primary energy mix (Climate Transparency, 2018). The implicit emission intensity targets for both 2020 and 2030 are projected *not* to be met under the current policy scenarios. These targets are based on the explicit unconditional emission reduction targets. In order to be able to reach the unconditional emission target, some *additional* stringent emission reducing policies would be required. There is room for improvement with regard to the use of more low-carbon fuels for the combustion process of generating electricity. Also CCS may be beneficial for lowering the carbon intensity statistics.	**Sources of implemented contributing policies:** • Various references via Kuramochi *et al.*, 2018

3.9 Japan



Japan
Energy intensity of GDP(PPP)
ktoe/billion US$2010
Final energy per capita
ktoe/#population
Fossil (and traditional biomass) energy share in energy supply
%
Renewable share in electricity mix (incl. hydro)
%
years
Fossil (and traditional biomass) CO2 intensity
MtCO2/ktoe
Fossil Utilization rate
%
years

Indicator targets

- **Renewable share in electricity mix (explicit target)**
  For 2030, the explicit target is 22%.
  Source: Long-term Energy Supply and Demand Outlook (References in Appendix B)
  > The target for 2030 is **projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Energy Intensity of GDP (implicit target)**:
  For 2030, the calculated implicit target is 52.91 Ktoe/billion US$2010.
  Based on explicit target: -10% final energy by 2030, compared to 2013.
  Source: 2030 Outlook for Energy Supply and Demand Japan (2015).
  > The target for 2030 is **projected to be met** under the current policy scenarios.

- **Final energy per capita (implicit target):**
  For 2030, the calculated implicit target is 2289.11 Ktoe/million people.
  Based on explicit target: -10% final energy by 2030, compared to 2013.
  Source: 2030 Outlook for Energy Supply and Demand Japan (2015).
  > The target for 2030 is **projected to be met** under the current policy scenarios.

- **Fossil fuels and traditional biomass share in energy supply (implicit target)**
  For 2030, the calculated implicit target is 73%.
  Based on explicit target: 13-14% of primary energy supply from renewable sources by 2030.
  Source: 2030 Outlook for Energy Supply and Demand Japan (2015).
  > The target for 2030 is **projected *not* to be met** under the current policy scenarios.

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**
  For 2020, the calculated implicit target is 3.00 $MtCO_2$/Mtoe.
  For 2030, the calculated implicit target is 2.82 $MtCO_2$/Mtoe.
  Based on explicit target: 3.8% reduction by 2020 from 2005 level. 26% GHG reduction by 2030 from 2013 level.
  Source: NDC and 2020-pledge.
  > The targets for 2020 and 2030 are both **projected *not* to be met** under the current policy scenarios.

Overall GHG emissions target

"Our latest assessment indicates that Japan is projected to miss its NDC target under current policies. This is largely due to the revised projections on F-gases as well as nuclear power generation, done by PBL. For 2020, the current policies scenario projections indicate that Japan would overachieve its current pledge (3.8% below 2005 levels by 2020)." (Kuramochi *et al.*, 2018).

> The overall GHG emission target for 2020 **is projected to be met** under the current policy scenarios of PBL and NewClimate calculations.

> The overall GHG emission target for 2030 is **projected *not* to be met** under the current policy scenarios.

Energy demand and savings

Japan has a tradition of many voluntary agreements with the private sector. Voluntary measures taken by companies are monitored by the government, without binding commitments or price signals on carbon. Already in 2009, the OECD published a working paper (Jones and Yoo, 2009) in which they argued that these agreements were not highly effective. Japan should shift from voluntary measures to market-based instruments, notably a mandatory and comprehensive emission trading scheme, supplemented, if necessary, by carbon taxes in areas not covered by trading, which minimize abatement costs and promote innovation to reduce emissions.

Implemented contributing policies

- Energy Conservation Act (2007)
- Amendment of Energy Conservation Act (adopted June 2018)
- Top Runner Programme: vehicle efficiency standards (1999)
- Various voluntary agreements

In the past few years some more restrictive policies have been implemented, which are expected to have a high impact on increasing energy efficiency. Kuramochi *et al.* (2018) mentions a couple of high-impact policies aimed at energy savings: *the Energy Conservation Act* (from 2007), its 2018 amendment and later the *Revised building energy efficiency standards*, which entered into force in 2017. The latter policy prescribes that new non-residential buildings >2,000 m^2 in floor area must meet certain standards; from 2020 onward, *all* new buildings (including residential) must meet these standards (METI, 2018). Japan's energy efficiency level is below G20 average and is decreasing at the same rate as the G20 average over time (-11% from 2012 to 2017) (ClimateTransparency, 2018). It is projected that the energy efficiency trend will continue, according to IMAGE and POLES projection.

However, energy per capita is relatively high compared to the average G20 country. In the *2030 Outlook for Energy Supply and Demand* (METI, 2015), Japan targets -10% final energy by 2030, compared to 2013. For this research, this explicit target has been translated into two implicit universalized targets: an energy efficiency target in terms of GDP and an energy per capita target. Both targets are projected to be met under current policy projections. In the *Japanese long-term strategy* (Government of Japan, 2019), the government stresses the importance of technological innovation in order to increase the energy efficiency on the one hand and on the other hand maintain the high standards of living of the Japanese citizens.

Renewable input and fossil phase-out

Much of the Japanese dependency on fossils has been discussed in the previous section. In 2017, 93% of the energy supply consisted of fossil fuels, higher than the G20-average of 82%. Japan has set itself the target to reach a share of 13 to 14% renewables in primary energy supply by 2030. Based on this explicit target, we have calculated our universalized implicit target: a maximum of 73% final energy from renewable sources by 2030. This target is projected *not* to be met under the current policy scenarios.

However, if we look for power mix statistics and allow for inclusion of large hydropower, we get a different picture. In the 2030 Outlook for Energy Supply and Demand, Japan outlines its plans for 9% of power generation to come from hydropower sources, 4% from biomass and 9% from other renewables (METI, 2015). Altogether this would be sufficient to meet the target of 22-24% of renewables in the power mix. Also the current policy scenarios show that this target is projected to be attained.

The renewables increase is positively impacted by the *(Feed-in-Tariff) FIT law* (METI, 2012). Therefore, since 2012, renewables have been supported by a 'guaranteed price', which covers solar, wind, hydropower, geothermal and biomass. The law is updated in 2017 (Kuramochi *et al.*, 2018).

Implemented contributing policies

- 2018 Basic Energy Plan
- Renewable Energy Act (feed-in tariff; FIT) (2012)

Carbon intensity and utilization

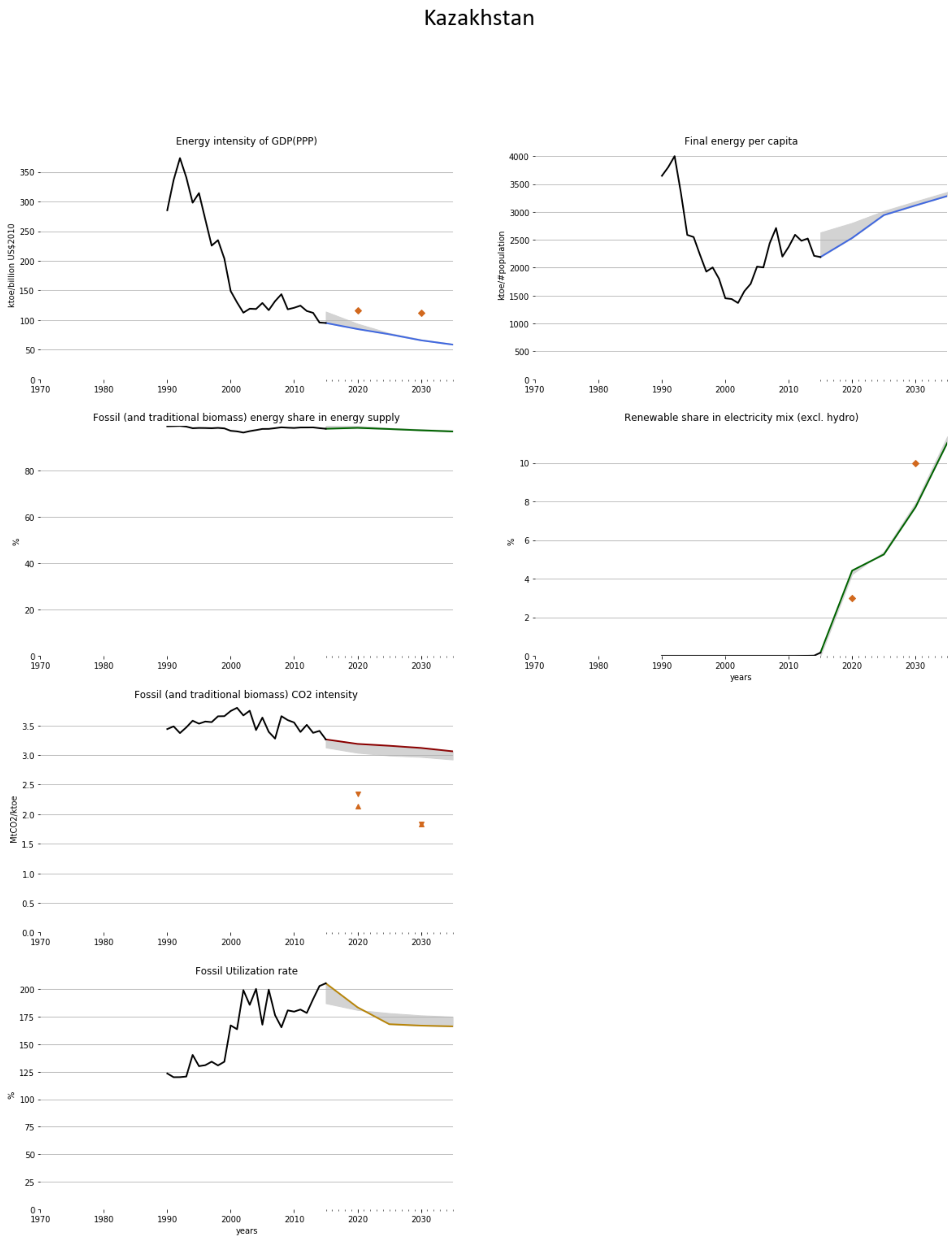
The CO_2 emissions from the energy sector are the largest driver of the overall GHG emissions of Japan. Climate Transparency (2018) reports that these particular emissions showed a slight downward trend in Japan, but started to increase again in 2017. Under current policy projections, it is expected that the Japanese emission intensity will stabilize in the coming years. Due to lack of progress, the fossil emission intensity targets for 2020

Implemented contributing policies

- Global warming countermeasures tax (2012)

and 2030 are both projected not to be met under the current policy scenarios. For every sector, the Japanese emissions are currently higher than the G20 average; only the industry and agriculture sectors are less carbon-intensive than in peer G20 countries. The main GHG emissions reduction effort in the Japanese industry is Keidanren's *Commitment to a Low-Carbon Society* (Keidanren, 2015), a voluntary action plan that has monitoring obligations under the *Plan for Global Warming Countermeasures*. The ambitions for reducing emission intensity rates are highest in the transport and buildings sectors: Japan aims for a 50% to 70% share of electric vehicles in total domestic vehicles sales by 2030. With regard to the buildings sector, Japan aims to have net-zero emissions in new public buildings by 2020, and in all new buildings by 2030 (Kuramochi *et al.*, 2018). Still, the aggregate of those ambitions is not sufficient for significantly cutting the Japanese fossil emission intensity ratio.	**Sources of implemented contributing policies:** ▪ References in Kuramochi *et al.,* 2018

3.10 Kazakhstan



Indicator targets

- **Renewable share in electricity mix (explicit share)**
  - At least 3% wind and solar power generation in power mix by 2020.
  - At least 10% wind and solar power generation in power mix by 2030.

  Source: Decree of the President of the Republic of Kazakhstan on the Concept on the transition of the Republic of Kazakhstan to the "green economy" No. 577 dated May 30, 2013. (References in Appendix B)

  > The target for 2020 is **projected to be met** under the current policy scenario of IMAGE.

  > The target for 2030 is **projected *not* to be met** under the current policy scenario.

- **Energy Intensity of GDP (implicit target)**:
  - For 2020, the calculated implicit target is 116.11 Ktoe/billion US$2010.
  - For 2030, the calculated implicit target is 112.00 Ktoe/billion US$2010.

  Based on explicit targets:
  - decrease energy intensity of GDP by 25 per cent by 2020 compared to 2008 baseline.
  - decrease energy intensity of GDP by 30 per cent by 2030 compared to 2008 baseline.

  Source: Transition of the republic of Kazakhstan to Green Economy

  > The targets for 2020 and 2030 are **projected to be met** under the current policy scenario.

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**
  - For 2020, the calculated implicit target is between 2.14 and 2.34 $MtCO_2$/Mtoe.
  - For 2030, the calculated implicit target is 1.84 $MtCO_2$/Mtoe.

  Based on explicit targets:
  - 15% reduction from 1990 levels in 2020.
  - 15% reduction in GHG emissions by 2030 compared to the 1990 base year.

  Source: NDC and 2020-pledge.

  > The targets for 2020 and 2030 are **projected *not* to be met** under the current policy scenario.

Overall GHG emissions target

“Under current policies, Kazakhstan’s GHG emissions are projected to be 395 to 430 $MtCO_2e$/year by 2030 (including LULUCF), which is similar to last year’s projections (despite the updates to include forestry policies and use more recent historical data and GWP values). Kazakhstan would, therefore, fail to achieve its unconditional NDC target by 2030 (280 $MtCO_2e$/year including LULUCF). The ETS was relaunched in 2018 but due to uncertainties regarding its implementation, it was not included in the current policies scenario projections.” (Kuramochi *et al.*, 2018).

> The overall GHG emission target for 2030 is **projected *not* to be met** under the current policy scenarios of PBL and NewClimate Calculations

Energy demand and savings

Kazakhstan has been a rather high amount of energy, for its moderate GDP levels as a middle-income country. In 2015, it had a similar efficiency (95 Ktoe/billion US$2010) to developed countries such as South-Korea (99 Ktoe/billion US$2010) and the United States (90 Ktoe/billion US$2010). Kazakhstan is projected to show a decrease in its energy efficiency ratio over the coming years (-12% between 2015 and 2030) under current policy scenarios. The targets of decreasing energy intensity of GDP by 25% by 2020 and 30% by 2030 (compared to 2008) are expected to be met. It is projected that Kazakhstan will perform slightly worse compared to the world average in 2030 with regard to energy efficiency.

Kazakhstan’s final energy per capita is projected to increase rapidly under current policy projections, which is common for many middle-income countries.

Implemented contributing policies

- Program on modernization of housing and communal services (2012)
- Concept for Kazakhstan’s Transition to Green Economy: Energy efficiency targets (2015)

Renewable input and fossil phase-out

Kazakhstan's economy is heavily dependent on the fossil industry, as is argued earlier in this profile. The fossil share in the total primary energy mix is projected to remain between 100% and 97% until 2035, according to current policy projections. In order to comply with the ambition put forward in the strategy documents, Kazakhstan first of all would need to present itself as an attractive renewable investment environment for private investors. Climate Action Tracker (2019) writes about this: "*Kazakhstan already reformed its energy tariffs, which have been regarded as one of the key reasons for underinvestment. In 2019, a power capacities market will function along the electric energy market, and the feed-in tariff be divided into two parts: an electric energy tariff (variable) and capacity tariff (fixed)*". And also: *"The Government has also launched the Solar Resources Atlas, a website mapping Kazakhstan's solar energy potential for the public to view in order to help with investment decisions"*.

Kazakhstan's government has set itself the following two targets: at least 3% wind and solar power generation in the power mix by 2020 and 10% by 2030. Under current policies, the first target is projected to be met, while the second is not projected to be met. Additional policy would be required in order to attain this particular target, as under continuation of current implemented policies the capacity of renewables is about to stabilize in the coming years.

Implemented contributing policies

- Support scheme for renewable energy (2014)
- Action Plan for the development of alternative and renewable energy in Kazakhstan for 2013-2020 (2013)

Carbon intensity and utilization

The CO_2 emissions from the energy sector are the largest driver of the overall GHG emissions of Kazakhstan. According to Climate Action Tracker (2019), energy-related activities account for 85% of the country's annual GHG emissions in 2016.

Under current policies projections, Kazakhstan's emission intensity is projected to only decrease to some extent. The implicit emission intensity targets are out of reach for both 2020 and 2030. If Kazakhstan is about to pursue their NDC emission reduction target, while at the same time it is projected that their energy demand will increase sharply, it is essential that they reduce the emission intensity at a faster rate.

With regard to Kazakhstan's fossil utilization rate, it is expected to show a steep decline in the coming years. This may reflect an improved thermal conversion efficiency or lack of losses throughout the process. This is a positive development from a sustainable perspective, although it is unclear what the driving factor for this process is.

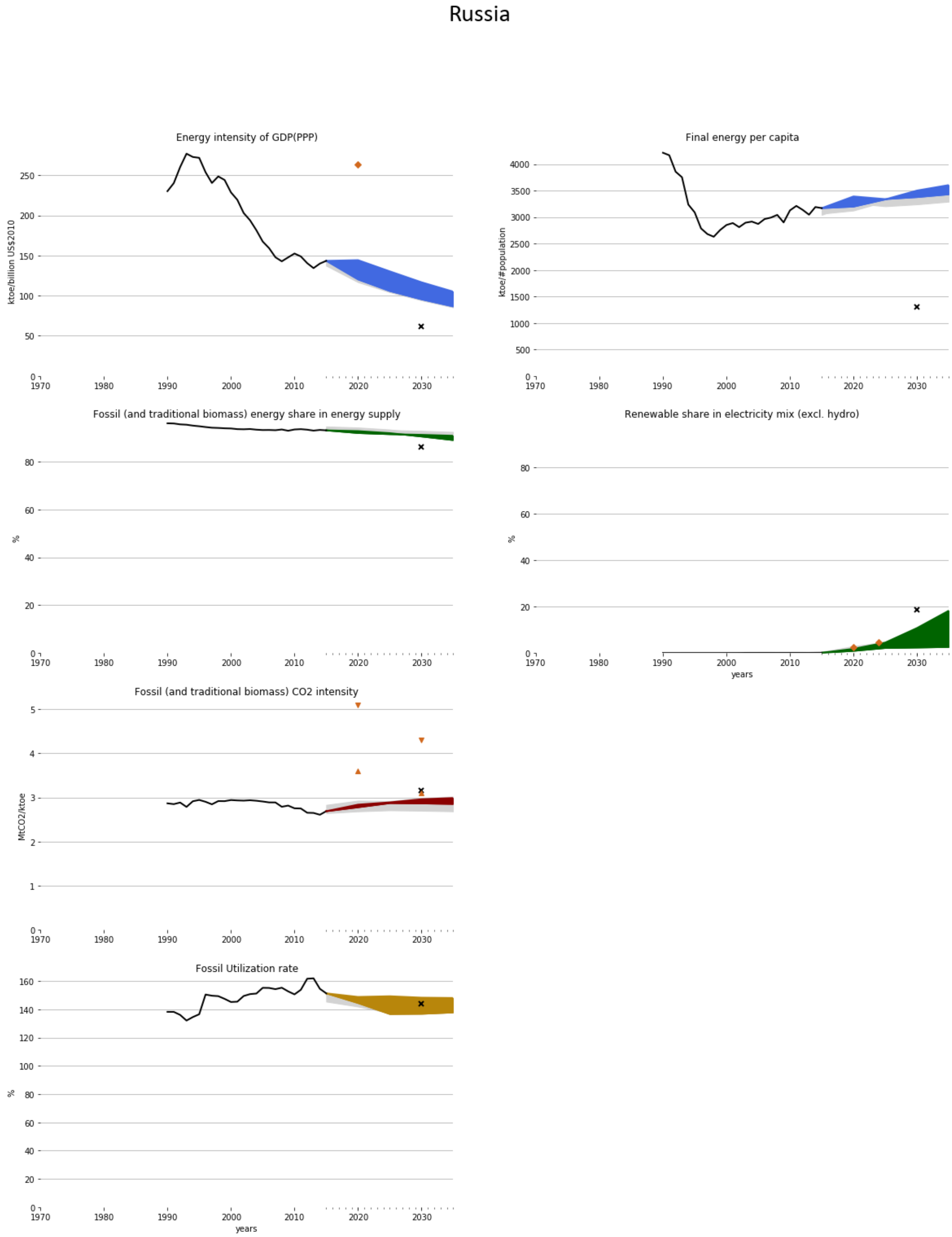
Implemented contributing policies

- National Allocation Plan for GHG emissions under KAZ ETS for 2018 to 2020 (December 2017)

Sources of implemented contributing policies:

- References in Kuramochi *et al.*, 2018

3.11 Russia


Russia
Energy intensity of GDP(PPP)
ktoe/billion US$2010
Final energy per capita
ktoe/#population
Fossil (and traditional biomass) energy share in energy supply
%
Renewable share in electricity mix (excl. hydro)
%
years
Fossil (and traditional biomass) CO2 intensity
MtCO2/ktoe
Fossil Utilization rate
%
years

Indicator targets

- **Renewable share in electricity mix (explicit targets):**
  - 2.5% renewable electricity share target by 2020.
  - 4.5% renewable electricity share target by 2024.

  Source: Russia's Energy Strategy to 2030, approved by Government Decree No. 1715-r of 13 November 2009 *and* Governmental resolution No. 512-r of 3 April 2013, Approving the State Programme for Energy Efficiency and the Development of the Energy Sector (References in Appendix B).

  > The targets are **projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Final energy intensity of GDP (implicit target)**: 264 Ktoe/billion US$2010 by 2020.
  Based on explicit targets: Decrease of 13.5% of primary energy intensity by 2020, relative to 2007.
  Source: Amendment to State Program on Energy efficiency and Energy Development (approved by Government Decree No 321), 2014

  > The target is **projected to be met** under the current policy scenarios of IMAGE and POLES.

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**:
  - For 2020, the calculated implicit target is in the range (3.60-5.10) $MtCO_2$/Mtoe.
  - For 2030, the calculated implicit target is in the range (3.14-4.33) $MtCO_2$/Mtoe.

  Based on explicit targets:
  - Reduction target for greenhouse gas emissions for 2020 between 15% and 25% below 1990 levels.
  - Limiting anthropogenic greenhouse gas emissions to between 70% and 75% of 1990 levels by 2030.

  Source: NDC.

  > The targets **are projected to be met** under the current policy scenarios.

Overall GHG emissions target

"Russian Federation is … likely to reach its 2020 pledge, and reach the lower end of its 2030 INDC range (2,615 to 3,605 $MtCO_2e$/year)." (Kuramochi *et al.*, 2018).

> The overall GHG emission targets **are projected to be met** under the current policy scenarios of PBL and NewClimate Institute.

Energy demand and savings

Russia is a major supplier of energy, as it is one of the main global exporters of gas and oil. The country is also a large consumer of energy as compared to other G20 countries: 215.4 GJ per capita total primary energy supply, compared to the G20 average of 97.2 GJ per capita. Energy use per capita in Russia dropped slightly in the 1990s, but demand has been increasing again in recent years (Climate Transparency, 2018) and this trend is projected to continue in the coming years, under current policies (see indicator graphs at the start of the country profile).

The historical and projected energy intensity of Russia is also relatively high. The graph on the left shows that the indicator is projected to be somewhere between 110 and 130 Ktoe/billion US$2010, under the current policy scenario. The global average is approximately 70 Ktoe/billion US$2010.

In order to improve its energy conservation and efficiency, Russia has adopted several laws and rules, including the 2003 federal Thermal Performance of Buildings code (Nachmany et al., 2014). This code prescribes thermal insulation for new and existing buildings. In 2018, the government adopted a target to decrease heat consumption by houses consisting of

Implemented contributing policies

- Energy intensity targets (2008)
- Strategy for development of building materials sector for the period up to 2020 and 2030, adopted by Government Decree no. 868 (2016)

multiple compartments by 15% from 2016 to 2030 (ClimateTransparency, 2018). Another policy is the 2009 Energy Efficiency legislation "On Saving Energy and Increasing Energy Efficiency".

Renewable input and fossil phase-out

According to Climate Action Tracker (2019), Russia's energy sector accounted for 87.3% of all emissions excluding LULUCF in 2016. This could be explained by the fact that over 90% of the total primary energy mix consists of fossil fuels and traditional biomass (see graph on the left). According to the current policy projections, this share will be slightly lower in 2030, but still, the fossil fuel share is projected to be somewhat higher than the world average ('X'-mark in the graph).

Most of the non-fossil energy in 2017 came from nuclear (approximately 70%) or hydropower (approximately 25%). Recently, an increase in renewable energy investments in Russia has been observed (IEA, 2018a). This may trigger an increase in the share of renewable energy, as Russia does not have many high-impact policies aimed at increasing renewables. An exception is a plan containing measures to further stimulate the development of generation facilities based on renewable energy sources with installed capacity up to 15 kW (Ministry of Environment and Natural Resources Russia, 2017).

The targets for renewable energy share in electricity generation are projected to be met under current policies. There are no targets for after 2024 as of August 2019.

Implemented contributing policies

- Renewable energy targets (2013)

Carbon intensity and utilization

The Russian fossil fuels (and traditional biomass) CO_2 intensity is projected to *increase* until at least 2030, under current policy scenarios. This is in contrast with the projected decrease in many other G20 countries. However, the indicator is projected to remain slightly below the world-average (Climate Transparency, 2018).

For most sectors, the Russian carbon intensity is slightly higher than the G20 average, except for its largest emitting sector: the energy sector. The transport, industry and agriculture sectors show above-average intensities, according to data of Climate Transparency for recent years (2018). However, the data in the Brown-to-green report shows that – different from many other G20 countries – rail, bus and pipeline are very common transport modalities, which are cleaner than the use of conventional cars. Furthermore, the Russian government has implemented a transport strategy, which aims for 20% to 25% emissions reduction from road, 50% to 53% from rail, 20% to 34% from air, and 20% to 24% from water transport, between 2011 and 2030 (Kuramochi *et al.*, 2018).

Although the absolute emissions of Russia's energy sector are relatively large, the relative carbon intensity (expressed in terms of tonnes of CO_2 per unit of total primary energy supply) is lower than the G20 average (54 vs. 60 tCO_2/TJ) and the difference between Russia and the G20 average has been increasing recently (Climate Transparency, 2018). This can be explained by

Implemented contributing policies

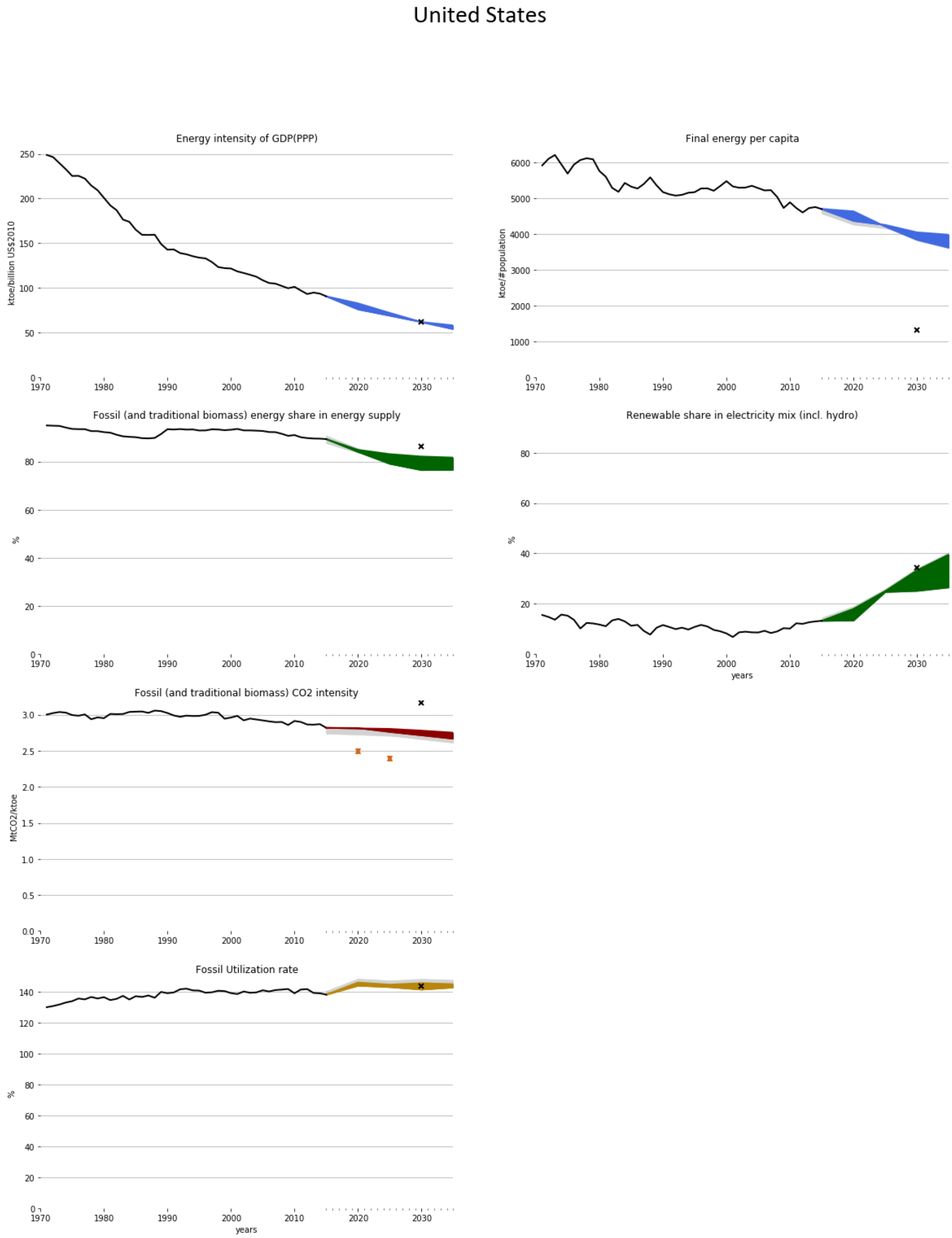
- Decrease flaring in oil (2009)

Sources of implemented contributing policies:

- Kuramochi *et al.*, 2018
- Government of Russian Federation, 2016
- Government of Russian Federation, 2017
- Nachmany *et al.*, 2014

the fact that a lot of gas is used in Russia, as compared to the more carbon-intensive coal. The fossil utilization rate has declined a bit after 2010 and stabilized in 2015. Under current policies, this ratio is projected to remain constant over the coming years.	

3.12 United States



Indicator targets

- **Fossil fuels and traditional biomass CO_2 intensity (implicit target)**:
  - 2.50 $MtCO_2$/Mtoe by 2020
  - 2.34 $MtCO_2$/Mtoe by 2025

Based on explicit targets: 26-28% GHG reduction by 2025 from 2005 levels.
Source: NDC (References in Appendix B).
> The targets **are projected *not* to be met** under the current policy scenarios.
> Please note that the USA government announced that the United States intends to "exercise its right to withdraw" from the Paris Agreement and cease implementation of the NDC.

Overall GHG emissions target

"*PBL and NewClimate calculations indicate that the United States is not on track to meet its 2020 and 2025 NDC targets with existing policies. 2020 emission levels are projected to be 6 to 9% below 2010 levels, and 2025 emissions levels are projected to be 7 to 19% below 2010 levels*" (Kuramochi *et al.*, 2018).
> The overall GHG emission targets **are projected *not* to be met** under the current policy scenarios of PBL and NewClimate Institute.

Energy demand and savings

With regard to the energy intensity target, the USA is close to the G20 average. However, the indicator is decreasing more slowly (-8%, 2012–2017) than the G20 average (-11%). Although some of the efficiency policies have been rolled back by President Trump, many policies remain in place: for instance, the *Efficiency standards light-duty vehicles (CAFE)* (EPA, 2018b) and the *Better buildings Challenge for commercial buildings* (US Department for Energy, 2019b). The latter aims to help American commercial and industrial buildings to become at least 20% more energy efficient by 2020.
Energy use per capita in the USA (11.700 kWh per capita in 2017) is higher than the G20 average (3.900 kWh per capita) (Climate Transparency, 2018). For both energy intensity and energy use per capita, the current policies projections show a continuation of their decrease. However, some (proposed) policy 'reversals' of the Trump administration were not yet taken into account. Those are, for instance, the repeal of light bulb efficiency regulation (as of February 2019) and 'freezing' the CAFE standards at 2020 levels (*via* Kuramochi *et al.*, 2019).

Implemented contributing policies

- Efficiency standards light-duty vehicles (CAFE)
- Efficiency standards heavy duty vehicles
- Better buildings Challenge (commercial buildings)
- Energy Star Tax credits for buildings
- Building Energy Codes Program

Renewable input and fossil phase-out

Climate Transparency (2018) reports that in 2017, 8% of the total primary energy supply came from renewable sources, half of which came from (non-traditional) biomass sources.
One of the policies encouraging biofuels is the *renewable fuel standard* from 2015 (EPA, 2018a), which – after changes by the Trump administration – aims to blend 36 billion gallons of renewable fuels into transportation fuels by 2022 (compared to 9 billion gallons in 2008). Therefore, there is a need for ethanol and other biofuels, reports National Interest (2019). Since Trump has proposed some large reforms to the EPA, the agency has been issuing waivers to small oil refineries relieving them of this ethanol requirement, agitating farmers. However, a "Giant package" of new policies would be coming up to support farmers (National Interest, 2019).

Implemented contributing policies

- Blueprint for a Secure Energy Future
- Renewable fuel standard (2015)

The share of fossil fuels (and traditional biomass) in energy supply is projected to stabilize at a slightly lower level (80%) by 2030, under current policies (compared to a global average of approximately 90%). On the Renewable share in electricity mix indicator, the USA is projected to be close to the global average.
However, these projections may be *too* optimistic, as the current policy scenarios only included policies through June 2018 (see Kuramochi *et al.*, 2019).

Carbon intensity and utilization

GHG emissions increased by 12% between 1990 and 2008, and then decreased to 3% above the 1990 level by 2015 (Climate Transparency, 2018). This could be explained mainly by the worldwide economic crisis, starting mid-2008 in the United States. Economic production shrunk and a smaller amount of energy was required. The crisis, therefore, had detrimental effects on the US energy sector; the sector that contributes most to the overall emissions.
Although the economic crisis is over, climate policy has become less stringent under the current Administration. The USA further strengthened its energy sector position. In 2018, the USA overtook Russia and Saudi Arabia to become the world's largest producer of crude oil. It is also the world's largest producer of natural gas, and it increased LNG exports by 53% in 2018 (Climate Action Tracker, 2019). These developments may explain why per capita GHG emissions in the USA were 20 tCO_2e/capita in 2017, well above the G20 average (8 tCO_2e/capita) (Climate Transparency, 2018). Fossil CO_2 intensity is projected to remain constant or decrease slightly, under current policies. In none of the scenarios, the *implicit* universalized intensity targets are projected be met.
Carbon intensities are also relatively high in other sectors. Especially the transport sector has a relatively high intensity (5.39 tCO_2/capita in the USA, compared to 1.13 tCO_2/capita G20 average) (Climate Transparency, 2018). The motorization rate in USA is exceptionally high – there were 891 vehicles per 1000 inhabitants in 2016 and only 1.2% of the sales consisted of electric vehicles. In August 2018, the US announced that it would revoke the country's clean car standards. From 2020, cars and trucks will no longer be required to become more fuel-efficient every year (Kuramochi *et al.*, 2019).
The actual development of economy-wide and sectoral emission intensity will heavily depend on short-term economic developments in the USA. As of august 2019, the USA is, for instance, in a trade war with China and markets respond heavily to developments in this field. In the long-term, the emission intensity projections will depend on future US administrations. The recent presentation of the Green deal resolution in the House of Representatives has sparked a discussion about the need for a much stronger approach to climate action in the USA. This lively discussion is likely to continue over the coming years.

Implemented contributing policies

- Clean Power Plan (CPP) (2014)
- Reduction in CH_4 emissions from oil and gas production

Sources of implemented contributing policies:

- References in Kuramochi *et al.,* 2018

4 Overview

Table 2 below summarizes the main results of the indicators and targets, as explained in the factsheets. We find that countries' level of progress regarding their targets on the driving factors of emissions (the six indicators) is quite diverse. Four out of the twelve analysed countries (China, India, Japan and the Russian Federation) are on track to meet their 2030 pledges with implemented policies and are projected to meet most of the indicator targets, which means that most of the analysed countries are *not* on track. More specifically:

- For energy intensity (final energy consumption per GDP), four out of six countries or regions for which we were able to find or derive national targets are on track to meet their targets for 2020 or 2030 with current policies *(China, Japan, Kazakhstan and Russia)*. One country is not on track to meet its target for 2030 (*Australia*), and one region is on track to meet its target for 2020, but progress towards the 2030 target is uncertain (*EU*).
- For the final energy consumption per capita, two out of three countries or regions are on track to meet their national targets for 2020 or 2030 (*China and Japan*), and one is not on track (*EU*).
- For the share of fossil fuels and traditional biomass in final energy consumption, one out of four countries is on track (*Indonesia*).
- For the share of renewables in total electricity generation, seven out of eight countries are on track to meet their targets for 2020, 2025 or 2030 (*Argentina*, *Australia, Brazil, China, India, Japan, and Russia*), and one country is on track for 2020, but not for 2030 (*Kazakhstan*).
- For the CO_2 intensity of fossil fuels (fossil fuel and traditional biomass CO_2 emissions per final energy consumption), two out of twelve countries are on track to meet both their 2020 and 2030 targets (*India and Russia*), two are on track to meet only their 2020 targets (*Brazil and EU*), seven are not on track, and for one country, progress is uncertain (*China*).

Table 2: Conclusions per country and per indicator: is the domestic target projected to be met? + indicates the target is projected to be met, - indicates it is projected not to be met, ? indicates progress is uncertain. Years between square brackets indicate the target year.

	1. Energy intensity *Kaya-indicator*	**2. Energy use per capita** *additional indicator*	**3. Fossil share (including traditional biomass)** *Kaya-indicator*
Argentina	N/A	N/A	N/A
Australia	['2030'] -	N/A	N/A
Brazil	N/A	N/A	['2030'] -
Canada	N/A	N/A	N/A
China	['2020'] +	['2020'] +	N/A
European Union	['2020'] +, ['2030'] ?	['2020'] -, ['2030'] -	['2020'] -, ['2030'] -
India	N/A	N/A	N/A
Indonesia	N/A	N/A	['2025'] +
Japan	['2030'] +	['2030'] +	['2030'] -
Kazakhstan	['2020'] +, ['2030'] +	N/A	N/A
Russia	['2020'] +	N/A	N/A
United States	N/A	N/A	N/A

'+' Target is projected to be met
'-' Target is projected not to be met
'?' Uncertain whether target is met

N/A = Not Applicable

	4. Renewable share *additional indicator*	**5. Fossil fuels CO_2 intensity (including Traditional biomass)** *Kaya-indicator*	**6. Utilization ratio** *Kaya-indicator*
Argentina	['2021'] - , ['2023'] -, ['2025'] +	['2030'] -	N/A
Australia	['2020'] +	['2020'] -, ['2030'] -	N/A
Brazil	['2030'] +	['2020'] + , ['2025'] -, ['2030'] -	N/A
Canada	N/A	['2020'] -, ['2030'] -	N/A
China	['2020'] +	['2020'] ?, ['2030'] ?	N/A
European Union	N/A	['2020'] +, ['2030'] -	N/A
India	['2022'] +, ['2027'] +	['2020'] +, ['2030'] +	N/A
Indonesia	N/A	['2020'] -, ['2030'] -	N/A
Japan	['2030'] +	['2020'] -, ['2030'] -	N/A
Kazakhstan	['2020'] +, ['2030'] -	['2020'] -, ['2030'] -	N/A
Russia	['2020'] +, ['2024'] +	['2020'] +, ['2030'] +	N/A
United States	N/A	['2020'] -, ['2025'] -	N/A

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Appendix A: Data

This section has two goals: the first one is to show how the indicators were calculated. The second one is to provide the reader with the data sources used.

Elements of the indicators

The following indicators were calculated:

I1	Final energy intensity of GDP	Ktoe/billion US$2010
I2	Final energy per capita	Ktoe/million people
I3	Fossil-fuel based (and traditional biomass) final energy share in total final energy supply	(%)
I4a	Renewable share in electricity mix (including hydropower)	(%)
I4b	Renewable share in electricity mix (excluding hydropower)	(%)
I5	Fossil-fuel based (and traditional biomass) primary energy CO_2 intensity	$MtCO_2$/**M**toe
I6	Fossil Utilization rate	(%)

Together, these indicators are the products of total Fossil fuels and traditional biomass CO_2 Emissions, calculated as:

$$CO2\ Fossil = I1 * I2 * I3 * I4(a\ or\ b) * I5 * I6 * GDP$$

Please note that this equation was explained in section 2[16]. Now, we will discuss each of the indicators and how they were calculated step-by-step.

- The first indicator is Final Energy intensity of GDP, which was calculated as Total Final Energy Consumption divided by Gross Domestic Product at purchasing power parity.
    - Total final energy consumption by all end-use sectors and all fuels, excluding transmission/distribution losses.
    - GDP converted to International billion US$ using purchasing power parity (PPP).
- The second indicator is Final energy per capita, which was calculated as Total Final Energy Consumption divided by the total population.
- The third indicator is Fossil-fuel based (and traditional biomass) final energy share in total final energy supply, which was calculated as Fossil fuels and traditional biomass Final Energy Consumption divided by Total Final Energy Consumption.
    - *Fossil fuels and traditional biomass Final Energy Consumption* is not 'pre-defined' in original datasets with a common definition. Therefore, this term will be further specified under 'Further specifications'.
    - The outcome of this calculation is a ratio, as both elements are expressed in terms of Ktoe.

[16] Please note that I5, Fossil fuels (and traditional biomass) CO_2-intensity, is expressed in terms of '$MtCO_2$/Mtoe'. However, to use the equation correctly, one would have to express the indicator in terms of '$MtCO_2$/ktoe'.

- The fourth indicator is Renewable share in the power mix, which was defined as the Net Electricity Production from renewable sources, divided by the total net electricity production.
    - *Net Electricity Production from renewable sources* is not 'pre-defined' in original datasets with a common definition. Therefore, this term will be further specified under 'Further specifications'.
    - The outcome of this calculation is a ratio, as both elements are expressed in terms of EJ (electricity production).
    - This indicator is expressed in terms of renewable sources either *including* hydropower, or *excluding* hydropower. The country-profile states which of the two indicators is shown.
- Indicator five is Fossil-fuel based (and traditional biomass) primary energy CO_2 intensity, which was defined as Fossil fuels and traditional biomass CO_2 emissions divided by Fossil fuels and traditional biomass Primary Energy Supply.
    - Fossil fuels and traditional biomass CO_2 emissions are defined here as CO_2 emissions including sources from fossil fuel use (combustion, flaring), industrial processes (cement, steel, chemicals and urea) and product use. For non-OECD countries (the only countries that potentially have some traditional use of biomass), emissions from traditional biomass were included in the data[17].
    - *Fossil fuels and traditional biomass Primary Energy Supply* is not 'pre-defined' in original datasets with a common definition. Therefore, this term will be further specified under 'Further specifications'.
- Indicator six is the Fossil Utilization Rate, which was defined as Fossil and traditional biomass primary energy supply divided by Fossil and traditional biomass Final Energy Consumption.

Further specifications

<u>Fossil and traditional biomass Final Energy Consumption</u>

For historical data (IEA-database) this is defined as:
= [TFC | Total] – ([TFC | 'memo: Renewables'] – [TFC | Primary Solid Biofuels]) – [TFC | Nuclear | Electricity and heat generated] – [TFC | Renewables incl. hydro |Electricity and heat generated]

For projection data (CD-LINKS current policy database) this is defined as:
= [TFC | Total] – ([non-fossil share electricity] * [TFC | Electricity]) - [TFC | biomass excl. traditional] - [TFC | Solar] – [TFC | Geothermal][18]

Where:

[non-fossil share electricity] = ([SE|elec|Biomass] + [SE|elec|hydro] + [SE|elec|Solar]+[SE|elec|Wind]+[SE|elec|Geothermal]+[SE|elec|Nuclear])/(SE|elec|total)

And

[TFC | biomass excl. traditional] = [FE|Transportation|Liquids|biomass] + ([FE|Solids|Biomass|Total] – [FE|Solids|Biomass|traditional])

[17] EDGAR data includes emissions from fuelwood and charcoal consumption from FAO, which is a traditional use of biomass. IMAGE uses EDGAR-data as input for their emission projections. Source for EDGAR methodology: https://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2015-iea-co2-emissions-from-fuel-combustion-1971-2013-part-3-total-greenhouse-gas-emissions.pdf
[18] TFC = Total Final Energy Consumption (in Ktoe), SE = Secondary Energy (in Ktoe), elec = electricity generation (in EJ)

Net Electricity Production from renewable sources (incl. hydro)

For historical data (IEA-database) this is defined as:
[Electricity Output | 'memo: Renewables']

For projection data (CD-LINKS Current policy database) this is defined as:
[SE|elec|Total] – [SE|elec|Fossil] – [SE|elec|Nuclear][19]

Net Electricity Production from renewable sources (excl. hydro)

For historical data (IEA-database) this defined as:
[Electricity Output | 'memo: Renewables'] – [Electricity output | Hydropower]

For projection data (CD-LINKS Current policy database) this is defined as:
[SE|elec|Total] – [SE|elec|Fossil] – [SE|elec|Nuclear] – [SE|elec|hydropower]

Fossil and traditional biomass primary energy supply

For historical data (IEA-database) this is defined as:
[TPES | Total] – ([TPES| 'memo: Renewables'] – [**TFC** | Primary Solid Biofuels]) – [TPES | Nuclear][20]

For projection data (CD-LINKS Current policy database) this is defined as:
[TPES | Fossil] + [TPES | Biomass | Traditional]

Sources

- Historical Energy Data: (IEA) *Extended world energy balances*
- Historical GDP/Population: OECD-countries: national account statistics / Non-OECD: World Development indicators (Via IEA: *World Energy Indicators)*
- Historical emission data: EDGARV5.0
- Projection Data: IMAGE & POLES NPi-update Reference Scenario, including current policies until mid-2018. See description: http://www.cd-links.org/wp-content/uploads/2016/06/CD-LINKS-global-exercise-protocol_secondround_for-website.pdf [No Open Access to the data]

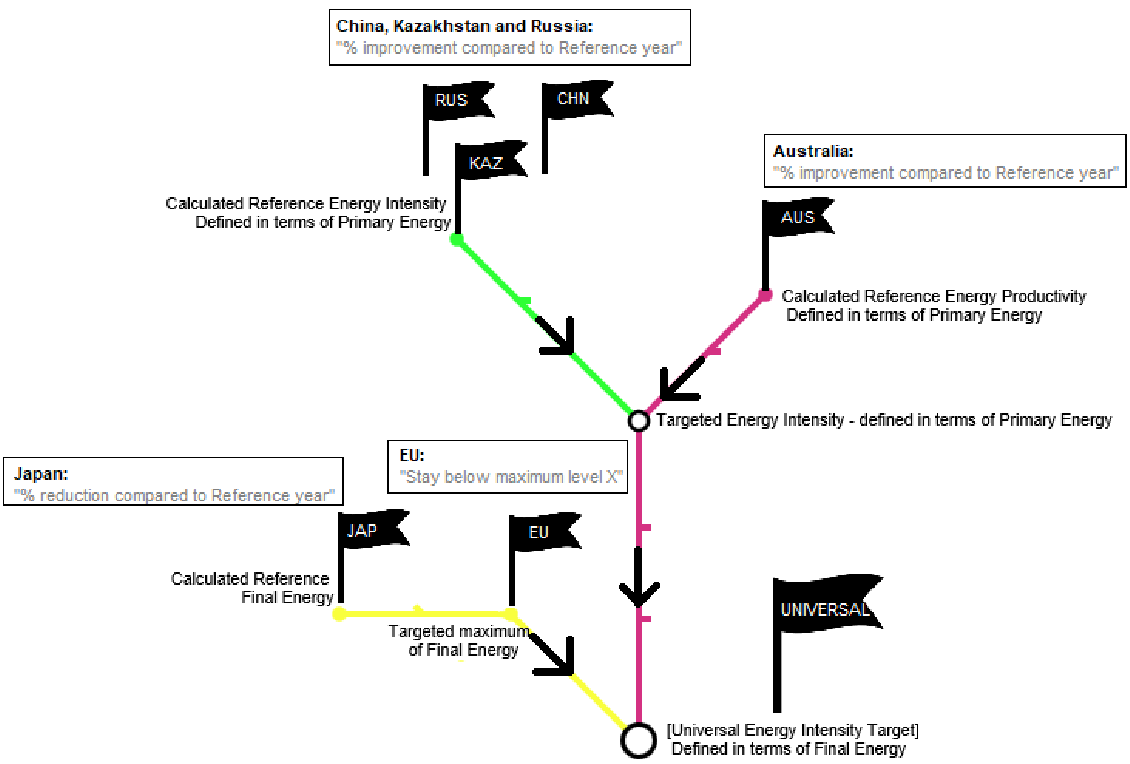
[19] SE = Secondary Energy (in Ktoe) Elec = electricity generation (in EJ)
[20] TPES = Total primary energy supply (in Ktoe)

Appendix B: Targets

Calculation of the Implicit 'universalized' target: Energy Intensity of GDP

Energy efficiency related targets are defined in different ways by the countries. The figure below shows the steps that were required to 'translate' the explicit target as set by the government of the particular country, into an implicit universalized target. The universalized target is defined as Total Final Energy divided by GDP (PPP). In order to make this transformation, some assumptions were needed. These assumptions depend on how the specific goal has been originally formulated by the government. For every country, the assumptions that were made will be mentioned.

In the figure below, we can see that there are some parallels in how the original targets was translated into terms of the implicit universalized target. For example: China, Kazakhstan and Russia have a rather similar target in terms of definition, as they aim for a gradual improvement as compared to a stated reference year. Of course, the ambitions and starting points of the countries are rather different, but there is a similar logic in the steps taken. The countries have in common that first, the targeted energy intensity in terms of *primary* energy is calculated, before the target is translated in terms of *final* energy.



Australia:

Background

Universalized target Energy Intensity of GDP Defined as: Total Final Energy divided by GDP	PPP. Expressed in: [% improvement]: Ktoe / billion US$2010

Based on explicit target: 40% improvement of energy productivity between 2015 and 2030.
Defined as: GDP divided by Total Primary Energy
Expressed in: [% improvement]: millions of Australian dollars / PJ
Stated in: The National Energy Productivity Plan (NEPP) – [implemented]
Link: https://www.energy.gov.au/government-priorities/energy-productivity-and-energy-efficiency/national-energy-productivity-plan

Calculation

Assumptions:

- We use the downscaled IMAGE current policies projection (or historical data) for primary energy in Australia in both 2015 and 2030. Furthermore, the final energy projection in 2030 is used.
- For the downscaling we assume that 80,8% of the Oceania energy is from Australia (based on: TFC 2015 AUS/TFC 2015 OCE)
- We use a utilization ratio in the calculation, calculated for 2030, based on energy projections, under current policies.
- GDP | PPP is used as proxy for GDP using Market exchange rates.

Steps:

- 2015 Australian GDP | PPP (see dataset; B1) = 1084.2 billion US$2010 [=A]
- 2015 Australian PE (IMAGE output, NPi_update, current policies) = 123114.2 ktoe [=B]
- 2015 Australian energy productivity is: 0.008807 billion US$2010 / ktoe [=A/B]
- A 40% increase in 2030 yields: 0.012329 billion US$2010 / ktoe [=A/B*1,40]
- In terms of energy intensity: 81,1 ktoe/billion US$2010 [=(A/B*1,40)^-1

> This is energy intensity in terms of Primary Energy, while the universalized target is expressed in Final Energy. Therefore, we estimate the final energy intensity, using a utilization ratio. In the following steps this will be calculated

- 2030 Oceania projection PE Total = 6,4EJ (IMAGE output, NPi_update, current policies)
- 2030 Australia projection PE Total is then (applying the downscale factor): 5,15 EJ. In terms of Ktoe this is 135077,0
- 2030 Australia Projection FE total is: 89902,6 Ktoe (IMAGE output, Dataset(C1), current policies)
- So, Utilization ratio in terms of FE tot / PE tot [Australia, 2030] = 0,6656
    - Please note that the Utilization ratio which we use in this research is the inverse of this ratio! (PE fossil and traditional/FE fossil and traditional)
- Applying this Utilization ratio on the implicit Primary energy intensity target of 81,1 ktoe/billion US$2010 yields an estimation of the implicit Final energy intensity target
    - 0,67*81,1 = **<u>53,9 ktoe/billion US$20</u>**

China:

Background

Universalized target Energy Intensity of GDP Defined as: Total Final Energy divided by GDP | PPP. Expressed in: [% decrease]: Ktoe / billion US$2010

Based on explicit target: Decrease energy intensity (TPES/GDP) by 15% by 2020, relative to 2015
Defined as: TPES / GDP
Expressed in: [% decrease]
Stated in: 13th Five Year Plan (2016-2020)
Link: http://www.lse.ac.uk/GranthamInstitute/law/13th-five-year-plan/
Assumptions:

- We use the downscaled IMAGE current policies projection (or historical data) for primary energy in China in both 2015 and 2020. Furthermore, the final energy projection in 2020 is used
- We use a utilization ratio in the calculation, calculated for 2020, based on energy projections, under current policies. Only unharmonized data is used.
- GDP | PPP is used as proxy for GDP using Market exchange rates.

Steps:

- 2015 China GDP | PPP (see dataset; B1) = 18609 billion US$2010 [=B]
- 2015 China PE (IMAGE output, NPi_update, current policies) = 3275150 ktoe [=A]
- 2015 China primary energy intensity is: 176,0 ktoe / billion US$2010 [=A/B]
- A 15% decrease in 2020 yields: 149,6 ktoe / billion US$2010 / [=A/B*0,85]

> This is energy intensity in terms of Primary Energy, while the universalized target is expressed in Final Energy. Therefore, we will make an estimation of the final energy intensity, using a utilization ratio. In the following steps this will be calculated

- 2020 China projection PE Total = 3429619 Ktoe (IMAGE output, NPi_update, current policies)
- 2020 China projection FE Total = 1981292 Ktoe (IMAGE output, Dataset(C1), current policies)
- So, Utilization ratio in terms of FE tot / PE tot [China, 2020] = 0,5777
- Applying this Utilization ratio on the implicit Primary energy intensity target of 149,5967 ktoe/billion US$2010 yields an estimation of the implicit Final energy intensity target
  - 0,58*149,6 = <u>**86,4 ktoe/billion US$2010**</u>

European Union:

Background

Universalized target Energy Intensity of GDP Defined as: Total Final Energy divided by GDP | PPP. Expressed in: [% improvement]: Ktoe / billion US$2010

Based on explicit target:

- 20% ("max. 1078 Mtoe of final energy in 2020") energy use reduction by 2020 compared to business as usual
- 32.5% ("max 956 Mtoe in 2030 of final energy consumption") final energy use reduction by 2030 compared to business as usual

Defined as: max. final energy use

Expressed in: Mtoe

Stated in:

- Climate and Energy Package European Union 2009 (2020) – [implemented]
- Climate & energy framework (2014; amended in 2018) (2030) – [implemented]

Link: https://ec.europa.eu/clima/policies/strategies/2020_en & https://ec.europa.eu/energy/en/topics/energy-efficiency

Calculation

Assumptions:

- We use the IMAGE current policies downscaled projection for GDP|PPP in EU-28 for 2020 and 2030 (unharmonized data).

Steps:

- 2020 EU GDP | PPP (see dataset; B1) = 117668,3 billion US$2010 [=B]
- 2020 EU's targeted max. FE = 1078000 ktoe [=A]
- 2020 EU primary energy efficiency is then: **61,0 Ktoe/billion US$2010** [=B/A]
- 2030 EU GDP | PPP (see dataset; B1) = 117668,3 billion US$2010 [=B]
- 2030 EU's targeted max. FE = 956000 ktoe [=A]
- 2030 EU primary energy efficiency is then: **45,9 Ktoe/billion US$2010** [=B/A]

Japan:

Background

Universalized target Energy Intensity of GDP Defined as: Total Final Energy divided by GDP | PPP. Expressed in: [% improvement]: Ktoe / billion US$2010

Based on explicit target:

- -10% final energy in 2030, compared to 2013

Defined as: max final energy
Stated in: 2030 Outlook for Energy Supply and Demand Japan 2015
Link: https://www.iea.org/policiesandmeasures/pams/japan/name-153002-en.php

Calculation

Assumptions:

- We use the IMAGE current policies downscaled projection for GDP|PPP in Japan for 2030. Furthermore, we use the historical data from IEA on total final energy in 2013.

Steps:

- 2030 Japan GDP | PPP (see dataset; C1) = 5252,7 billion US$2010 [=B]
- 2013 Japan FE (see dataset;B1) = 308815,9 Ktoe
- 2030 Japan max allowed FE is then: (0.9* 308815,9=) 277934,3 Ktoe [=A]
- 2030 Japan targeted implicit energy efficiency is then: **52,9 Ktoe/billion US$2010** =[A/B]

Kazakhstan:

Background

Universalized target Energy Intensity of GDP Defined as: Total Final Energy divided by GDP | PPP. Expressed in: [% improvement]: Ktoe / billion US$2010

Based on explicit targets:

- decrease energy intensity of GDP by 25 percent by 2020 compared to 2008 baseline;
- 30% by 2030 below 2008 levels
- 50% by 2050 below 2008 levels

Defined as: reduction of ratio primary energy / GDP with a certain %
Stated in: Transition of the republic of Kazakhstan to Green Economy
Link: https://www.oneplanetnetwork.org/resource/concept-transition-republic-kazakhstan-green-economy

Calculation

Assumptions:

- In this calculation GDP in PPP is used as a proxy of GDP using market exchange rates.
- Furthermore, we use projected utilization ratios, which are based on the projection of primary energy divided by final energy, obtained from the Kazakhstan-region (including some smaller neighbouring countries). This utilization ratio will proxy for the utilization ratio of Kazakhstan individually.
- Furthermore, historical data from 2008 is used, as this is the baseline reference in our calculation. Both GDP | PPP from IEA data (in the dataset; B1) and the Total Primary Energy Supply from IEA data are obtained for Kazakhstan individually.
- Each of the data used is unharmonized.

Steps:

- 2008 Kazakhstan GDP | PPP (see dataset; B1) = 295,96 billion US$2010 [=B]
- 2008 Kazakhstan PE (IEA historical data) = 69870 Ktoe [=A]
- 2008 Kazakhstan PE Energy efficiency is 236,08 Ktoe/billion US$2010 =[A/B]. This is the reference baseline for the calculation of the targets

> Then we apply the % of targeted reduction

- The targeted Primary Energy efficiency indicator in 2020 is: (0.75 * 236,1=) 177,1 Ktoe/billion US$2010
- The targeted Primary Energy efficiency indicator in 2030 is: (0.70 * 236,1=) 165,3 Ktoe/billion US$2010
- The targeted Primary Energy efficiency indicator in 2050 is: (0.5 * 236,1=) 118,0 Ktoe/billion US$2010

> Now we have calculated the primary energy efficiency indicators, however, our universalized implicit target is expressed terms of final energy. Therefore, we need to apply utilization ratios (Final energy/Primary energy) for 2020, 2030 and 2050

- FE Kazakhstan region 2020 (IMAGE output, NPi_update, current policies) = 5,0 EJ
- PE Kazakhstan region 2020 (IMAGE output, NPi_update, current policies) = 7,6 EJ
- Utilization rate (FE/PE) = 0,655741 => 66%
- FE Kazakhstan region 2030 (IMAGE output, NPi_update, current policies) = 6,0 EJ
- PE Kazakhstan region 2030 (IMAGE output, NPi_update, current policies) = 8,9 EJ
- Utilization rate (FE/PE) = 0,67771 => 68%
- FE Kazakhstan region 2050 (IMAGE output, NPi_update, current policies) = 6,786 EJ
- PE Kazakhstan region 2050 (IMAGE output, NPi_update, current policies) = 9,5 EJ
- Utilization rate (FE/PE) = 0,71 => 71%

> Then we apply the Utilization ratios on the primary energy efficiency indicator, which we have calculated earlier.

- The targeted implicit Final Energy efficiency indicator in 2020 is: (0.66 * 177,06=) **116,1 Ktoe/billion US$2010**
- The targeted implicit Final Energy efficiency indicator in 2030 is: (0.68 * 165,25=) **112,0 Ktoe/billion US$2010**
- The targeted implicit Final Energy efficiency indicator in 2050 is: (0.71 * 118,04 =) **84,1 Ktoe/billion US$2010**

Russia:

Background

Universalized target Energy Intensity of GDP Defined as: Total Final Energy divided by GDP | PPP. Expressed in: [% improvement]: Ktoe / billion US$2010

Based on explicit target:

- Decrease of -13.5% of primary energy intensity as compared to 2007-values in 2020.
- Defined as: reduction of ratio primary energy / GDP with a certain %
- Stated in: Amendment to State Program on Energy efficiency and Energy Development (approved by Government Decree No 321) Russian Federation 2014
    - First the target was 40% reduction in the same period, but this one is lowered to 13,5% reduction.
- Source: CD-Links database

Calculation

Assumptions:

- In this calculation GDP in PPP is used as a proxy of GDP using market exchange rates.
- Furthermore, we use projected utilization ratios, which are based on the projection of primary energy divided by final energy, obtained from the Russia-region (including some smaller neighbouring countries). This utilization ratio will proxy for the utilization ratio of Russia individually.
- Furthermore, historical data from 2007 is used, as this is the baseline reference in our calculation. Both GDP | PPP from IEA data (in the dataset; B1) and the Total Primary Energy Supply from IEA data are obtained for Russia individually.
- Each of the data used is unharmonized.

Steps:

- 2007 Russia GDP | PPP (see dataset; B1) = 1504.5 billion US$2010 [=B]
- 2007 Russia PE (IEA historical data) = 672679.9 Ktoe [=A]
- 2007 Russia PE Energy efficiency is 447.1 Ktoe/billion US$2010 =[A/B]. This is the reference baseline for the calculation of the targets

> Then we apply the % of targeted reduction

- The targeted Primary Energy efficiency indicator in 2020 is: (0.87 * 447.121=) 386.8 Ktoe/billion US$2010

> Now we have calculated the primary energy efficiency indicators. However, our universalized implicit target is expressed terms of final energy. Therefore, we need to apply utilization ratios (Final energy/Primary energy) for 2020

- FE Russian region 2020 (IMAGE output, NPi_update, current policies) = 19.2 EJ
- PE Russian region 2020 (IMAGE output, NPi_update, current policies) = 28.2 EJ
- Utilization rate (FE/PE) = 0,682 => 68%

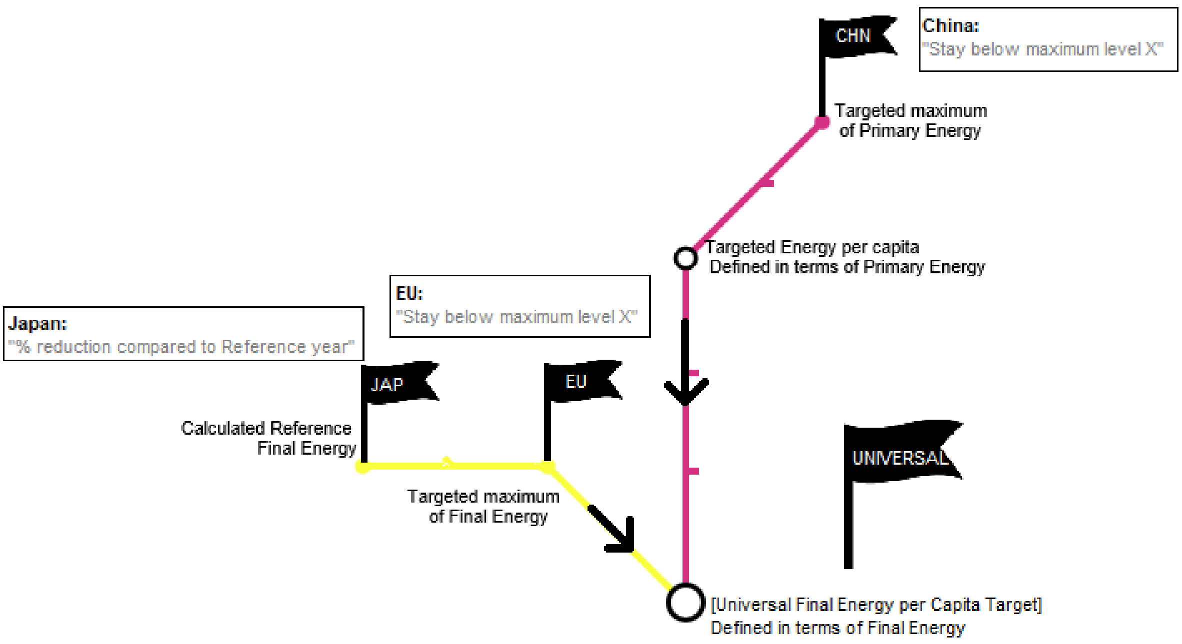
> Then we apply the Utilization ratios on the primary energy efficiency indicator, which we have calculated earlier.

- The targeted implicit Final Energy efficiency indicator in 2020 is: (0.68 * 386.8=) **<u>263.6 Ktoe/billion US$2010</u>**

Calculation of the Implicit 'universalized' target: Final Energy per capita

For previous indicator, energy efficiency, it has been explained already that countries have their own specific way of defining their energy efficiency and savings targets. The figure below shows the steps which are required to 'translate' the explicit actual target as set by the government of the particular country, into an implicit universalized target. The universalized target is defined as Total Final Energy divided by the population size of that particular country. In order to make this transformation, we need to make some assumptions. Also for these calculations some assumptions are made and mentioned.

In the figure below we can see that there are some parallels in the way of translating the original targets into terms of the implicit universalized target. For example: Japan has defined a target which aims to reduce its' final energy with a certain percentage, compared to a reference year. As we know the final energy in the reference year, we can calculate the targeted maximum of Final Energy for Japan. The EU expressed their target in a similar way as Japan, however, they have already stated the maximum level of final energy clearly in their policy documents, so we don't need to make this calculation ourselves. From that point onwards we divide the targeted final energy by the projected population for the year in which the target should be reached. Of course the ambitions and starting points of the both EU and Japan are rather different, but still we can find some similar logic in the steps taken as is shown here.



China:

Background

Universalized target Final energy per capita Defined as: Total Final Energy divided by population size Expressed in: Ktoe / million people

Based on explicit targets:

- Cap on primary energy consumption – 165 EJ in 2020.
- Government will modify family planning to keep the national population around 1.42 bn people based on one couple and a maximum of two children

Defined as: TPES & population
Expressed in: EJ & billion people
Stated in: 13th Five Year Plan (2016-2020)
Link: http://www.lse.ac.uk/GranthamInstitute/law/13th-five-year-plan/
Also see: http://www.cepii.fr/CEPII/en/publications/pb/abstract.asp?NoDoc=9474

Calculation

Assumptions:

- We use the downscaled IMAGE current policies projection for primary energy in China in both 2020. Furthermore, the final energy projection in 2020
- We use a utilization ratio in the calculation, calculated for 2020, based on energy projections, under current policies. Only unharmonized data is used.

Steps:

- First 165 EJ is translated in terms of Ktoe, which is 3940957,3 Ktoe
- 1.42 bn people is equal to 1420 million people
- So implicitly the targeted energy per capita is 2775,3 Ktoe/million people (PE / capita)

> This is energy per capita in terms of Primary Energy, while the universalized target is expressed in Final Energy. Therefore, we will make an estimation of the final energy intensity, using a utilization ratio. In the following steps this will be calculated.

- 2020 China projection PE Total = 3429619 Ktoe (IMAGE output, NPi_update, current policies)
- 2020 China projection FE Total = 1981292 Ktoe (IMAGE output, Dataset(C1), current policies)
- So, Utilization ratio in terms of FE tot / PE tot [China, 2020] = 0,58
- Applying this Utilization ratio on the implicit Primary energy per capita target of 2775,3 Ktoe/million people yields an estimation of the implicit Final energy per capita target.
    - 0,5777*2775,3 = **1603,3 ktoe/million people**

European Union:

Background

Universalized target Final energy per capita Defined as: Total Final Energy divided by population size Expressed in: Ktoe / million people

Based on explicit target:
- 20% ("max. 1078 Mtoe of final energy in 2020") energy reduction in 2020 compared to business as usual
- 32.5% ("max 956 Mtoe in 2030 of final energy consumption") energy reduction in 2030 compared to business as usual

Defined as: max final energy
Expressed in: Mtoe
Stated in:
- 2020 Climate and Energy Package European Union 2009 (2020) – [implemented]
- 2030 climate & energy framework (2014; amended in 2018) (2030) – [implemented]

Link: https://ec.europa.eu/clima/policies/strategies/2020_en & https://ec.europa.eu/energy/en/topics/energy-efficiency

Calculation

Assumptions:
- We use the IMAGE current policies downscaled projection for Population in EU-28 for 2020 and 2030 (unharmonized data).

Steps:
- 2020 EU Population (see dataset; B1) = 522,1 million people[=B]
- 2020 EU's targeted max. FE = 1078000 Ktoe [=A]
- 2020 EU primary energy efficiency is then: **2064,6 Ktoe/million people** [=B/A]
- 2030 EU GDP | PPP (see dataset; B1) = 533,0 million people [=B]
- 2030 EU's targeted max. FE = 956000 ktoe [=A]
- 2020 EU primary energy efficiency is then: **1793,4 Ktoe/million people** [=B/A]

Japan:

Background

Universalized target Final energy per capita Defined as: Total Final Energy divided by population size Expressed in: Ktoe / million people

Based on explicit target:

- -10% final energy in 2030, compared to 2013

Defined as: max final energy
Stated in: 2030 Outlook for Energy Supply and Demand Japan 2015
Link: https://www.iea.org/policiesandmeasures/pams/japan/name-153002-en.php

Calculation

Assumptions:

- We use the IMAGE current policies downscaled projection for Population in Japan for 2030. Furthermore, we use the historical data from IEA on total final energy in 2013 (unharmonized data for both)

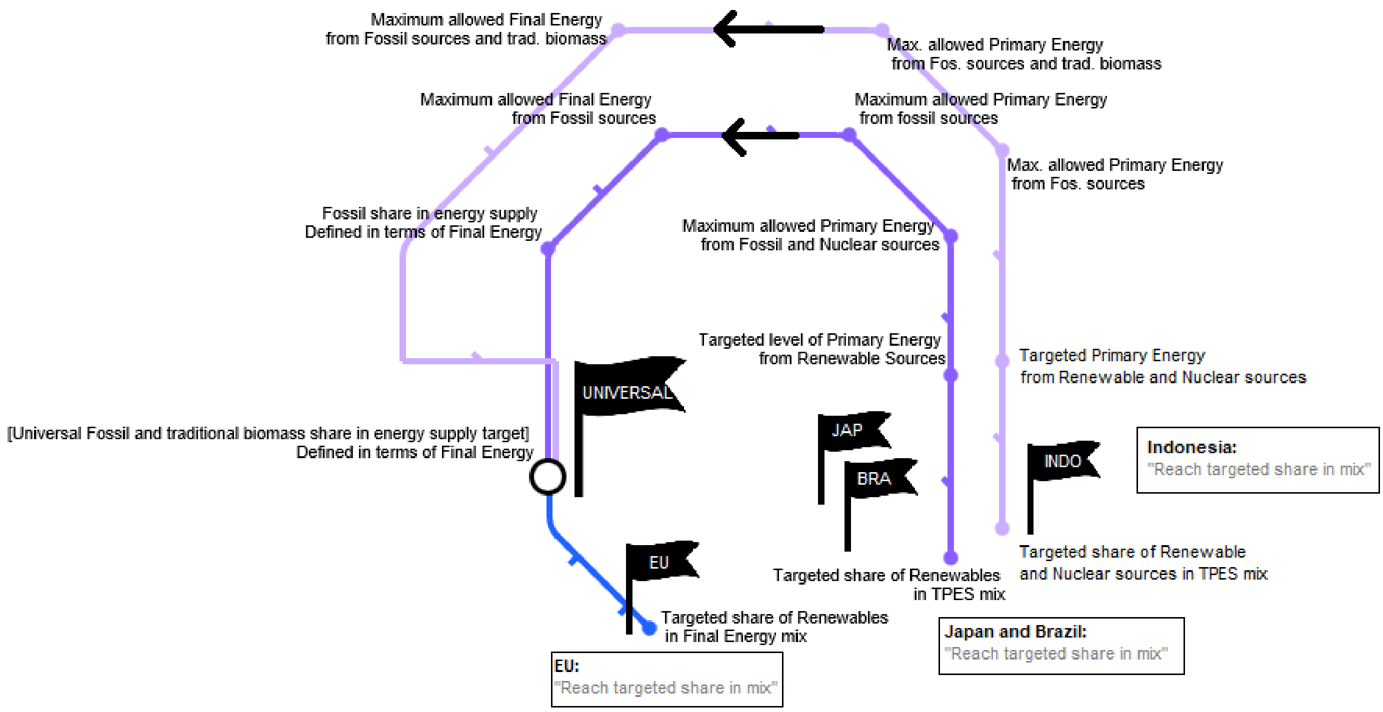
Steps:

- 2030 Japan Population (see dataset; C1) = 121,4 million people [=B]
- 2013 Japan FE (see dataset;B1) = 308815,9 Ktoe
- 2030 Japan max allowed FE is then: (0.9* 308815,9=) 277934,3 Ktoe [=A]
- 2030 Japan targeted implicit energy efficiency is then: **2289,1 Ktoe/million people** =[A/B]

Calculation of the Implicit 'universalized' target: Fossil and traditional biomass share in energy supply

For previous indicators it has been explained already that countries have their own specific way of defining their targets, which makes it hard to compare countries with each other. The figure below shows the steps which are required to 'translate' the explicit actual target as set by the government of the particular country, into an implicit universalized target. The universalized target is defined as the Fossil and traditional biomass share of the Final Energy use. In order to make this transformation, we need to make some assumptions. Also for these calculations some assumptions are made and mentioned.

The first thing which you see when looking at the figure is the large number of steps taken in this the transformation of targets of Japan, Brazil and Indonesia. Each of the countries has defined a target in terms of a share of non-fossil sources in an energy mix. Using projections of future energy use, we can determine what is the absolute targeted level of energy from non-fossil sources. After some specific steps we find another parallel: both explicit targets are defined in terms of primary energy, while the universalized target is defined in terms of final energy. In the elaborated steps for each specific country it is shown how an estimation of the Utilization ratio of energy is used, in order to make this calculation. This shows that also for this particular indicator we find some similar logic in the calculation steps. Only the EU is rather different from the three other countries, it has defined a target which is close to our universalized target already.



Brazil:

Background

Universalized target fossil share in energy supply Defined as: Fossil and Traditional Final Energy divided by Total Final Energy Expressed in: Ktoe/Ktoe [%]

Based on explicit target: 45% of renewables in the energy mix [TPES] by 2030.
Defined as: PE renewable / PE total
Expressed in: %
Stated in: Renewables NDC target Brazil 2015 – [final version NDC sent]
Link: Climate policy database

Calculation

Assumptions:

- We use the IMAGE current policies projection for primary nuclear energy, the utilization-ratio and the total primary and final energy for Brazil in 2030. Only unharmonized data is used. Furthermore, IEA projections on traditional biomass in 2030 are used.
- In its NDC Brazil refers to the definition of renewables, as provided by OECD. This would imply that they *include* traditional used biomass to renewables. Note that in this research traditional use of biomass is *included* in the definition of fossil and *excluded* in the category of renewables.

Steps:

- Projection: 2030 Brazil PE (IMAGE output, NPi_update, current policies) = 367712,1 Ktoe
- Of this energy 45% is targeted by the Brazilian government to be renewable or traditional biomass (which is 165470,4 Ktoe). The remaining part is therefore for fossil and nuclear sources.
- Projection: 2030 Brazil PE Nuclear (IMAGE output, NPi_update, current policies) = 3396,2 Ktoe
- If we subtract the targeted renewable share and the projected nuclear share from the projected total primary energy, 198845,5 Ktoe of Primary Energy remains. This is therefore the maximum primary energy which can be spent on fossil sources.

> However, our universalized implicit target is defined in terms of final energy instead of primary energy. Therefore, an estimation is made of the final energy which can be spent on fossil fuel, using the calculated utilization ratio. This ratio has been calculated in the research already

- Utilization ratio in terms of FE fossil and traditional / PE fossil and traditional [2030] for brazil is: 0.772 Ktoe/Ktoe (IMAGE output, Dataset(C1; inverse of [PE fossil and traditional/FE fossil and traditional]), current policies)
- Applying this Utilization ratio on the primary energy max. consisting of fossil sources yields an estimation of the implicit Final energy intensity target in 2030 of:
    - 0,772 * 198845,5 = 153499,7 Ktoe
- Projection: 2030 Brazil FE = 281375,0 Ktoe
- Dividing the final energy max. consisting of fossil sources by the total final energy yields an implicit target fossil share of: 0,55 Ktoe/Ktoe, which is 54,6% in 2030.

> However, our universalized implicit target is defined in terms of fossil *and traditional biomass* energy. This is a different definition then Brazil's fossil energy-target of 54,55%. Therefore, it is important to "stretch" that particular fossil target, such that it also allows for the traditional biomass in 2030, such as projected under the current policies scenario.

- IEA has projected that in 2030 1,42% of the final energy consist of traditional biomass (=4 EJ TFC traditional biomass / 280 TFC total) (Word Energy Outlook, 2018).
- Therefore, the implicit Fossil and traditional biomass share in energy supply is estimated to be: 54,6% + 1,4% = 56,0 ≈ **56%**

European Union:

Background

Universalized target fossil and traditional biomass share in energy supply Defined as: Fossil and Traditional Final Energy divided by Total Final Energy Expressed in: Ktoe/Ktoe [%]

Based on explicit targets:

- 20% of Final energy from renewable sources in 2020
- 32% of Final energy from renewable sources in 2030
- Stated in: Renewable Energy Directive (2018/2001) (2020) & Renewable Energy Directive (2009/28/EC) (2030)

Calculation

Assumptions:

- We use the EU's Final Energy targets in 2020 and 2030. Furthermore, we use the Nuclear Final Energy projections and traditional biomass projections from the 2018 IEA World Energy Outlook for the EU for 2020 and 2030.

Steps:

- 2020 EU's targeted max. FE = 1078000 Ktoe
  - Of which 20% should at least be from renewable sources in 2020
  - Of which 6% share is projected to be from nuclear sources in 2020
  - Of which 0% share is projected to be from traditional biomass sources
  - Such that, at most, **74%** of the FE could consist of fossil (and traditional biomass) sources: 797720 Ktoe.
- 2030 EU's targeted max. FE = 956000 ktoe
  - Of which 32% should at least be from renewable sources in 2030
  - Of which 5% share is projected to be from nuclear sources in 2030
  - Of which 0% share is projected to be from traditional biomass sources
  - Such that, at most, **63%** of the FE could consist of fossil (and traditional biomass) sources: 797720 Ktoe.

Indonesia:

Background

Universalized target fossil and traditional biomass share in energy supply Defined as: Fossil and Traditional Final Energy divided by Total Final Energy Expressed in: Ktoe/Ktoe [%]

Based on explicit target: 23% TPES new and renewable energy (incl. nuclear)
Defined as: (Renewable + Nuclear energy PE) / total PE
Expressed in: Ktoe/Ktoe [%]
Source: National Energy Policy (Government Regulation No. 79/2014)
link: https://www.iea.org/policiesandmeasures/pams/indonesia/name-140164-en.php

Calculation

Assumptions:

- We use the IMAGE current policies projection for total primary energy (unharmonized) and traditional biomass primary energy use (unharmonized), the utilization-ratio for Indonesia in 2030. Only unharmonized data is used. Furthermore, IEA projections on traditional biomass in 2030 are used.

Steps:

- Projection: 2025 Indonesia PE (IMAGE output, NPi_update, current policies) = 14,4 EJ
- Of this energy 23% is targeted by the Indonesian government to be renewable and nuclear and traditional biomass (0,23 * 14,4 = 3,3 EJ). The remaining part is the fossil share *excluding* traditional biomass
- If we subtract the targeted renewable/nuclear/traditional share from the projected total primary energy, 11,1 EJ of Primary Energy remains. This is therefore the maximum primary energy which can be spent on fossil sources (still excluded traditional biomass).

- Projection: 2025 Indonesia PE Traditional Biomass (IMAGE output, NPi_update, current policies) = 1,9 EJ
- If we add the projected traditional biomass to the primary energy budget which we just calculated, we yield (11,1+1,9=) 13,0 which can be at most spent on fossil sources *and traditional biomass*

> However, our universalized implicit target is defined in terms of final energy instead of primary energy. Therefore, an estimation is made of the final energy which can be spent on fossil fuel, using the calculated utilization ratio. This ratio has been calculated in the research already

- Utilization ratio in terms of FE fossil and traditional / PE fossil and traditional [2025] for Indonesia is: 0,77 % (IMAGE output, Dataset(C1; inverse of [PE fossil and traditional/FE fossil and traditional]), current policies)
- Applying this Utilization ratio on the primary energy max. consisting of fossil sources yields an estimation of the implicit Final energy intensity target in 2030 of:
    - 0,772 * 13,0 = 10,1 EJ
- Projection: 2025 Indonesia FE = 10,4 EJ
- Dividing the final energy max. consisting of fossil sources by the total final energy yields an implicit target fossil share (incl. trad. Biomass) of: 0,97, which is **97%** in 2025

Japan:

Background

Universalized target fossil and traditional biomass share in energy supply Defined as: Fossil and Traditional Final Energy divided by Total Final Energy Expressed in: Ktoe/Ktoe [%]

Based on explicit target: 13-14% of primary energy supply from renewable sources by 2030
Defined as: PE renewable / PE total
Expressed in: Ktoe/Ktoe [%]
Stated in: 2030 Outlook for Energy Supply and Demand Japan 2015
Link: https://www.iea.org/policiesandmeasures/pams/japan/name-153002-en.php

Calculation

Assumptions:

- We use the IMAGE current policies projection for total primary energy for 2030 (unharmonized) and the projections for nuclear primary energy in 2030 (unharmonized), Furthermore the projected utilization-ratio for Japan in 2030 is obtained and used. Furthermore, IEA projections on traditional biomass in 2030 are used.

Steps:

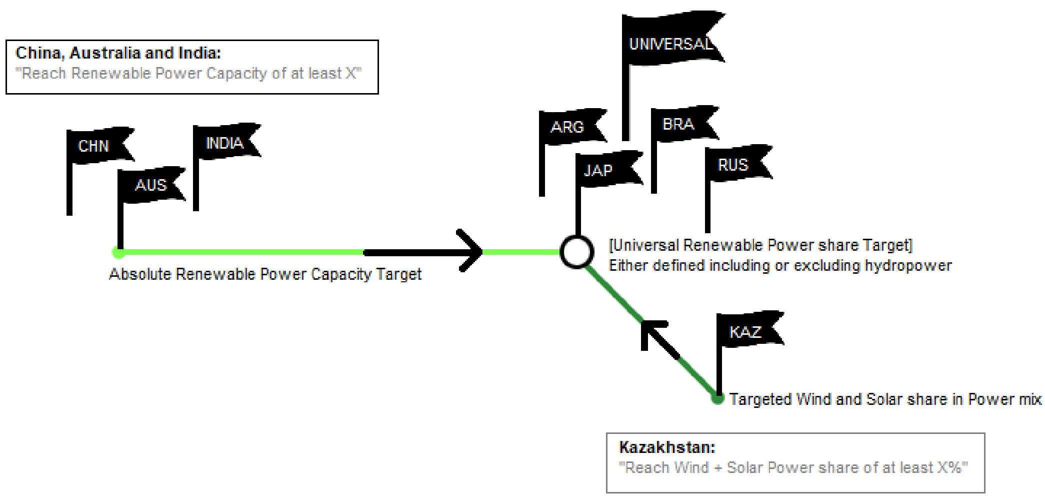
- Projection: 2030 Japan PE (IMAGE output, NPi_update, current policies) = 16,488 EJ
- Of this energy 13.5% is targeted by the Japanese government to be renewable or traditional biomass (which is 0 Ktoe in the case of Japan). The remaining part is therefore for fossil and nuclear sources. This is (0.135 * 16,448=) 2,2 EJ.
- Projection: 2030 Japan PE Nuclear (IMAGE output, NPi_update, current policies) = 1,212 EJ
- If we subtract the targeted renewable share and the projected nuclear share from the projected total primary energy, 13,1 EJ of Primary Energy remains. This is therefore the maximum primary energy which can be spent on fossil sources.

> However, our universalized implicit target is defined in terms of final energy instead of primary energy. Therefore, an estimation is made of the final energy which can be spent on fossil fuel, using the calculated utilization ratio. This ratio has been calculated in the research already

- Utilization ratio in terms of FE fossil and traditional / PE fossil and traditional [2030] for Japan is: 72% (IMAGE output, Dataset(C1; inverse of [PE fossil and traditional/FE fossil and traditional]), current policies)
- Applying this Utilization ratio on the primary energy max. consisting of fossil sources yields an estimation of the implicit Final energy intensity target in 2030 of:
    - 0,72 * 13,1 EJ = 9,4 EJ
- Projection: 2030 Brazil FE = 12,9 EJ
- Dividing the final energy max. consisting of fossil sources by the total final energy yields an implicit target fossil and traditional biomass share of: 0,73 EJ/EJ, which is **73%** in 2030.

Calculation of the Implicit 'universalized' target: Renewable share in electricity mix

The figure below shows the steps which are required to 'translate' the explicit actual target as set by the government of the particular country, into an implicit universalized target. However, as you can see, there is a great amount of countries which has a definition which is equal to the universalized target already. The universalized target is defined as the share of power from renewable sources. In order to make this transformation, we need to make some assumptions. Also, for these calculations some assumptions are made and mentioned.
The first thing which you see when looking at the figure is that not much steps have to be taken in this the transformation of actual explicit targets to implicit universalized targets. For China, India and Australia we look into work of CD-Links which has analysed the Energy capacity targets of these countries. Based on this information they have calculated estimated Renewable power share targets. This information is used here. For Kazakhstan there are not required any active calculations either. They have defined their target in terms of wind and solar share. As shares of other types of renewables are quite neglectable in Kazakhstan and we didn't find any major plans to change this, we assume the wind and solar target as the 'overall' renewable power target.
Please note that there are actually *two* universalized targets. In some cases, the universalized target is defined in terms of *including* hydropower, in other cases it is *excluding* hydropower.



Argentina:

Background

Universalized target Renewable share in electricity mix Defined as: renewable electricity (incl. hydro) generated divided by total electricity generated Expressed in: [absolute %]: [GWh/GWh]

Explicit targets:

- **16%** renewable electricity share target for 2021 (excl. large hydro, incl. small (<30MW) hydro)
- **18%** renewable electricity share target for 2023 (excl. large hydro, incl. small (<30MW) hydro)
- **20%** renewable electricity share target for 2025 (excl. large hydro, incl. small (<30MW) hydro)
- Defined as national target. Furthermore, large energy users (demand > 300kW) are obliged to reach these targets individually, or pay a penalty.
- Please note that the renewable historical data and projections, as shown, do not display small-hydro power. There is no trustworthy data available to include here. Nevertheless, it is expected that small-hydro sources will not have a large share of the total electricity generation (yet).

Stated in: Law 27191 on renewable energy – [implemented]
Link: http://climatepolicydatabase.org/index.php?title=Law_27191_on_renewable_energy

Australia:

Explicit target:
realizing 33,000 GWh capacity of large-scale electricity generation in 2020. In a government report this is equated to **23.5%** of Australia's electricity generation in 2020.
Stated in: The Renewable Energy Target (RET) scheme (impacted by amendment act 2015) – [implemented]
Link: https://www.environment.gov.au/climate-change/government/renewable-energy-target-scheme
No calculations required

Brazil:

Explicit target:
Share of renewables in power supply at least **23%** (excl. hydro) in 2030
Defined as: renewable electricity (excl. hydro) generated divided by total electricity generated
Expressed in: %
Stated in: Renewables NDC target Brazil 2015 – [final version NDC sent]
Link:http://www.climatepolicydatabase.org/index.php?title=Renewables_INDC_target_Brazil_2015> The target excl. hydro is the same as incl. hydro.
No calculations required

China:

Background

Universalized target Renewable share in electricity mix Defined as: renewable electricity (incl. hydro) generated divided by total electricity generated Expressed in: [absolute %]: [GWh/GWh]

Based on explicit target: realizing 340GW Hydro electricity capacity, 210GW Wind, 15GW biomass, 105GW solar PV and 5 GW Solar thermal in 2020. CDLINKS (CDLINKS, 2018) has made a calculation and equates this to an implicit target of **26,5%** share of renewables in the electricity mix (incl. hydro)
Stated in: 13th Five Year Plan (2016-2020)
Link: http://www.lse.ac.uk/GranthamInstitute/law/13th-five-year-plan/

India:

Background

Universalized target Renewable share in electricity mix Defined as: renewable electricity (excl. hydro) generated divided by total electricity generated Expressed in: [absolute %]: [GWh/GWh]

Based on explicit targets:
realizing capacity additions. CDLINKS (CDLINKS, 2018) has made a calculation and equates this to a **20%** share of renewables in the electricity mix (incl. hydro) for 2022 and **24%** in 2027.

Japan:

Explicit target:
Share of renewables in total energy generation electricity should be 22-24% in 2030. So at least **22%**
Source: Long-term Energy Supply and Demand Outlook based on the Strategic Energy Plan (2014).
link: https://www.iea.org/policiesandmeasures/pams/japan/name-153002-en.php
No calculations required

Kazakhstan:

Background

Universalized target Renewable share in electricity mix Defined as: renewable electricity (**excl**. hydro) generated divided by total electricity generated Expressed in: [absolute %]: [GWh/GWh]

Based on explicit targets:

- At least **3%** wind and solar power generation in power mix by 2020 (other kinds of renewables are nihil)
- At least **10%** wind and solar power generation in power mix by 2030 (other kinds of renewables are nihil)

Source: Decree of the President of the Republic of Kazakhstan on the Concept on the transition of the Republic of Kazakhstan to the "green economy" No. 577 dated May 30, 2013
link: https://pavlodar.gov.kz/en/concept-of-transition-of-the-republic-of-kazakhstan-to-green-economy/

Russia:

Based on explicit targets:

- **2.5%** share of renewable electricity generation in 2020
- **4.5%** share of renewable electricity generation in 2024

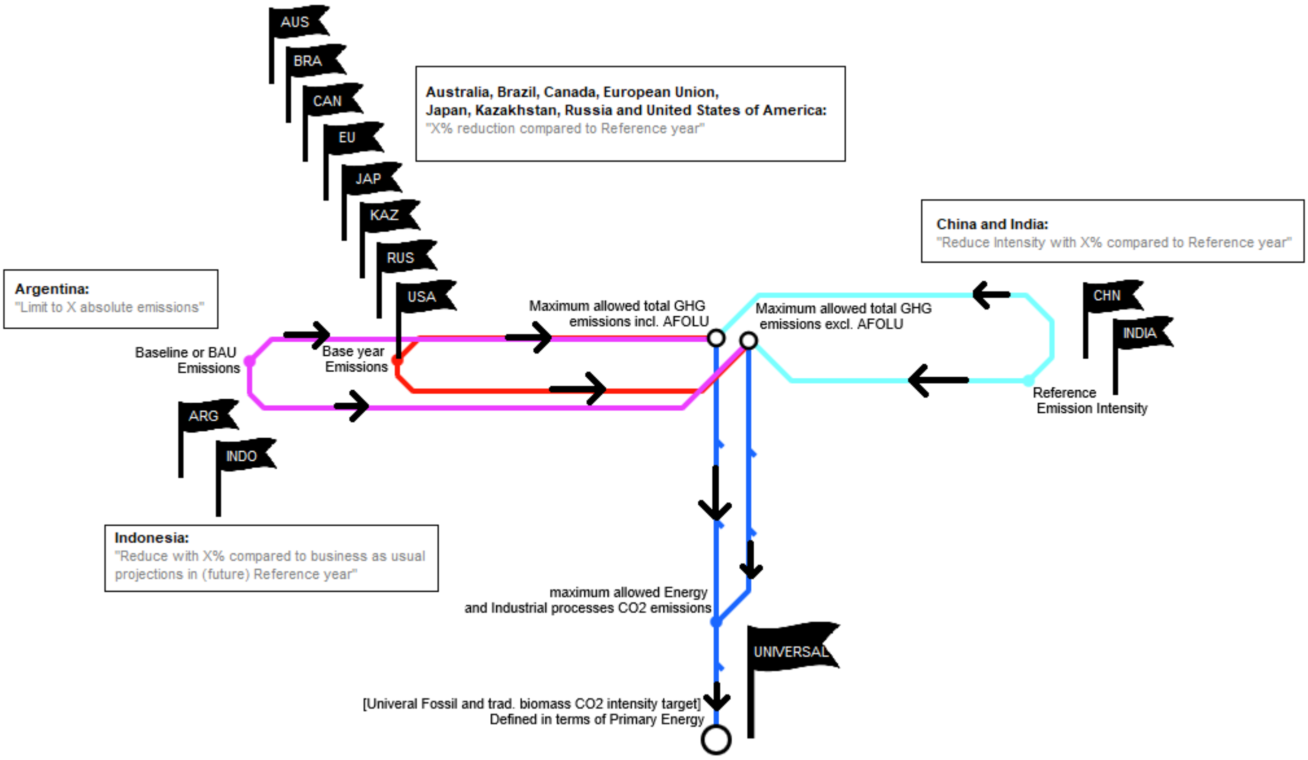
Source:

Russia's Energy Strategy to 2030, approved by Government Decree No. 1715-r of 13 November 2009, set a renewables-based power generation target of 4.5% by 2020, excluding large hydropower. Governmental resolution No. 512-r of 3 April 2013, Approving the State Programme for Energy Efficiency and the Development of the Energy Sector, introduced a lower target for renewables, of at least 2.5% by 2020. Also the resolution amends the target year in the official decree to 2024 (four years later) and left the target share as it was: 4.5% (IRENA, 2017).

Link: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Apr/IRENA_REmap_Russia_paper_2017.pdf

Calculation of the Implicit 'universalized' target: Fossil and traditional biomass CO2 intensity

For previous indicators it has been explained already that countries have their own specific way of defining their targets. This is especially the case for emission reduction targets. These are the targets which are for instance mentioned in the NDC-documents of countries, which are handed in to the UNFCCC. Some countries defined their target in terms of reductions compared to a baseline or business as usual projections, other countries define their target in terms of targeted levels of emission intensity. Still the majority of major economy has defined their target in terms of targeted percentage of reduction as compared to a specific base year. From these greenhouse gas emission reduction targets we can calculated our universalized target Fossil and traditional biomass CO_2 emission intensity.
Based on the explicit targets of countries it is easy to calculate the maximum allowed total of greenhouse gases for the countries, either including or excluding AFOLU. These calculations have been made earlier by Kuramochi *et al.* (2018) and these results have been used for these calculations[21]. From maximum allowed levels of greenhouse gases, we can make an estimation of the maximum allowed CO_2 emissions from fossil energy and traditional biomass. The last step which has to be taken is dividing the maximum CO_2 emissions by the total projected primary energy for the particular year in which the emission reduction target has been set. Finally we find the universalized intensity target which corresponds with the targeted level of emission reduction. These calculations require a couple of assumptions, which are mentioned throughout the steps.
In the figure below we can see that there are many parallels in the way of translating the original targets into terms of the implicit universalized target. This is why each of the transformation processes (from explicit to implicit universalized target) is not explained into details. The process has been described extensively for Australia first, then shortly the other countries have been discussed.



[21] For a couple of countries there have been large uncertainties when calculating the maximum allowed emission levels for the explicit targets. That is why Kuramochi *et al.* (2018) have presented then a minimum and a maximum level of maximum GHGs. Therefore, we have decided to also present both minimum and maximum values of our calculated universalized emission intensity targets.

Australia [extensive explanation]:

Background:

Universalized target Fossil and traditional CO2 intensity Defined as: CO_2 emissions from energy and industrial processes (incl. traditional biomass)[22] divided by Fossil and Traditional Primary Energy[23]. Expressed in: $MtCO_2$ / Mtoe

Based on the following explicit targets:

- Unconditional: 5% GHG reduction by 2020 from 2000 level
- Unconditional: 26 to 28% GHG reduction by 2030 from 2005 level (NDC)
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

Assumptions:

- The Fossil and traditional CO_2 intensity goal is solely based on the target on maximum allowed CO_2 emissions in 2020 and 2030, given the emission reduction targets in the 2020 pledge and NDC. The primary energy aspect (the denominator in the ratio) in the constructed implicit target is *not* a target as set or communicated by government of the country/region itself. It is solely a projection of upcoming energy supplies, given the current implemented policies
    - Some other countries do also have implicit targets for 2025 as well, as these also have set a target on emissions in 2025.
- Current Policy scenario data obtained from IMAGE will be used in order to make a projection of the Fossil and Traditional Primary Energy supply in both 2020 and 2030. Only unharmonized data is used.
    - For some of the countries which are analysed in this research, no IMAGE data is available. In this case similar data will be used from POLES. In the sheets it will be explained if the country data is solely based on POLES data.
- Energy and industrial processes CO_2-emissions are used as a proxy for the total GHG emissions, which are covered in the explicit emission reduction target of the country/regions. As land-use, bunkers and CCS are beyond the scope of this research and therefore not taken into account, negative emission-effects are also not dealt with in this research.
- Energy and Industrial processes CO_2 emissions are a fraction of the total GHG emissions. In the steps below, it will be calculated how large this share is. This is calculated based on a static point in time (2015). For simplicity it is assumed that this share is equal over time (at least until 2035). Furthermore, this calculation is based on IMAGE data for Oceania, which functions as a proxy for Australia.
    - For mostly any other country data for the individual country *itself* is used. In this particular case no individual data for specifically Australia was available. Other countries/regions for which data from a larger overarching region is obtained are: the European Union, Kazakhstan, South-Korea, Russia and Ukraine.
    - For some of the available countries no IMAGE data is available; even no suitable overarching region data. In this case similar data will be used from POLES. In the sheets it will be explained if the country data is solely based on POLES data.

Steps:

[22] CO_2 emissions from energy use on supply and demand side (IPCC category 1A, 1B) and from industrial processes (IPCC categories 2A, B, C, E)

[23] Fossil and traditional biomass primary energy is defined as coal, gas, conventional and unconventional oil primary energy consumption plus traditional biomass primary energy consumption

- PBL and NewClimate Institute have calculated maximum allowed GHG emissions in 2020 and 2030, given the explicit unconditional targets stated above (Kuramochi *et al.*, 2018)
    - For 2020 this is between 464.95 and 519.65 $MtCO_2$ [=X-range]
    - For 2030 this is between 435.38 and 447.47 $MtCO_2$ [=Y-range]
    - *Please note that for every country we work with the unconditional emission target, instead of conditional targets.*
- Then the fraction of Energy and Industrial processes CO_2 emissions of total GHG emissions is calculated. For the latter variable it is important to include the AFOLU emissions, as these particular emissions are included in the 2020 and 2030 Australian emission reduction target
    - For some of countries we find that the AFOLU emissions are *not* included in the emission target. In this case we will work with GHG emissions *excluding* AFOLU. For each of the countries it will be mentioned in the appendix whether the target consists of these land-use-emissions.
- We obtain the (unharmonized) data for 2015 Oceania from the IMAGE current policies scenario:
    - Emissions | CO_2 | Energy and Industrial processes [2015]: 431 $MtCO_2$ [=A]
    - Emissions| Kyoto Gases | Total (=> incl. AFOLU) [2015]: 711 $MtCO_2$ [=B]
    - Dividing those two gives the following ratio: 60.6 % [=(A/B)*100]
- Having this 'downscaling-ratio', it is possible to estimate the maximum allowed Energy and Industrial processes CO_2 emissions:
    - For 2020 this is 0.606 * range(464.95 to 519.65) = range(281.60 to 314.72) $MtCO_2$ [=downsc X-range]
    - For 2030 this is 0.606 * range(435.38 to 447.47) = range(263.68 to 271.01) $MtCO_2$

      [=downsc Y-range]
- Then we look into the (harmonized) Fossil and Traditional Primary Energy supply projections (see dataset C1):
    - For 2020 this is: 119.52 Mtoe [=Q]
    - For 2030 this is: 104.48 Mtoe [=R]
- The final step is the calculation of the implicit emission intensity targets, by dividing the downscaled max. allowed Energy and Industrial CO_2 emissions by the Fossil and Traditional Primary Energy supply projections:
    - For 2020 this is: range(281.60 to 314.72)/ 119.52 [=downsc X-range/Q]= **range(2.36 to 2.63) $MtCO_2$/Mtoe**
    - For 2030 this is: range(263.68 to 271.01)/ 104.48 [=downsc Y-range/R] = **range(2.52 to 2.59) $MtCO_2$/Mtoe**

Argentina:
Based on the following explicit target:

- Limit GHG emissions to 483 MtCO2e in 2030 (unconditional)
- Land-use (AFOLU) emissions are included in the target
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation
For 2030 the calculated implicit target = **2,493803 $MtCO_2$/Mtoe**

Brazil:
Based on the following explicit targets:

- Unconditional: Between 36.1 and 38.9% reduction by 2020 from a baseline scenario in 2020
- Unconditional: 37% GHG reduction by 2025 from 2005 level and indicative contribution of 43% GHG reduction by 2030 from 2005 level (equivalent to 4% to 8% below 2010 levels by 2030)
- Land-use (AFOLU) emissions are included in the target
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target = **2,90 $MtCO_2$/Mtoe**
- For 2025 the calculated implicit target = **1,65 $MtCO_2$/Mtoe**
- For 2030 the calculated implicit target = **1,42 $MtCO_2$/Mtoe**

Canada:
Background:
Based on the following explicit targets:

- Unconditional: 17% GHG reduction by 2020 from 2005 level
- Unconditional: 30% GHG reduction by 2030 from 2005 level
- Land-use (AFOLU) emissions are included in the target. However, the accounting approach not specified, approach being used to account for the LULUCF sector is currently being examined. Furthermore the NDC target excludes emissions from natural disturbances and only account for anthropogenic emissions and removals. Therefore a calculation for emissions *excluding AFOLU-emissions* is made here. Based on the targets PBL and NewClimate Institute have calculated: allowed emissions between the 1,975 to 2,070 MtCO2e, 41% to 48% by 2020. And 1,195 MtCO2e, -15% by 2030
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target = **2,71$MtCO_2$/Mtoe**
- For 2030 the calculated implicit target = **2,51 $MtCO_2$/Mtoe**

China:
Background:
Based on the following explicit targets:

- Unconditional: 40-45% CO2 emission intensity reduction by 2020; 15% non-fossil fuels in primary energy consumption and increased forest stock volume
- Unconditional: Peaking CO2 emissions around 2030; 60-65% CO2 emission intensity reduction by 2030, compared to 2005 levels; 20% non-fossil fuels in primary energy consumption by 2030 and increased forest stock volume
- Land-use (AFOLU) emissions are included in the target. As for many countries and regions accounting approaches and methodologies are not specified.

> The Chinese explicit emission intensity target is defined as CO2-emissions/GDP, while the universalized target is specified as CO_2 emissions from energy and industrial processes (incl.

traditional biomass) divided by Fossil and Traditional Primary Energy. Therefore a calculation is made in order to translate this explicit target into terms of the universalized implicit target for this report.

- PBL and NewClimate Institute took the Chinese intensity targets and estimated a range of targeted total emissions in 2020 and 2030[24].
    - 12,160 to 14,300 MtCO2e, 20% to 42% by 2020
    - 12,900 to 15,775 MtCO2e, 28% to 56% by 2030
    - See Kuramochi et al., 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target = **range(3,05 to 3,59) $MtCO_2/Mtoe$**
- For 2030 the calculated implicit target = **range(2,90 to 3,57) $MtCO_2/Mtoe$**

European Union:

Based on the following explicit targets:

- Unconditional: 20% GHG reduction by 2020 from 1990 level
- Unconditional: At least 40% greenhouse gas reduction by 2030 from 1990 level
- The Land use sector is excluded in the target for 2020. Land use sector is included in the target for 2030. Earlier it was unclear whether land-use emissions were included in the EU emission target for specifically 2030. However, recently this had been made clear: The regulation on the inclusion of greenhouse gas emissions and removals from the LULUCF sector into the 2030 climate and energy framework was adopted by the Council on 14 May 2018 (Official Journal of the European Union, 2018c) (Kuramochi *et al.*, 2018)
- The arbitrary choice is made to calculate both implicit targets in terms of *excluding* biomass.
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target = **3,01 $MtCO_2/Mtoe$**
- For 2030 the calculated implicit target = **2,68 $MtCO_2/Mtoe$**

India:

Based on the following explicit targets:

- Unconditional: 20% GHG reduction by 2020 from 1990 level
- Unconditional: Reduce emissions per unit of GDP by 20% to 25% below 2005 level by 2030 (excluding agriculture emissions)
- The Land use sector is included in the target for 2030. Unclear whether included for 2020 or not.
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target is in the **range(2,768-3,383) $MtCO_2/Mtoe$**
- For 2030 the calculated implicit target is in the **range(2,833-3,500) $MtCO_2/Mtoe$**

Indonesia:

Based on the following explicit targets:

- Unconditional: 26% GHG reduction by 2020 from baseline scenario
- Unconditional: 29% GHG reduction by 2030 from baseline scenario
- The Land use sector is included in the targets
- See Kuramochi *et al.*, 2018 for the exact details.

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[24] Please note that the range of implicit intensities is rather large, as also the implicit targets for total allowed emissions (as calculated by PBL and NewClimate Institute) had a rather broad range.

Calculation

- For 2020 the calculated implicit target is **1.94 $MtCO_2$/Mtoe**
- For 2030 the calculated implicit target is **1.80 $MtCO_2$/Mtoe**

Japan:

Based on the following explicit targets:

- Unconditional: 3.8% reduction by 2020 from 2005 level
- Unconditional: 26% GHG reduction by 2030 from 2013 level
- The Land use sector is included in the targets
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target is **3.00 $MtCO_2$/Mtoe**
- For 2030 the calculated implicit target is **2.824 $MtCO_2$/Mtoe**
-

Kazakhstan:

Based on the following explicit targets:

- Unconditional: 15% reduction from 1990 levels in 2020
- Unconditional: 15% reduction in GHG emissions by 2030 compared to the 1990 base year
- The Land use sector is included in the 2030 target.
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target is between **range(2.136-2.337) $MtCO_2$/Mtoe**
- For 2030 the calculated implicit target is **1.842 $MtCO_2$/Mtoe**

Russia:

Based on the following explicit targets:

- Unconditional: 15% to 25% GHG reduction by 2030 from 1990 levels
- Unconditional: Limiting anthropogenic greenhouse gases to 70% to 75% of 1990 levels by 2030
- Land-use is included in the 2030 target
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target is **range(3.600-5.100) $MtCO_2$/Mtoe**
- For 2030 the calculated implicit target is **range(3.143-4.332) $MtCO_2$/Mtoe**

United States:

Based on the following explicit targets:

- Unconditional: GHG reduction in the range of 17% by 2020 below 2005 levels
- Unconditional: 26-28% GHG reduction by 2025 from 2005 levels
- Land-use is included in both targets
- See Kuramochi *et al.*, 2018 for the exact details.

Calculation

- For 2020 the calculated implicit target is **2.502 MtCO2/Mtoe**
- For 2025 the calculated implicit target is **2.338 MtCO2/Mtoe**

Please note that there are no countries that have set explicit targets for the last Kaya-indicator: "Fossil Utilization ratio"

Appendix C: Country profiles – background information

C.1 Argentina

Climate change policy in Argentina

Argentina is one of the few countries that have strengthened the ambition of their NDC targets since the adoption of the Paris Agreement. Nevertheless, this new overall emission target is not met, as projected by PBL and NewClimate Institute. In order to keep track of the NDC targets, the Government of Argentina has established the so called "*National Cabinet for Climate Change*", next to its already existing Ministry of Environment and Sustainable Development. The idea is that the Cabinet consists of members from multiple ministries in Argentina. The Cabinet is responsible for the implementation and coordination of climate financing. Furthermore, it functions as a platform: debates will take place, referred to as the "*expanded cabinet*", which are open to representatives from civil society (Konrad Adenaur Stiftung, 2019).

So far, the discussions have led to the development of various plans for the energy, forestry and transport sectors. The Cabinet is still working on the plans for the other sectors. The UN Emissions Gap Report 2018 (UNEP, 2018) shows that the entire package of actions in sectoral plans is expected to reduce emissions by approximately 110 $MtCO_2$ compared to business as usual scenarios.

The UN Emissions Gap Report discusses this new package: "*The success of these mitigation actions in achieving the 2030 unconditional NDC target depends on several factors, including the opposition of the civil society to the construction of two mega hydroelectric dams in Patagonia and to two new nuclear power plants, and the country's recurrent financial constraints to sustain the implementation of some actions, such as the RenovAr program*" (UNEP, 2018). Climate change does not seem to be a top priority among the broader society in Argentina. According to a poll by Atlas Politico in 2019, voters did not bring up this particular theme, if asked about political priorities. Argentinian citizens would like the politicians to focus (instead) on the situation of consumer price increases, the high taxations and fighting corruption and unemployment (The Economic Times, 2019).

Climate policy

- **NDC Target :** Limit GHG emissions to 483 $MtCO_2e$ by 2030.
  The target is unconditional. The land use sector is included in the target.
- **Most important climate strategy document:**
  Argentina has not yet communicated their long-term strategy to the UNFCCC. The country has not yet adopted any emissions target for 2050. The National Cabinet for Climate Change is working on a long-term strategy. So far, plans for a couple of individual sectors are available (Climate Transparency, 2018).
- **Policies with largest impact on reducing GHG emissions:**
  Important policies that have been implemented for some time already are the (updated) Biofuels Law (Ministerio de Energia y Mineria, 2016) and the Renewable Energy Law (*via* Grantham Institute, 2015). The latter consists of the share of renewable power target (as shown in the graphs), which is overall target on a national level, but at the same time the target levied on *individual* large energy users (with a demand > 300kW). These individual users are obliged to reach these targets, otherwise they have to pay a penalty. On the other hand, the law provides a series of tax benefits to the new

renewable energy projects over a period of 10 years and the law establishes a fund for the support of those renewable energy projects (Climate Action Tracker, 2019).

The Renewable Energy Law has, in a later phase, led to the implementation of the RenovAr program in which renewable power projects are auctioned. The government received funding from the Green Climate Fund to guarantee the investment through the World Bank (PV Magazine, 2019). In November 2018, Argentina announced its fourth round of auctions in the RenovAr program, this time focusing mainly on small-scale renewables. The total volume auctioned so far is 400 MW.

Finally, one of the most recent implemented policies with a large potential future impact on emission reductions is the *carbon tax* from 2017 (Climate Action Tracker, 2019). Currently the is price not as high, when e.g. compared to the carbon price in the EU emission trading system. The tax started at 10 US dollar per ton of CO_2 and increases with 10% on a yearly basis. Some international sources suggest significantly higher carbon prices are required for Paris compatibility (at least USD40–80/tCO2 by 2020 and USD50–100/tCO2 by 2030 (Stiglitz *et al*., 2017)).

- **Important remark on Climate Policy in Argentina:** This report does not focus on the emission (sequestration potential) from the Agriculture, Forestry and Other Land Use (AFOLU) sector. It should be highlighted that important challenges for Argentina are ahead in this particular sector. Since 1996, when the government authorized the introduction of genetically modified soya bean, Argentina has cleared nearly a quarter of its native forests (Guardian, 2018a). A lot of forest has also disappeared for other crops such as wheat and maize, and the agricultural management on the new cropland has affects the amount of carbon being captured in the soils.

  Recently, a couple of programs have been implemented, which would counteract the Argentinian deforestation rates. An important example is the national *"Green Insurance Program",* which promotes forestation and enrichment of the native forests. Effectively, forested areas will expand with 62,000 hectares per year up to 2030 (Eversheds Sutherland & Fratantoni, 2018).

C.2 Australia

Climate change policy in Australia

Australia is relatively dependent on fossil fuels, as compared to other G20 countries. Australia has a long tradition in coal mining; in actually every state of the country coal is mined. About 75% of coal mined in Australia is exported, mostly to eastern Asia (Resources and Energy Quarterly June, 2018). Another fossil industry that is quickly increasing its market share is LNG. After being the World's second largest coal exporter, Australia is currently projected to become the world's largest LNG exporter by 2020 (Climate Action Tracker, 2019).

The current government recently pointed to the merits of LNG with regard to sustainability. The Minister for Energy and Emissions Reduction argued that LNG exports are expected to cut emissions abroad by displacing coal over there (Guardian, 2019a). Regardless of the question whether the Australian government actually has some valid point here, it is quite clear that emission reductions *within* the own country's borders are lacking behind as compared to Australia's own NDC-ambitions (see: 'Overall GHG emissions target'). In the previous decade emissions have been increasing continuously. It is not clear yet whether the intended decline in emission reductions will actually take place after 2020. This will mainly depend on the plans of the recently re-elected Liberal-National coalition, which is not likely to put the transition away from coal on top of the government's agenda (Carbon Brief, 2019a).

As is the case for many federal systems in the world such as Canada and the USA, also in Australia the states have retained extensive environmental competencies. Although in many other federal systems the locus of policymaking has shifted towards the central government in previous decades, we find for Australia the opposite movement: some regions turn out to be far more ambitious than the central government. Many of the states and territories in Australia have strong renewable targets, net-zero emissions targets or a combination of both. The State of Victoria aims, for instance, for 25 per cent renewables by 2020 and 40 per cent by 2025 (Victoria State Government, 2019). The State of Queensland aims for 50 per cent by 2030 (Queensland Government, 2019). Although these targets may have a strong impact on sustainable development in Australia, we do not further analyse the regional targets in this report, as this report focusses primarily on targets by the central governments.

Climate policy

- **NDC Target :** 26 to 28% GHG reduction by 2030 from 2005 level.
  The target is unconditional; no conditional target is defined. The land use sector is included in the target.
- **Most important climate strategy document:** Australia is lacking a clear strategy document, which outlines how to live up to the ambitions written down in the NDC. However, this does not mean that Australia has no overarching strategy at all. Recently the government presented the "*Climate Solutions Package*", which consists of some climate policies for the coming years. The Australian government states to make a $3.5 billion investment, to deliver on Australia's 2030 Paris climate commitments (Australian Government, 2019a). The government invests for example in in the Climate Solutions Fund, replacing the existing Emission Reduction Fund. Furthermore the government develops a new National Electric Vehicle Strategy and aims to keep improving energy efficiency (Australian Government, 2017). In the current projections the impact of these investments is not yet taken into account, as the policy is rather new. However, it is not expected that the policy will have major impact on the indicator projections. Some of the funds have been used for fossil fuel projects that would have been built anyway, so it is difficult to say what the additional emissions reduction impact would be. With regard to the sustainable transport strategy, no concrete policy is developed as of May 2019. The strategy does not have quantified targets either (Kuramochi *et al.*, 2019).
- **Policies with largest impact on reducing GHG emissions:** One of the high-impact policies is the *Renewable Energy Target* (2010). The policy aims at largescale generation of 33,000 gigawatt-hours (GWh) in 2020, which would double the amount of large-scale renewable energy being delivered by the scheme compared to current levels (Australian Government, 2019b). Another important policy that is at the core of Australia's climate change policies is the *Emissions Reduction Fund (ERF)* and linked safeguard mechanisms (Kuramochi *et al.*, 2018).

Australia used to have an ambitious carbon pricing scheme that received attention from policy makers over the entire world. However, the scheme was repealed on July 2014. In its place the Abbott Government set up the *Emission Reduction Fund* in December 2014 (Carbon Brief, 2019a). Activities supported through the Emissions Reduction Fund provide environmental, economic, social and cultural benefits for farmers, businesses, landholders, Indigenous Australians and others (Australian Government, 2019c).

C.3 Brazil

Climate change policy in Brazil

One of the most important determinants of Brazil's emissions are its forest management practices. Although this report does not focus on the emissions (or sequestration potential) from the Agriculture, Forestry and Other Land Use (AFOLU) sector, the Brazilian situation cannot be explained without shortly touching on this theme. In the previous decade, the Amazon and other forest areas in Brazil showed significantly decreased deforestation rates. LULUCF emissions were reduced by 86% between 2005 and 2012 according to the Brazilian Government (Ministry of Science, Technology and Innovation, 2016). However, recent trends show a 52% increase in deforestation rates from 2012 to 2017 (Climate Transparency, 2018).

In the UN Emissions Gap Report 2018, the political situation is sketched in the following way: *"In fact, the recent political crisis in the country has forced a weak government to concede reversals in environmental regulation as a bargaining chip to maintain power, which may potentially impact GHG emissions from land use as well as Brazil's contribution towards global climate targets"* (UNEP, 2018). After winning the elections, the president indicated that he wants to limit environmental constraints on agriculture (Associated Press, 2018).

It is too early to conclude whether the new Brazilian government will actively pursue the climate ambitions that were put forward in the NDC by the previous government. However, it should be recognized that there are international coalitions which pressure Brazil to keep their promise. The EU for instance, negotiated for a major trade agreement framework between the Mercosur countries and the EU, with the precondition that both regions' countries will stick to the implementation of the Paris climate agreement (EU, 2019a).

So far, there is no overarching strategy or policy implemented - or even planned - that will guide Brazil towards the target of45% share of renewables in the energy mix by 2030 and the target of 37% GHG emission reduction by 2025 from 2005 levels.

Climate policy

- **NDC Target:** 37% GHG emissions reduction by 2025 from 2005 level and indicative contribution of 43% GHG reduction by 2030 from 2005 level (equivalent to 4% to 8% below 2010 levels by 2030). The target is unconditional and land-use is included in the target.
- **Most important climate strategy document:** Brazil has not yet communicated their long-term strategy to the UNFCCC. The country has not yet adopted any emissions target for 2050. There are indications that public officials are beginning to plan a low-emission strategy (COMMIT, 2018). Until 2020, The National Plan on Climate Change (Government of Brazil, 2008) and the 10-year National Energy Expansion plan (Ministry of Mines and Energy, 2012) are effective, which have some strategic characteristics. Still, these plans do not provide concrete pathways or explanation on how to reach the NDC or the aggregate of other targets in the field of energy- and climate policy.
- **Policies with largest impact on reducing GHG emissions:** The main policies are the enforcement of the Brazilian Forest code and efforts to reduce deforestation in the Amazon and Cerrado regions. Those policies are more cost-effective than the emissions abatement measures in many of the other sectors (Kuramochi *et al.*, 2018).

  Other important policies in Brazil focus on the large bioenergy potential of the country. There are several challenges to leverage this potential in a sustainable manner. Biofuels might be the key for the country's low-carbon future. The use of these low-carbon fuels can reduce the high emission intensity in the Brazilian transport sector. Biokerosene and biodiesel could act as a sustainable alternative for many of the transport fuels, until electricity or hydrogen options are attractive for the country. Policies that are aimed at stimulating the Brazilian bio-economy are the *National Biodiesel Programme* (from 2005), *The Ethanol Blending Mandate* (from 1993) and the more recent *RenovaBIO policy* (from 2017) (via Kuramochi *et al.*, 2018). The latter policy aims to improve the carbon intensity of biofuels by 7% between 2017 and 2028 (Kuramochi *et al.*, 2018).

C.4 Canada

Important: Please note that only major policies were quantified in this research (non in particular for Canada) which have been implemented *before* June 2018. However, it is important to mention here that since June 2018, there have been some major policy changes in Canada. Newly introduced policies include the Greenhouse Gas Pollution pricing act, the Phase-out of traditional coal power, regulations for limiting carbon dioxide from natural gas fired generation of electricity and altered clean fuel standards.

Climate change policy in Canada

Canada is one of the first major countries worldwide that submitted a *Mid-Century Long-term Low-Greenhouse Gas Development Strategy* (MCS) for 2050. In the introduction of the strategy, the Canadian Government describes its aim: "*Canada's Mid-Century Strategy is not a blueprint for action, and it is not policy prescriptive. Rather, the report is meant to inform the conversation about how Canada can achieve a low-carbon economy. This includes describing modelling analyses that illustrate various scenarios towards deep emissions reductions. Canada's Mid-Century Strategy outlines potential GHG abatement opportunities, emerging key technologies, and identifies areas where emissions reductions will be more challenging and require policy focus in the context of a low carbon economy by 2050*" (Minister of Environment, 2016).

The Allianz Climate and Energy Monitor (2018) qualifies it as a document that is not very concrete, but still ambitious. The label 'ambitious' may apply due to the aim of 80% reduction in greenhouse gas emissions relative to 2005 levels by 2050, or the government hinting in the document at a full coal-phase out in 2030. However, the document can also be considered ambitious from the perspective of the extensive *process* that is proposed: Canada will have an inclusive bottom-up approach, in order to come up with new policies ultimately leading to the 2050 targets.

Somewhat interwoven with the process of coming to a final and concrete version of the strategy is the finalization of the Pan-Canadian Framework on Clean Growth and Climate Change (PCF). To deliver on Canada's short-term action, the Government of Canada works together with provinces, territories and representatives of Indigenous peoples to finalize this PCF. The PCF is described by the Canadian Government as a plan that "*will include actions to reduce emissions, build resilience, and spur innovation and create jobs*" (Minister of Environment, 2016 p.5), and it would allow Canada to exceed its NDC ambitions. Various parties, other than only the federal government, commit themselves to several actions that together would lead to the implementation of this plan: funding has been mobilized already and programs are currently being established and implemented.

As with many federal systems worldwide, the focus of policymaking has shifted towards the central government in previous decades. This is also the case for Canada. While the central government takes an important 'coordinating' role, most of the formal juridical power remains with the provinces with regard to climate change policies. The legal power to use natural resources remains mainly in the hands of the provincial governments, as they have the juridical right to govern and manage the natural resources that fall within their territorial boundaries. This would mean that they are also the main responsible governing party for forestry management, electricity generation and the use of fossil fuels (Nachmany *et al.*, 2014).

Climate policy

- **NDC Target :** 17% GHG reduction by 2020 from 2005 level and 30% GHG reduction by 2030 from 2005 level.
  Both targets are unconditional and land-use is included in the targets.
- **Most important climate strategy document:** Canada has communicated its long-term strategy to the UNFCCC. The target is clear, but the actual path towards that target is still unclear. See "Climate Change policy in Canada" for more information.
- **Policies with largest impact on reducing GHG emissions:** According to Kuramochi *et al.* (2018), one of the most important policy is Canada's fuel efficiency standard for passenger vehicles. Another policy that has a large effect on GHG emissions reduction is the carbon standard for newly built coal-fired power plants.
  Many policies with an expected high impact have been introduced after June 2018 and are,

therefore, not yet quantified. One of those policies is the plan to price carbon pollution. This new law would require individual provinces to either place a direct price on carbon pollution or adopt a cap and trade system (Government of Canada, 2018). It should be recognized that four provinces already have carbon pricing systems in place; those regional policies have been quantified and are part of the current policy projections.

C.5 China

Climate change policy in China

As the world's largest greenhouse gas emitter, China's climate change policy has a significant impact. Therefore China's climate policy is watched by stakeholders related to climate change over the entire world. The projections of Chinese CO_2 emissions are subject to a large degree of uncertainty. The authors of the UN Emissions Gap Report write: *"Recent independent studies have revised their emissions projections downwards compared with previous years, but do not strongly suggest that CO_2 emissions will peak before 2030. Contrastingly, other recent studies argue that recent structural shifts in the economy are likely to result in much steeper reductions in CO_2 intensity of Gross Domestic Product (GDP). Green and Stern (2017) provide an illustrative pathway in which intensity is halved from 2005 to 2020, resulting in peaked CO2 emissions between 2020 and 2025"* (UNEP, 2018). It is not surprising that it is hard to make a projection for CO_2 emissions in China, as also the reported historical data may not always be easy to compare with many other international datasets (Korsbakken *et al.,* 2016).

Irrespective of the challenges with regard to the interpretation of the historical data, it is clear that China's economy has been heavily depended on fossil fuels for decades, especially domestic coal. Energy use increased rapidly until 2010. In 2008, however, the Chinese government surprised many of its critics, with the introduction of their ambitious 12th Five-Year-Plan. The plan (and also the subsequent 13th Year plan) is responsible for the introduction of a strong policy shift towards a new low-carbon development model (Li and Wang, 2012). Renewable energy generation is currently increasing at fast pace and the production and consumption of coal are decreasing. Nowadays, China is even one of the leading producers of wind and solar power technologies. In the paper of Urban (2018) a reconstruction is made of China taking a lead position in innovation with regard to various renewable energy technologies.

As China is taking large steps towards a low-carbon future, the question arises whether they will be actually able to reach the mitigation targets for 2030 as projected by integrated assessment models (such as IMAGE and POLES). In a commentary paper of Engels (2018) some clear first answers on the difficult question are provided. She argues that there are a couple of factors that might affect the effectiveness of China's particular state-led non-participatory climate policy. Internal contestation, fragmentation and non-participation could in the end turn-out to be a Chinese climate policy showstopper, according to Engels.

Climate policy

- **NDC Target :** Peaking CO_2 emissions around 2030; 60-65% CO_2 emission intensity reduction by 2030, compared to 2005 levels; 20% non-fossil fuels in primary energy consumption by 2030 and increased forest stock volume.
  The target is unconditional and the land use sector is included in the NDC.
- **Most important climate strategy document:**
  China is currently developing a long-term low-emissions strategy, this might include a target for 2050 if they follow the example of other countries which have already handed in their strategy. China is about to make a two-stage development plan for the period from 2020 to the middle of this century. At the 19th National Congress of the communist party of China, some first ideas were shared on this topic (COMMIT, 2018).
  Currently the most important climate strategy document is the 13th Five Year Plan (2016-2020) (China Government, 2016). This plan is summarized by the Grantham Institute in the following way: *"The 13th Five Year Plan lays down the strategy and pathway for China's development for 2016-2020 and includes concrete environmental and efficiency targets. It gives top priority to economic development to reach a GDP growth rate of 6.5-7% per annum, consistent with the goal of becoming a 'moderately prosperous society' by 2020, guided by five key principles of "innovative, coordinated, green, open, and shared development". At the same time, the 13th Five Year Plan sets peak targets for carbon emissions and energy and water consumption, as well as goals for increasing efficiency of industries and eliminating outdated or overcapacity production facilities, increasing energy production from renewables, and developing green infrastructure. It follows the 11th Five Year Plan, which implemented the concept of energy intensity targets in a number of pilot projects, and the 12th Five Year Plan, which broadened the nature of economic growth towards social inclusiveness and sustainability"* (Grantham Institute, 2016a)

- **Policies with largest impact on reducing GHG emissions:** 13th Five Year Plan (2016-2020) (China Government, 2016) (see previous section) and the *Energy Development Strategy Action Plan 2014-2020* (China Government, 2014b).

C.6 European Union

Climate change policy in the EU

Different from other profiles, the EU is not a country, but a political and economic union of 28 member states that are located primarily in Europe. Therefore, the political power with regard to climate change policies, is somewhat distributed over multiple levels of government. The "environment" and "energy" topics belong to the category of "*shared competences*" of the EU and Member States. This means that both bodies can legislate, but member states can only legislate to the extent to which the EU has not already overarching legislation in place. At the European level, a package of policy measures to reduce greenhouse gas emissions has been initiated. Each of the EU Member States has also put in place its own domestic actions that build on the program's measures or complement them. European climate policies can be broadly classified into two categories: (1) the EU Emission Trading System (ETS), the EU-wide cap-and-trade system covering power generation, energy-intensive industry and aviation, and (2) policies targeting non-ETS sectors (buildings, transport, agriculture) including Member State-specific targets for emission reduction (Effort Sharing Decision) (EU, 2019b).

As the EU recognized that it is not on track to meet its 2030 target with current policies and because it acknowledged some of the disadvantages of having a structurally low carbon price in its emission trading system, it adopted a package of measures to accelerate the reduction of GHG emissions in different areas (EU, 2019c). Many of these policies are aimed at a reform of the EU ETS. The Effort Sharing Decision on GHG emissions from sectors not covered by the EU ETS was adopted in May 2018 and would lead to an EU-wide emission reduction of 30% by 2030 relative to 2005; this will be achieved by binding emission limits for each EU Member State by 2030 (EU, 2019d). The policy framework is also complemented with sector-specific measures, such as a new Energy Efficiency Directive and the Energy Performance of Buildings Directive.

The EU claims that *"preventing dangerous climate change is a key priority for the European Union"* and furthermore they state *"Europe is working hard to cut its greenhouse gas emissions substantially while encouraging other nations and regions to do likewise"* (EU, 2019b). Although the EU is implementing a large set of 'worldwide-best-practice' policies (see for instance IEA, 2017), current policy scenarios project that most of the EU's 2030 targets will not be met.

Climate policy

- **NDC Target :** At least 40% greenhouse gas emissions reduction by 2030 from 1990 level.
  The target is unconditional and the land use sector is included in the NDC.
- **Most important climate strategy document:**
  The European Commission (EC) has initiated discussions on the EU's long-term climate strategy. The strategy would replace the 2011 Low Carbon Roadmap (including its 2050 reduction target of 80% to 95% from 1990 levels). In November 2018, the Commission presented its proposal for a 2050 long-term strategy, which included a commitment to climate neutrality by 2050. However, until now, EU leaders have been unable to agree on the target, reflecting the divisions in attitude towards coal of Western and Central and Eastern European Countries.
  Earlier, the European Commission (EC) presented the "Clean Energy for all Europeans", a package of measures to keep the EU competitive in the context of clean energy transition (see *Climate change policy in the EU*) (EU, 2019e). The proposed policies and legislation are aligned with the EU NDC commitments to the Paris Agreement and the 2030 policy objectives regarding GHG emissions reduction, renewable energy and energy efficiency.
- **Policies with largest impact on reducing GHG emissions:**
  As discussed before, the two most important policies in the EU are the EU ETS Directive and the Effort Sharing Regulation. The EU ETS is a cap-and-trade system that is applied to power supply and industry sectors of the EU, covering around 45% of the EU's GHG emissions. A cap is set on the total amount of greenhouse gases that can be emitted by the installations covered by the system. The cap is reduced over time—at an annual rate of 2.2% from 2021 onwards—such that total emissions decrease (EU, 2019b). Within the cap, companies receive or buy emissions allowances that they can trade with one another as needed. After each year, a company must surrender enough allowances to cover its emissions, otherwise they well be punished by a penalty. An additional benefit of the system would be that it promotes investment in clean, low-carbon technologies.

The Effort Sharing Regulation translates the demand for an overall emission reduction target (40% by 2030) into binding annual country-specific targets for each Member State (EU, 2019d). This translation is based on the principles of fairness, cost-effectiveness and environmental integrity. For each Member State, the 2030 target is the end point of a linear reduction trajectory defining annual emission reductions for the years 2021-2030.

C.7 India

Climate change policy in India

India has the second largest population, at 1.3 billion and counting. Population is an important driver of greenhouse gas (GHG) emissions; therefore, it is not surprising that India is among the three largest worldwide emitters of GHGs. Also India's economy (another important driver of emissions) is large. Globally, the Indian economy ranks sixth in terms of GDP and is the world's fastest growing. Per capita emissions are well below the global average at present, but absolute emissions are increasing and projected to keep doing so over the years to come. This growth is mainly driven by the combination of a highly carbonized power sector and increasing power demand, as well as the combination of an increasing number of mouths to feed and highly emitting rice paddies and cattle (Carbon Brief, 2019b).

While India is one of the largest worldwide GHG emitters, the country itself is also very vulnerable to climate change, due to melting of the Himalayan glaciers and changes to the monsoon. According to a 2015 poll from the Pew Research Centre, 75% of Indians are very concerned about global warming. Current prime minister Narendra Modi is known as a strong advocate for fighting climate change. This year, in one of the largest elections ever held in India, he reassured his position as country leader. In 2018, he told world leaders on the annual meeting of the World Economic Forum that climate change is on the three greatest threats to the survival and human civilization (World Economic Forum, 2018).

India's 'flagship legislation', is according to Nachmany *et al.* (2014) the *National Action Plan on Climate Change* from 2008 (*via* Grantham Institute, 2008). The plan emphasizes the importance of maintaining high economic growth rates; the plan "*identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively*". In order to decouple the economic catch-up effect as a developing country from polluting emissions, is not an easy job. A large share of the population faces many challenges, such as poverty alleviation and increasing low living standards: many inhabitants are lacking proper housing and potable water, and still 15% of the population has no access to electricity (2018). Given the fact that an important part of India's energy infrastructure is yet to be built, a 'sustainable transition' is an important requirement to prevent many additional emissions in the future. Another climate related problem of the developing nation is that 63% of the Indian population still rely on traditional biomass (charcoal etc.) for cooking in 2014 (Climate Transparency, 2018). This use of biomass has detrimental effects on both environment and public health.

Many initiatives have been launched by the Indian government which are expected to contribute significantly to India's NDC-targets. India has pledged to reduce its emissions intensity per unit of GDP by 33% to 35% below 2005 by 2030 and create an additional carbon sink of 2.5 to 3 $GtCO_2$. Kuramochi *et al.* (2018) summarize a couple of the recently introduced or planned programs and policies, which will have a large impact on reducing emissions: the *National Solar Mission*, the programs implemented under the *National Mission for Enhanced Energy Efficiency* such as the *Perform, Achieve and Trade scheme* and the *Standards and Labelling scheme*, and the *Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles initiative* adopted in April 2018. COMMIT (2018) states that there are still considerable uncertainties regarding the scale and pace of adopting various technologies. They refer to the example of electric vehicles and renewable-based power generation. The scale-up and adoption of these options depend on how quick technology and battery costs can attain commercial viability and become attractive alternatives for fossil-based driven vehicles. Another hurdle may be the delays in legislation for various policies.

Climate policy

- **NDC Target :** Reduce emissions per unit of GDP by 33% to 35% below 2005 levels by 2030.
  The emission intensity target is unconditional and includes land-use. Some additional NDC targets have been specified, which are indirectly related to emission reductions.
- **Most important climate strategy document:**
  India published its National Action Plan on Climate Change (NAPCC) in 2008 (*via* Grantham Institute, 2008), split into eight missions on diverse aspects of climate mitigation and adaptation policy. India's states are also required to produce decentralized climate action plans. Some of these include

emissions reduction commitments, e-mobility policies or solar and wind capacity quotas (Nachmany *et al.,* 2014).

Climate Transparency (2018) reports that India is in the process of developing its long-term emissions development strategy.

- **Policies with largest impact on reducing GHG emissions:**

  According to Kuramochi *et al.* (2018), the main mitigation-related policies implemented in India include renewable energy targets and a range of support schemes laid out under the *12th Five Year Plan*, the market-based mechanism *Perform Achieve and Trade (PAT) scheme for energy efficiency*, the *Clean Energy Cess* (coal tax), and increasingly the support for electric vehicles.

- **Important side note:**

  Please note that many of the major Indian targets for 2030 are *conditional*, which effectively means that India demands that foreign developed countries help them, before India will turn its ambitions consequently into action. The share of non-fossil fuel power generation has to increase to about 40%, for instance, on the condition of transfer of technology and low-cost international finance. Altogether, India estimates it will need at least $2.5tn up to 2030, from both domestic *and* international funds, in order to attain its targets (Carbon Brief, 2018). According to an analysis by Carbon Brief, India already received some funding from foreign parties. COMMIT (2018) argues that it is “*difficult to assess whether the funds are going towards the development of clean technologies or towards the broader development agenda*”. Either way, the available finance under current conditions would be definitely too low in order to support India in their sustainable ambitions, according to COMMIT.

  The issues at stake are not solely economic ones - also some institutional challenges would be involved. When it comes to technology transfers, parties would need to carefully assess the risks involved before applying the technology in India, due to India’s underdeveloped institutional environment: parties should, for instance, take into account that there are not many safeguards for protecting the intellectual property rights. Overall, one cannot be certain about India consequently living up to the conditional targets if additional help is not provided (COMMIT, 2018).

C.8 Indonesia

Climate change policy in Indonesia

A large share of Indonesia's emissions are related to forestry and land use, due to developments with regard to deforestation, peatland destruction and other forms of land-use change. There is large uncertainty in Land use, land-use change, and forestry (LULUCF) emissions, particularly related to peat oxidations (not including peat fires), which can vary between the 30% to 50% of total LULUCF emissions. Uncertainty concerning emissions from peat fires is also high and it is well known that these emissions differ significantly between years. Altogether, it is difficult to project emissions for Indonesia, argue Kuramochi *et al.* (2018). It has been difficult to assess whether the 2020 pledge and 2030 NDC targets will be achieved. Still, the authors expect it more likely that Indonesia will fall short on their targets. Contrastingly, two other recent studies (Keramidas *et al*., 2018; Climate Action Tracker, 2019), both excluding LULUCF emissions, project that the conditional NDC may be achieved.

The Indonesian president Joko Widodo was re-elected in 2019 (Carbon Brief, 2019). He declared victory in the presidential election, after his campaign which focused primarily on stimulating Indonesia's economic growth. The Jakarta Post (2019), an English language Indonesian newspaper, says that any mention of climate change is "tragically absent". Carbon Brief (2019) refers to research by an Indonesian NGO (called 'Jatam'), which found that a major share of the donations reported in the Widodo campaign would relate in some way to big mining and fossil-fuel companies. The same applies to his biggest competitor in the race for presidency.

In Indonesia, climate change is a moderately important theme for voters; across the country, 41% of people describe themselves as "very concerned" about climate change, according to a poll taken in 2015 (Carbon Brief, 2019). However, this is lower than the proportion of people concerned in neighbouring Vietnam (69%), Malaysia (44%) and the Philippines (72%). Economy-related themes have scored higher in the same poll. This voting behaviour may be explained by the fact that the economic growth in Indonesia has been consistently low over the past years. Indonesia's main challenge with regard to climate change is to develop a strategy that will lead to low-cost mitigation and at the same time will increase economic growth: decoupling GDP growth from emission growth.

Climate policy

- **NDC Target :**
  - 26% GHG emissions reduction by 2020 from baseline scenario.
  - 29% GHG emissions reduction by 2030 from baseline scenario (unconditional).
  - 41% GHG emissions reduction by 2030 from baseline scenario (conditional).

  The emission targets include land-use. Some additional NDC targets were specified, which are indirectly related to emission reductions: the NDC refers, for instance, to the renewable energy targets policy (2014), which aims at a 15-23% share of renewable energy in primary energy supply by 2025.

- **Most important climate strategy document:**

  According to Nachmany *et al.* (2014) the 'flagship policy' in Indonesia, would be the *National Action Plan to reduce GHG emission*, from 2011. This policy would be the national guideline for emission reduction covering 70 programmes, to be conducted together by the Central Government, Local Governments, private sectors/business actors and civil society. Different sectors are covered in the document, including the forestry, peat land and agriculture sector which are responsible for many of the emissions of the country. Also the energy, transportation and industry sector are represented.

  In October 2017, the Indonesian government announced a new initiative aimed at incorporating climate action into the country's development agenda. Until that moment, the country's development agenda consisted of four separate five-year plans, spanning the period between 2005 and 2025 (Carbon Brief, 2019). The country's National Medium-Term Development Plan for 2015-19 (the third) says that a "green economy" should be at the foundation of Indonesia's development. The plan targets the eradication of illegal logging, fishing and mining and increased participation of local people in forest management.

The Indonesian government is currently forming a long-term low emission development strategy (2050 strategy). The strategy has not been communicated to the UNFCCC as of July 2019 (Climate Transparency, 2018).

- **Policies with largest impact on reducing GHG emissions:**
  The main mitigation-related policies implemented in Indonesia include the policies that are targeted at the LULUCF sector, according to Kuramochi *et al.* (2018). Examples which are mentioned in the same research are the *Presidential Instruction number 6/2013 on Forest Moratorium*, which restricts oil palm extension. From 2016 to 2017, forest loss in Indonesia fell by 60%, say analysts (Carbon Brief, 2019). This would be partly due to the moratorium. In early 2018, president Widodo even announced a nationwide moratorium on the draining of Indonesia's peatlands. He later set up the Peatlands Restoration Agency and tasked it with restoring two million hectares of tropical peatlands by 2020. Also in September 2018, Widodo issued a presidential instruction to place a moratorium on new permits for palm plantations for three years (Carbon Brief, 2019). New policies, such as those ones, implemented *after* June 2018 were not included in the current policy projections used for the projections of the indicators.
- **Important remark on Climate Policy in Indonesia:**
  This report does not focus on the emissions (sequestration potential) from the LULUCF sector. It should be highlighted that important challenges for Indonesia still need to be faced in this sector. Think, for instance, about all the tropical peatlands that are drained. These wet and swampy forested environments have soils that can hold up to 20 times more carbon than other types of mineral soil. Large areas of peatland are currently drained for agriculture (especially palm-oil cultivation). Due to the drainage, a large share of GHGs are lost from the soil and due to these practices, the risk of fire and flooding increases, which is problematic due to related environmental and socio-economic costs (Carbon Brief, 2019).

C.9 Japan

Climate change policy in Japan

Japan is the world's third largest economy and seventh largest emitter of greenhouse gases (GHGs). Its plans for decarbonisation were significantly changed after the 2011 Fukushima nuclear disaster led it to move away from nuclear power. The former Japanese decarbonisation plan heavily relied on nuclear energy. However, after the Fukushima event, all nuclear power plants were shut down. To date, only a few plants have resumed operations and until recently, no new construction plan was running (Climate Action Tracker, 2019; Carbon Brief, 2018). Under current policies, Japan is projected to overachieve its 2020 emission pledge *and* its 2030 renewable electricity target of 22-24% by 2030.

In June 2019, Japan published its long-term climate strategy, providing more insight in their desired future energy mix. Japan is not shying away from nuclear energy anymore, but does not merely rely on the source only (also exploring other options including energy efficiency, renewable energy, battery storage, hydrogen and CCS). The strategy states: *"The non-fossil power ratio is expected to reach approximately 44% of the energy mix in FY 2030 by promoting the introduction of renewable energy and restarting nuclear power plants that are recognized to have met the world's strictest regulatory standards set by the Nuclear Regulation Authority (NRA). The non-fossil ratio in FY 2013 was approximately 12%, meaning an increase of about 2 percentage points a year is necessary to meet the level set out in this energy mix"* (Government of Japan, 2019).

The strategy would rely especially on 'business-led disruptive innovation', thereby realizing a 'virtuous cycle of environment and growth'. Following this road, Japan claims to be able to swiftly implement actions from now on, leading to a reduction of GHG emissions by 80% by 2050 (compared to 2010) within the country's borders. At the same time, the country argues it wants to share its knowledge with the rest of the world. The strategy includes plans to innovate in areas such as hydrogen, carbon capture and utilization (CCU) and carbon capture and storage (CCS). The strategy aims to establish commercial-sized CCU technology by 2023, and to commercialize CCS applied on coal-fired power generation by 2030. It also sets out plans to become a 'hydrogen society'. It includes, for instance, plans to cut the cost of producing CO_2-free hydrogen to less than one-tenth by 2050.

Japan keeps relying on coal, but will increase the efficiency and deals with its emissions differently, by storing a part of it in sinks or re-using it for other industrial purposes. The actual impact of these new measures should be calculated later, when concrete policy measures have been developed and implemented. Yet, the strategy makes clear that full phase-out of coal will not take place. This is not consistent with the findings of the IPCC Special Report on 1.5°C (UNEP, 2018), which recommends that coal-fired power needs to be phased out by 2050 globally to keep warming below 1.5 °C with limited or no overshoot.

Japan has a long-established tradition of legislation on climate change issues, according to Nachmany *et al.* (2014). In 1998 Japan introduced an *Act on Promotion of Global Warming Countermeasures*, which created a legal framework for climate change policy. The law stipulated that a plan for reaching Japan's target should be established when the Kyoto Protocol came into effect. Japan itself hosted the third formal meeting of the UNFCCC in Kyoto, leading to the adoption of the famous international treaty. Japan established a *Kyoto Achievement Plan*, reached its own Kyoto-target and is now well on its way to meet its 2020-emission reduction pledge. Still, Japan has to deal with a lot of criticism with regard to their climate policies (Carbon Brief, 2018).

Climate policy

- **NDC Target :** Japan aims in its NDC to reduce GHG emissions by 26% by 2030 compared to 2013 levels.

  The target is unconditional and includes land-use.
- **Most important climate strategy document:**

  Japan's climate policy strategy is strongly connected to the targets set in an international context. Japan's first coordinated large-scale action on climate took place under the Act on Promotion of Global Warming Countermeasures, which has been mentioned already. This law was passed in 1998 and aims to reduce human-caused global warming by "formulating a plan for attaining targets".

  A more recent nation-wide strategical plan on climate change measures was released in May 2016. This revision of the *Plan for global warming countermeasures* (Grantham Institute, 2016b) serves to "clarify the pathway" in order to achieve Japan's NDC goal. The biggest cuts are expected to come from the commercial, residential and transport sectors, writes Carbon Brief (2018).

In June 2019, the long-term strategy for 2050 was published (see "Climate Change Policy in Japan").

- **Policies with largest impact on reducing GHG emissions:**

  The main GHG mitigation policies implemented in Japan include the renewable feed-in tariff scheme, 2018 Basic Energy Plan, Top Runner Standards program as well as the F-gas Act and the Ozone Layer Protection Act on F-gases, according to Kuramochi *et al.* (2018).

  In July 2018, the new *Basic Energy Plan* was adopted by the Cabinet (METI, 2018). It foresees 20–22% of electricity being supplied by nuclear energy, 22–24% by renewable energy and the remaining 56% by fossil fuel sources. The same target was mentioned in the NDC for 2030. The analysts of Climate Action Tracker (2019) are concerned about these targets, because fossil fuels keep playing an important role in future scenarios. 26% of total electricity generation is still expected to come from coal-fired power plants. They argue that this share could increase even further, as the government may still need them as 'back-up-plan'. The Fukushima-event is still well-remembered by a large part of the Japanese population. The strong public opposition and conflicting district court rulings with regard to new nuclear generation (see JAIF, 2018) brings major challenges to the foreseen nuclear contribution to the future energy mix.

  A new policy with the potential of some high impact could be Japan's carbon pricing proposal. Japan's environment ministry is currently working on a carbon pricing proposal, although opposition remains in parts of the government. The plans will be discussed in the coming years, according to the Japanese long-term climate strategy (Government of Japan, 2019).

C.10 Kazakhstan

Climate change policy in Kazakhstan

Kazakhstan is an interesting casus with regard to climate policy. On the one hand it is one of the largest contributors to worldwide emissions on a per capita basis. While on the other hand, it is also one of the countries that will face many early negative consequences of climate change. The main source of economic growth is the country's raw resources. The country exports large amounts of oil and gas and is a leading producer of many mineral commodities. It also produces large amounts of Uranium (world leader) and hydrocarbons. Since 1985, the production of hydrocarbons has increased with 225% (UNDP, 2019).

The second most important sector for Kazakhstan is the agriculture sector. However, it is estimated that nearly 75% of the country's territory is subject to high-risk ecological destabilization – having major impact on the economy, food security and public health. The UNDP (2019) summarizes the situation in the following way: *"While Kazakhstan has a rapidly growing economy, rural population, farmers and pastoralists outside of the main urban centres face significant climate change risks to their livelihoods stemming from increased aridity, water management challenges and extreme weather events. The average annual air temperature increased by 0.31 °C in the 10 years since 2000".*

In 2007, Kazakhstan adopted *The Ecological Code of the Republic of Kazakhstan*. The Ecological Code is a general law that addresses a variety of environmental and climate issues. Principally, it is the most basic juridical framework on which further climate policies will build. It states that the country shall prioritize prevention and mitigation of climate change and regulate according to principles that limit the amount of GHGs released into the atmosphere. However, 8 years later, Kazakhstan's fossil share in the primary energy mix is still 100%, the GHG emissions have increased significantly and the government announced various plans for increasing oil and gas extraction (Nachmany *et al.*, 2014).

In 2015 the Ministry of Environment and Protection published a final document titled "*Transition of the Republic of Kazakhstan to Green Economy*", which identified regulatory priorities as well as legislative opportunities for green growth. The recommendations include adjusting existing laws and regulations to coincide with a "green economy". The policy aims for 30% of electricity generation originating from alternative and renewable energy sources (including nuclear) by 2030 and 50% by 2050, and reducing current CO_2 emissions in electricity production by 40% by 2050, while also increasing the share of gas power plants to reach 30% by 2050 (Government of Kazakhstan, 2015).

Climate policy

- **NDC Target :** 15% reduction in GHG emissions by 2030 compared to the 1990 base year.
  The target is unconditional and includes land-use. It should be recognized that Kazakhstan also has a conditional pledge, aiming for a 25% reduction in GHG emissions by 2030.
- **Most important climate strategy document:** Nachmany *et al.* (2014) state that one of the most important climate change related strategy documents in Kazakhstan is *The Concept of Transition of the Republic of Kazakhstan to Sustainable Development for the Period 2007-2024.* It is an exhaustive policy document, which helps Kazakhstan to plan national development over two decades, while going through several stages. The Concept was developed within the framework of the World Summit on Sustainable Development by the Ministry of Environment with support from UNDP, UNEP-EU, as well as scientists and experts (Nachmany *et al.*, 2014). In the latest stage (2019-2024), Kazakhstan should have been working on achievement of international standards of sustainable development and the county would plan to adopt an own emissions trading system in 2016. After its introduction, the system ('KAZ ETS') was suspended until 2018 (ICAP, 2016). Although it has been relaunched effectively, uncertainties remain over its implementation.
  Another strategy document is the "*Transition of the Republic of Kazakhstan to Green Economy*" (Government of Kazakhstan, 2015) (See *Climate Change in Kazakhstan*). This document sets, for instance, targets on energy efficiency and renewable electricity generation. So far, Kazakhstan has not communicated a long-term strategy to the UNFCCC. Nevertheless; Kazakhstan already has chosen an emission reduction target for 2050, according to Climate Transparency (2018); Kazakhstan would have proposed a 2050 target of 25% reduction below 1992 levels excluding LULUCF (equivalent to an emission reduction of 34% below 1990 levels excluding LULUCF).
- **Policies with largest impact on reducing GHG emissions:**

The policy with the relatively highest impact on GHG emissions is probably the *Action Plan for the development of alternative and renewable energy in Kazakhstan for 2013-2020* (Government of Kazakhstan, 2013b). This policy consists of plans to build around 106 renewable energy installations with a total installed capacity of 3055 MW, which enter into operation by 2020.

C.11 Russia

Climate change policy in Russia

While some countries' climate policy relies on legislated acts (e.g. Mexico or the UK), or strategic policy documents (e.g. South Africa), Russian climate policy exists mostly of executive orders. In general, the President can pass such executive decrees on any issue without limits, if a valid federal law does not regulate that issue (Nachmany *et al.,* 2014).

The Climate Doctrine policy (*via* Grantham Institute, 2009), approved in December 2009, marked a crucial step in Russia's recognition of the potential threats of climate change, as described in Nachmany *et al.* (2014) in their Climate Policy overview of Russia. It is meant to set strategic guidelines and targets for the years to come and serve as a foundation for developing and implementing future climate policy; the Doctrine is based on fundamental and applied scientific knowledge, including various studies carried out within the Russian Federation.

Climate policy

- **NDC Target :** Limiting anthropogenic greenhouse gases to 70% to 75% of 1990 levels by 2030**.**
  The target is unconditional. The land use sector is included in the target.
- **Most important climate strategy documents:**
  The most important policy strategy is probably the Climate Doctrine (*via* Grantham Institute, 2009) (see *Climate Change Policy in Russia*). The policy sets guidelines and serves as a foundation for future policies (Nachmany *et al.,* 2014). Nevertheless, the policy is relatively old, legally non-binding and, according to researchers in the COMMIT project (COMMIT, 2018), the follow-up process of implementing actual mitigation policies is not comprehensive or well-coordinated. A new climate policy document that is currently being written is the *National strategy for adaptation to climate change* (350.org, 2017). Russia has neither a long-term emissions strategy, nor a 2050 target.
- **Policies with largest impact on reducing GHG emissions:**
  The highest-impact policies include the Russian State Program targets for energy efficiency and renewable electricity generation. Russia's gas flaring policy could lead to additional emission reductions, especially because Russia has the globally largest emissions from flaring practices (Nachmany *et al.*, 2014), but it is unclear whether this policy will be fully implemented according to Kuramochi *et al.* (2018).

  Other important planned policies, which are not included in the current policy projections, are, for instance, the transport strategy and the plan to stimulate the development of renewable energy generation facilities with installed capacity up to 15 kW. Some other high-impact policies may be coming up soon; the draft amendment of the *Law on Environmental Protection* would enable the government to introduce GHG reduction targets for companies and impose fines for those that failed to meet the targets (Kuramochi *et al.*, 2018). This bill, the draft of which was published in December 2018, refers to the development of a market-based mechanism. Several sources report that Russia is working on a cap-and-trade system for major carbon emitters (Climate Action Tracker, 2019; Bloomberg Environment, 2019). Russia announced to work on both carbon pricing and participation in international mechanisms already in their 2009 strategy; however, none of these legislations have been passed as of August 2019.

C.12 United States

Climate change policy in the United States of America

The major changes in US climate policy, after the Trump Administration entered the White House, have drawn the attention from a worldwide audience. This major interest could be explained by the fact that the USA is the globally second largest emitter of absolute GHG emissions, with 14.36% of the global GHG emissions in 2017 (WRI, 2017).

Under the Obama Administration, The United States of America submitted its NDC to reduce its GHG emissions by 26%–28% from 2005 levels (20% to 24% from 2010 levels) by 2025 and ratified the Paris Agreement in September 2016 (UNFCCC, 2019). The government also set a 2020 pledge of a 17% reduction from 2005 levels (13% from 2010 levels). However, the Trump administration has announced that the United States intends to "exercise its right to withdraw" from the Paris Agreement and cease implementation of the NDC. In 2018, the administration has stopped, replaced, or proposed to weaken many of the main national level mitigation-related policies implemented to date. Climate Action Tracker summarizes them: *"Since the beginning of 2018, the US Environmental Protection Agency (EPA) has proposed a weak replacement for the Clean Power Plan, has weakened methane emissions standards for oil and gas facilities, has proposed freezing emissions standards for light duty vehicles after 2020 and will not enforce measures to reduce HFC emission"* (Climate Action Tracker, 2019).

While many existing stringent climate policies have been abolished, also new climate resolutions were voted down. For instance, the Green deal resolution was introduced in the US House of Representatives in February 2019, consisting of non-binding resolution calls for reaching net-zero GHG emissions (Ocasio-Cortez, 2019). Climate Action Tracker (2019) argues that the resolution has sparked a discussion about the need for a much stronger approach to climate action in the USA.

In this report and in the report by Kuramochi *et al.* (2018), no sub-national policies were included in the current policies projections. However, individual state and local actions are important for the USA because of their impact on GHG emissions. These local initiatives have seen a boost after national climate policy has become less stringent. An analysis of recorded and quantified commitments from sub-national and non-state actors in the US suggests that if these commitments were fully implemented, the ambitions of the NDC will still not be met (Kuramochi *et al.*, 2018).

Climate policy

- **NDC Target :** 26%–28% GHG reduction by 2025 from 2005 levels.
  The target is unconditional. The land use sector is included in the target.
- **Most important climate strategy document:**
  The US submitted a mid-century strategy ('For Deep Decarbonization') to the UNFCCC in 2016 (UNFCCC, 2019), under Presidency of Barack Obama. The strategy looks into possible pathways to reduce emissions by 80% by 2050 from 2005 levels. Climate Action Tracker (2017) writes that the Trump Administration has removed the mid-century strategy from all government websites. Therefore, it is unclear whether the target still stands. There is no overarching or strategic policy for economy-wide emission reductions in the USA. Also on the website of the United States Environmental Protection Agency (EPA), no such strategies are found (EPA, 2019).

- **Policies with largest impact on reducing GHG emissions:**
  Policies that affect GHG emissions are, for instance, the *Renewable Portfolio Standards* from various individual States (US Department of Energy, 2019a) and the *Renewable fuel standard* (EPA, 2018a), as shown by Kuramochi *et al.* (2018). The latter demands that the volume of renewable fuel that is blended into transportation fuel increases from nine billion gallons in 2008 to 36 billion gallons by 2022. Other high-impact policies were introduced in California; for example, the *Global Warming Solution Act* of 2006, their cap-and-trade system and their *Advanced Clean Cars Program* including the *Zero Emissions Vehicle program* (Kuramochi *et al.*, 2018).