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Are the G20 economies making enough progress to meet their NDC targets?

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ABSTRACT

Under the Paris Agreement, countries committed to a variety of climate actions, including post-2020 greenhouse gas (GHG) emissions reduction targets. This study compares projected GHG emissions in the G20 economies under current climate policies to those under the GHG targets outlined in the nationally determined contributions (NDCs). It is based on an assessment of official governmental estimates and independent national and global studies. The study concludes that six G20 members (China, India, Indonesia, Japan, Russia and Turkey) are projected to meet their unconditional NDC targets with current policies. Eight members (Argentina, Australia, Canada, the European Union, Republic of Korea, South Africa and the United States) require further action to achieve their targets. Insufficient information is available for Saudi Arabia, and emission projections for Brazil and Mexico are subject to considerable uncertainty. The study also presents high-level decarbonisation indicators to better understand the current progress towards meeting the NDCs – Saudi Arabia and South Africa were found to continue increasing both emission intensity per unit GDP and emissions per capita under current policies by 2030 from 2015 levels.

1. Introduction

Now that the Paris Agreement has entered into force, governments urgently need to increase ambition of post-2020 climate commitments to ensure meeting the temperature goals outlined therein (Höhne et al., 2017; Rogelj et al., 2016). The Paris Agreement aims to hold global warming to well below 2 °C relative to pre-industrial levels, while pursuing efforts to limit warming to 1.5 °C (UNFCCC, 2015a). In advance of the Paris meeting, almost all countries submitted national post-2020 climate action plans and commitments, as part of their Intended Nationally Determined Contributions (INDCs). These commitments are the foundation of the Paris Agreement. By 15 November 2017, 192 of the 197 Parties to the UNFCCC, representing about 98% of global 2012 emissions, had submitted their INDCs. Over 170 Parties have ratified the agreement, thus turning their INDCs into NDCs. While the current NDCs are projected to reduce warming relative to a no-policy baseline scenario, even if they were fully implemented, their combined mitigation impact would fall far short of what is required to limit global warming to well below 2 °C, let alone 1.5 °C (Rogelj et al., 2016).

NDCs are not static or one-off commitments; countries have the obligation to strengthen them regularly, informed by progress assessments that occur every five years under the Paris Agreement. That process begins with the 2018 Facilitative Dialogue (now known as "Talanoa Dialogue"), in which countries for the first time take stock of their collective efforts towards meeting the Paris climate goals, and use the assessment to inform the preparation of NDCs. In addition to the collective assessment, the extent to which individual countries are progressing towards achieving their NDCs/INDCs (hereafter referred to as NDCs, unless mentioned in relation to a country that has not ratified the Paris Agreement) is also pertinent to the preparation of future NDCs, in that countries on track to meet or exceed their current

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commitments may be particularly well positioned to take on stronger commitments.

There is also an increasing need for a consistent and harmonised approach to track progress of countries towards their NDCs at different levels of detail and taking into account different perspectives. A number of assessment indicators and frameworks have been proposed in recent years (Compston and Bailey, 2016; Höhne et al., 2018; Peters et al., 2017).

This paper presents an updated assessment of the emissions associated with the NDC targets and current policies of each of the G20 members (that is, the non-EU members of the G20 as well as the European Union (EU28) as a whole – thus a total of 16). As these economies are collectively responsible for around three quarters of global GHG emissions, their success in implementing (or exceeding) their NDCs will have a major impact on the achievement of the Paris Agreement goals. To date, however, no peer-reviewed literature has assessed the progress toward the NDC commitments of all G20 economies in a consistent manner. Independent, comparable analyses can complement assessments conducted under the UNFCCC.

This study updates and expands on the work undertaken under the 2017 UNEP Emissions Gap Report (UNEP, 2017) by updating emissions projections of the current policy scenario from recently published National Communications and Third Biennial Report for seven G20 members (Argentina, Australia, Canada, EU28, Japan, Russia and Turkey) (UNFCCC, 2018b, 2018d), new and/or updated country-specific studies for seven G20 members (national models) and four global model studies. In addition, this study describes the detailed methodology underlying the analysis (Section 2), and compares NDCs and current policy scenario projections by looking at commonly used high-level decarbonisation indicators to provide further insights into the G20 members' progress towards the NDC targets (Section 5). This study also presents a discussion with the caveats and methodological limitations (Section 6). Finally, conclusions and policy implications of this study are drawn in Section 7.

2. Methodology

2.1. Scenario definition and data sources

To assess the progress of G20 members towards their NDC targets, this study compares target-year emissions under each member's current policies to those associated with the achievement of its NDC. For each G20 member, estimates of emissions in the NDC target year (2025 or 2030) are compared for the following scenario groups:

2.1.1. NDC scenarios (unconditional and conditional)

Identifies the GHG emissions that each member could emit in the target year (2025 for the US, 2030 for the other G20 members) under the unconditional and, when available, conditional NDCs. Where available, the emission levels reported by the national governments are used as central estimates (UNFCCC, 2016); alternatively, the emission levels are calculated from base-year or baseline data based on the NDCs and on other official documents submitted by countries to the UNFCCC (e.g. national GHG inventories, national communications, biennial reports and biennial update reports) (Table 1 and Appendix A). Emission level estimates published in the literature are also considered (if official values were not available) (Table 1: independent sources).

2.1.2. Current policy scenario (official data)

Identifies the most recent, available official estimates of target year emissions, accounting for the projected emission trends resulting from current climate-, energy- and land-use policies. The sources of country estimates from official documents are provided in Table 1. The modelling base year of the current policy scenario projections differ across reports.

2.1.3. Current policy scenario (independent studies)

Identifies emissions estimates for the target year, accounting for emission projections resulting from the full implementation of current policies based on independent studies. Emissions projections reviewed here cover main energy and climate policies that were implemented by a recent cut-off date (i.e., 2016 or 2017 depending on the studies) and do not consider prospective policies that were still under consideration or planning as of the cut-off date. Moreover, while studies differ in their approaches for policy impact quantification, they do not automatically assume that policy targets will be achieved when they are enshrined in the form of a law or a strategy document – studies also consider the status of policy implementation and the extent to which the policy plan is supported by measures. Estimates were drawn from four global model analyses: the Climate Action Tracker (CAT, 2018a), International Energy Agency (IEA, 2017), Joint Research Centre (JRC) (Kitous et al., 2017), and PBL Netherlands Environmental Assessment Agency (Kuramochi et al., 2017a; PBL, 2017; den Elzen et al., 2016). In addition, we also covered estimates published in a wide range of country-specific sources using national models (Table 1). The independent analysis of current policy trajectories supplements the official sources described in Section 2.1.2 by providing data that targets consistency across countries and political independence.

2.2. Evaluation of whether countries are on track to meet the NDC targets

Based on the emissions data collected as described in Section 2.1, we assessed whether G20 members are on track to meet their NDC targets. The following evaluation categories were defined: (i) on track, (ii) further action needed, and (iii) uncertain or insufficient information. The evaluation did not consider the potential use of offsets to achieve the emissions reduction targets; it considered only national emission trends.

We first evaluated whether a country would fall into the first two categories, based on the number of independent studies that support each of the evaluation categories. When the studies were inconclusive or showed large ranges, we also assessed the average estimates of the current policy scenario projections across all studies (median estimates are used when more than five studies are available). The second evaluation category ('further action needed'), was divided into two subcategories – 'low additional effort' denoting a current policy trajectory (average estimate across studies) less than 15% lower than the (average) unconditional NDC target, and 'high additional effort' denoting a current policy trajectory (average) more than 15% higher than the unconditional NDC target.

The third evaluation category ('uncertain or insufficient information') was applied when studies disagreed considerably on their current policy scenario projections or when there was not enough information to judge the countries' progress towards their NDC targets.

2.3. Assessment of high-level decarbonisation indicators

The quantified emissions range for NDC targets and current policy scenario projections were also assessed using a number of high-level decarbonisation indicators that are frequently used in the context of climate policy making. We considered IPAT[1] and Kaya identity indicators (Blanco et al., 2014): population, Gross Domestic Product (GDP) per capita, and GHG emissions per unit of GDP, as well as GHG emissions per capita to obtain further insights into the G20 members' current effort levels and the mitigation contributions under the Paris Agreement.

[1] The IPAT identity, proposed by Ehrlich and Holdren (1971) is described as: Impact = Population * Affluence * Technology. The Kaya identity is "a special case of the more general IPAT identity" and only considers CO_2 emissions from fuel combustion (Blanco et al., 2014).

Table 1
Studies used from official data and independent sources to estimate the emissions in the target year under the NDC and under current policies for G20 members.

Country	NDC scenario Official data sources	Current policy scenario Official data sources	Current policy & NDC scenario Independent sources (1. global models and 2. national models)
Argentina	NDC - Government Argentina (2016)[a]	Ministry of the Environment and Sustainable Development Argentina (2015)[b]	1. CAT, JRC
Australia	NDC (UNFCCC, 2016)[c]	Government of Australia (2017)	1. CAT, JRC, PBL2. RepuTex (2016); Climate Works Australia (2018)
Brazil	NDC (UNFCCC, 2016)	N/A	1. CAT, JRC, PBL2. COPPE (Rochedo et al., 2018).
Canada	NDC; Environment and Climate Change Canada (2017)	Environment and Climate Change Canada (2017)	1. CAT, JRC, PBL
China	N/A[d]	N/A	1. CAT, IEA[e], JRC, PBL2. ERI – updated (based on Jiang et al., 2013)[f], NCSC (Sha, 2018; Sha et al., 2017)[f]
EU28	NDC (UNFCCC, 2016)[c]	EEA (2017); European Commission (2016b, 2017); E3MLab and IIASA (2018)	1. CAT, JRC2. E3MLab (Fragkos et al., 2017)[g]
India	N/A[d]	N/A	1. CAT, IEA[e], JRC, PBL2. Mitra et al. (2017); IIMA[e] (Vishwanathan and Garg, 2017); Energy Division, NITI Aayog, Government of India (Dubash et al., 2018)
Indonesia	NDC (UNFCCC, 2016)[a]	N/A	1. CAT, JRC, PBL
Japan	NDC (UNFCCC, 2016)[c]	N/A	1. CAT, JRC, PBL2. AIM model (Spencer et al., 2015)
Mexico	NDC (UNFCCC, 2016)[a]; Government of Mexico (2015)[a]	N/A	1. CAT, JRC, PBL
Russia	INDC (UNFCCC, 2015b)[c]	Government of Russia (2015)	1. CAT, JRC, PBL
Saudi Arabia	N/A: Saudi Arabia did not formulate a post-2020 GHG target (UNFCCC, 2016)	N/A	1. CAT (based on KAUST, 2014), JRC
South Africa	NDC (UNFCCC, 2016)	Department of Environmental Affairs (2014)	1. CAT, JRC, PBL
Republic of Korea	NDC (UNFCCC, 2016)[a]	N/A	1. CAT, JRC, PBL
Turkey	INDC (UNFCCC, 2015b)[a]	Third Biennial Report (UNFCCC, 2018d)	1. CAT, JRC, PBL
United States	NDC – U.S. Department of State (2016)[c]	U.S. Department of State (2016)	1. CAT, JRC, PBL2. Chai et al. (2017); Iyer et al. (2017); Rhodium Group (Larsen et al., 2018)

N/A: Not available.

[a] The 2030 emission level is calculated using the BAU scenario presented in the country's NDC.

[b] http://unfccc.int/resource/docs/natc/argnc3s.pdf, see also inventory report: http://ambiente.gob.ar/wp-content/uploads/Inventario-GEIs-Argentina.xlsx.

[c] The 2030 target level of the emissions is calculated based on historical country's GHG emissions levels submitted via the Common Reporting Format 2017 (2016 inventory for the United States and Canada) to the UNFCCC after converting GWP values from those in the IPCC Fourth Assessment Report to those in the IPCC Second Assessment Report (SAR).

[d] There are no official estimates for the NDC projections available. Projections are based on country-specific studies and independent global analyses. The 2030 emission levels resulting from the NDC of China and India highly depend on the assumptions about future rates of GDP growth. Here the median estimate of independent studies are used as described in Table 1, and in addition: University of Melbourne dataset (Meinshausen, 2016), Climate Interactive (Climate Interactive, 2017), Pacific Northwest National Laboratory (PNNL) (Fawcett et al., 2015).

[e] Only CO_2 emissions from energy, therefore augmented with CAT, JRC and PBL estimates to produce economy-wide projections.

[f] Augmented with the historical non-CO_2 GHG emissions data from China's First Biennial Update Report on Climate Change (The People's Republic of China, 2017), combined with the median estimate of the 2010–2030 non-CO_2 emissions growth rates for China from five integrated assessment models (Tavoni et al., 2015), to produce economy-wide figures.

[g] The current policy scenario is based on the EU reference scenario 2016 (European Commission, 2016b).

GDP and population projections underlying the NDCs and current policy scenario projections were not always reported in the independent studies as well as the government documents covered in this study; the reported underlying projections also differed considerably across studies for some G20 members. Therefore, the GDP projections were taken from the OECD GDP long-term forecast indicator, based on the economic climate in individual countries, using a combination of model-based analyses and expert judgement (OECD, 2018); population projections were taken from the UN World Population Prospects (medium fertility case) (UN, 2017). The use of an up-to-date, consistent set of GDP and population projections, which consider the most recent economic and demographic circumstances, from intergovernmental organisations allows for an analytically robust and more politically neutral assessment.

3. NDCs and emission trends of individual G20 members

To assess G20 members' progress towards achieving their NDC targets, this section compares current emissions trajectories with those associated with the achievement of these members' NDCs. Fig. 1 shows the projected impact of the NDCs and current policies on target-year GHG emissions for each of the 16 G20 members (with EU28 represented collectively instead of by the four Member States, which are individual G20 members), noting that for some countries and studies, data is not always fully available. By comparing the current policy scenarios and the NDC scenarios, the figure provides an indication of whether a country needs to enhance or implement additional policies to meet its NDC target.

Table 2 presents the evaluation results on whether G20 members are on track to meet their unconditional NDCs. This section should be read with three important caveats in mind. First, not all NDCs demand the same level of effort to implement, so a country currently on track to achieve its NDCs is undertaking more mitigation action than a country not yet on track. It depends highly on the ambition level of the NDCs, which this study does not assess, as well as on how strong the current set of policies are. Second, these projections are subject to the uncertainty associated with macroeconomic trends, such as gross domestic product (GDP) and population growth, technology developments as well as with the impact of policies. Section 6 discusses the caveats and limitations of the methodology in more detail.

We conclude that a country (i) is on track or (ii) needs further action based on the number of studies that support each of the evaluation categories (Section 2.2). Following these criteria, recent studies suggest that China, India, Indonesia, Japan, Russia and Turkey are on track to meet or overachieve their unconditional NDC targets through their current policies within the level of uncertainty (Table 2). Argentina, Australia, Canada, the EU28, South Africa, the Republic of Korea and the United States require further action to meet their NDCs, according

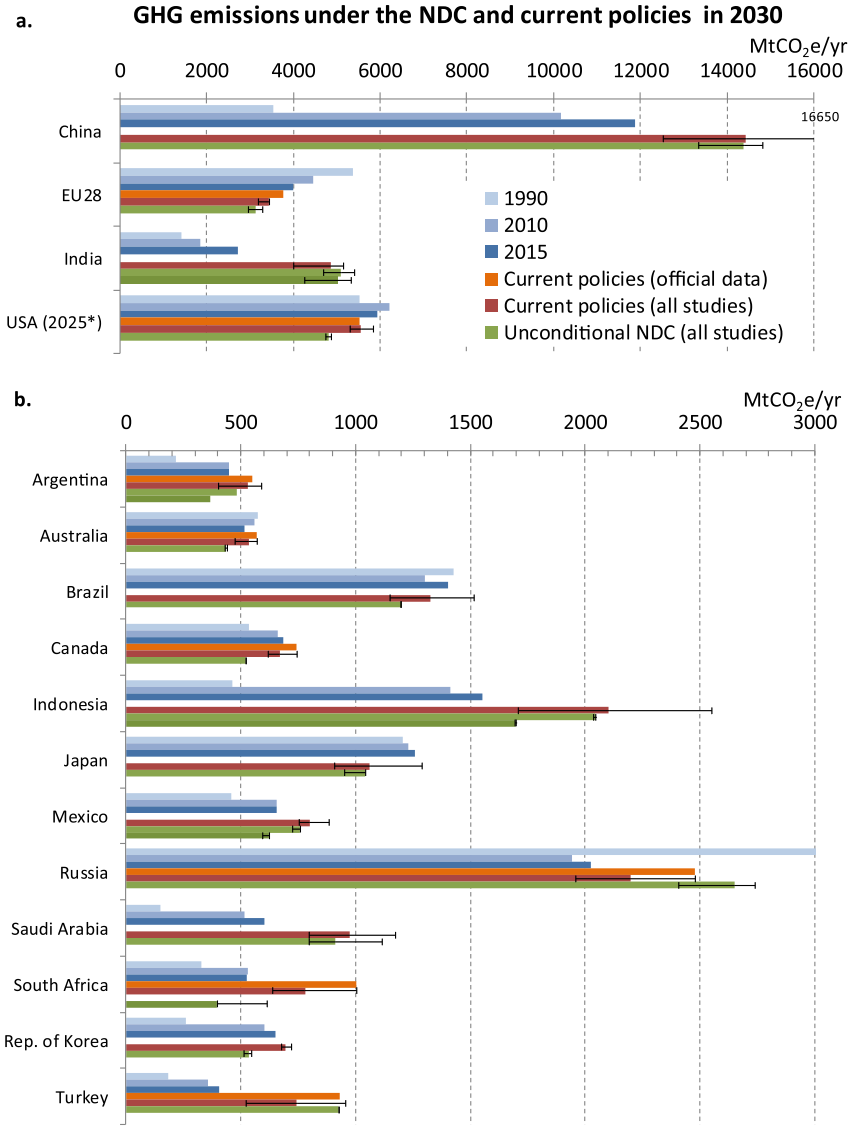

Fig. 1. Greenhouse gas emissions of the G20 members in the target year (2030, except for the USA: 2025) for current policy scenario from official data sources (fourth bar) and from official and independent sources (fifth bar), and unconditional and conditional NDC scenarios (sixth and seventh bar) from all data sources. Bars show the average estimate across studies (median estimate is used if more than five studies are available) of each range (official values are used for NDC scenarios when available). For current-policy and NDC scenarios, the 10th–90th-percentile ranges across all studies are provided, except if the number of studies is three or lower than the minimum–maximum ranges are used (Table 1). The historical emissions for 1990, 2010 and 2015, shown as first three bars, are described in Appendix A. For reporting reasons, the emissions projections for China, EU, India and United States are shown in panel (a), and the other countries in panel (b), with different horizontal axes. Note: * For the US, the unconditional NDC and current policies is for 2025. South Africa's NDC is based on an emission trajectory with an emissions range of 398–614 $MtCO_2e$. Source: based on Figure 3.3a and 3.3b of UNEP (2017), with updated emission projections from official and independent data sources and updated historical emissions data (up to 2015).

Table 2
Progress towards achieving the unconditional NDC targets for the G20 economies (methodology explained in text) in the target year (2030, except for the USA: 2025). The number of studies that support the finding (on track, further action needed and uncertain) are compared to the available studies, as indicated between brackets.

On track	Further action needed		Uncertain or insufficient information
	Low additional effort[a]	High additional effort[b]	
• China (5 of 6 studies) • India (7 of 7 studies) • Indonesia (2 of 3 studies) • Japan (3 of 4 studies) • Russia* (4 of 4 studies) • Turkey* (3 of 4 studies)	• Argentina (2 of 3 studies) • EU28 (6 of 6 studies)[c]	• Australia (5 of 5 studies) • Canada (4 of 4 studies) • South Africa (4 of 4 studies) • Republic of Korea (4 of 4 studies) • United States (2025) (7 of 7 studies)	• Brazil (studies disagree)[d] • Mexico (studies disagree)[d] • Saudi Arabia (insufficient information, 2 studies disagree)

* denotes if the average estimate of the current policy scenario projections across all studies (median estimates are used when more than five studies are available) in 2030 is more than 10% lower than the average 2030 NDC target.

[a] Low additional effort denotes if the average estimate (across all studies) of the current policy trajectory is less than 15% lower than the (average) unconditional NDC target.

[b] High additional effort denotes if the average estimate (across all studies) of the current policy trajectory is more than 15% higher than the average unconditional NDC target.

[c] The impact of the recently adopted revisions of ETS and 2030 goals of renewable energy and energy savings are not included in these three studies (See EU section).

[d] Two of the four studies for Brazil and Mexico show on track, but two other studies show not on track.

to government and independent estimates. In particular, Australia, Canada, South Africa, the Republic of Korea and the United States need a high additional effort (current policy trajectory more than 15% above the unconditional NDC target. From existing studies, it is not possible to determine whether Brazil and Mexico are on track to meet their NDCs, as about half of the studies indicate they are on track, but the remaining studies find the opposite. For Turkey, most studies agree that it is on track to meet its NDC, but also indicate a wide range of projections (Fig. 1). For Saudi Arabia, there is insufficient information to judge progress towards its NDC, because an official projection reflecting current policies is unavailable and it has not published the baseline corresponding to its NDC target.

In addition to unconditional targets, four G20 economies have communicated conditional targets in their NDCs – Argentina, Indonesia and Mexico are not on track to meet their conditional NDC target, whereas India is on track to meet its conditional NDC target.

Fig. 1 furthermore illustrates that progress on reducing absolute GHG emissions varies across the G20 members. (Some NDC targets allow absolute emissions to grow.) For nine of the 16 G20 members (Argentina, China, India, Indonesia, Mexico, Republic of Korea, Saudi Arabia, South Africa and Turkey), emissions would continue increasing through 2030 under current policies. Annual emissions in the other members are projected to remain stable at around 2010 levels (including in Australia, Brazil, Russia and the United States), or to decrease further (such as in the EU28, Japan and Canada), under current policies.

The following section provides more detail on each of the G20 members, starting with the four highest-emitting economies, China, EU28, India and the United States.

China's NDC includes three major mitigation targets: (1) to peak CO_2 emissions around 2030, making best efforts to peak earlier, (2) to reduce the carbon intensity of its GDP by 60–65% from 2005 levels by 2030, (3) to achieve 20% share of non-fossil fuels in primary energy consumption by 2030. These targets address only energy-related carbon dioxide (CO_2) emissions. China also pledges to increase the forest stock volume by around 4.5 billion m^3 from 2005 levels by 2030. An official estimate of the 2030 emissions associated with the NDC targets is not available. However, two national estimates for CO_2 emissions from the energy sector (and cement) are available from National Center for Climate Change Strategy and International Cooperation (NCSC) (Sha, 2018; Sha et al., 2017) and Energy Research Institute (ERI) (updated calculations based on Jiang et al., 2013). These were augmented with the historical non-CO_2 GHG emissions (The People's Republic of China, 2017), and non-CO_2 emission growth rates (Tavoni et al., 2015), to produce GHG emission projections. Independent studies (CAT, 2018a; IEA, 2017; Kuramochi et al., 2017a) estimated China's emissions under national policies from China's 13th Five-Year Plan (FYP) and 13th FYP for Renewable Development (including renewable capacity targets and a cap on coal consumption). These studies suggest that China's 2030 emissions will fall below the emission levels calculated from the full implementation of the NDC targets, although there is significant range in emission projections. Total GHG emissions are projected to keep growing up to 2030, albeit at a lower rate than the historical (2000–2012) emissions, which is also concluded in the analysis of Jiang et al. (2017). Many studies included here have revised their projections downwards compared to their previous projections, but only a few studies indicate that CO_2 emissions will peak before 2030 (Climate Action Tracker – lower end; (Green and Stern, 2017)). Driven by air pollution control policies (State Council, 2013), China started to reduce coal use and promote clean energy use in 2012. Together with structural changes, i.e. shifting its economy away from heavy industry to services, this resulted in a slowdown of most energy-intensive production, a peak in coal consumption in 2013, and continued decline from 2014. In the last two years, new installed capacity of wind power, solar power, and hydropower has increased to more than 120 GW. However, increases in coal use increased again in 2017, which would reverse part of their decreases since 2013 (Le Quéré et al., 2017) and energy related CO_2 emissions are estimated to have reached a new all-time high in 2017 (IEA, 2018).

The **EU28**'s NDC contains a commitment of at least a 40% reduction in domestic emissions by 2030 compared to 1990. The studies of Kuramochi et al. (2017a), JRC (Kitous et al., 2017), the EEA Trends report (European Environment Agency, 2017) and the EU Reference Scenario 2016 (European Commission, 2016b), E3MLab and IIASA (2018) and Fragkos et al. (2017) and Seventh National Communication (European Commission, 2017) suggest that the EU28 will fall short of its NDC target under current policies. E3MLab and IIASA (2018) and Fragkos et al. (2017) also developed policy scenarios based on the EU Reference Scenario 2016, and designed to achieve the 2030 targets of the 2030 Climate & Energy Framework[2] (NDC target, binding renewable target, energy efficiency target). European climate policy can be classified into two categories: (1) the EU Emission Trading System (EU ETS), the EU-wide cap-and-trade system covering electricity generation, energy-intensive industry and aviation, and (2) policies targeting non-ETS sectors, such as transport, agriculture and buildings, including Member State-specific targets for emission reduction captured by the Effort Sharing Decision (2013–2020). To reach the NDC target, both policy pillars need to be strengthened for the period 2021–2030. The EU is in the process of adopting a large package of measures (Clean Energy for All Europeans[3]) aiming to accelerate GHG emissions reductions in different areas. The impact of these adopted policies is not included in the analysis of the studies cited above because they have not been adopted by the European Council; the adoption is expected to follow.[3] More specifically, a revision of the EU ETS for the period from 2021 to 2030 was adopted in March 2018, which encompasses three key elements: reducing the cap at an annual rate of 2.2%, from 2021 onwards; doubling the Market Stability Reserve (MSR) feeding rate between 2019 and 2023 to reduce surplus of allowances; and invalidating allowances in the MSR exceeding the number of allowances auctioned in the previous year, from 2023 onwards (Council of the European Union, 2017b). This binding cap measure contributes to achieving the planned 2030 reductions for the ETS sector (43% reduction below 2005) (European Commission, 2015). The provisionally agreed Effort Sharing Regulation applying to GHG emissions from sectors not covered by EU ETS, i.e. transport, buildings, agriculture and waste management, was adopted in May 2018. The overall targeted GHG emission reduction from these sectors is 30% by 2030, relative to 2005, to be achieved by legally binding annual emission limits for each Member State for the years 2021–2030 (Council of the European Union, 2017c; European Commission, 2016b). There is also the adopted regulation to integrate GHG emissions and removals from land use, land-use change and forestry (LULUCF) into the 2030 climate and energy framework (European Parliament 2018), an adopted proposal for amending the Energy Efficiency Directive and the Energy Performance of Buildings Directive (Council of the European Union, 2017a; European Commission, 2016a). In 2018, the Energy Union Governance Regulation was agreed, which sets out interim targets towards achieving the 2030 goals of 32% renewable energy and 32.5% energy savings. The European Commission anticipates that emission reductions would go beyond 40% below 1990 in 2030, if these new targets are met.[4]

India's NDC commits to, by 2030, reducing its emissions intensity of GDP, excluding the agriculture sector, by 33–35% below 2005 levels, increasing the share of non-fossil energy in total power generation capacity to 40% (with the help of transfer of technology and low cost international finance), and creating an additional cumulative carbon

[2] https://ec.europa.eu/clima/policies/strategies/2030_en.

[3] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans.

[4] http://europa.eu/rapid/press-release_SPEECH-18–4236_en.htm.

sink of 2.5–3 $GtCO_2e$ through additional forest and tree cover. The main mitigation-related policies implemented in India include the market-based mechanism Perform, Achieve and Trade (PAT) scheme for energy efficiency initiatives in energy-intensive sectors of the economy, renewable energy capacity targets, Clean Environment Cess (coal tax) and a range of support schemes laid out under the 12th Five Year Plan. In Fig. 1, the NDC projections of independent studies labelled "unconditional" assume either current policies or only the intensity target, while NDC projection labelled "conditional" assume full implementation of the NDC targets, including the non-fossil fuel target. Independent studies (CAT, 2018a; Dubash et al., 2018; IEA, 2017; Mitra et al., 2017; PBL, 2017; Vishwanathan and Garg, 2017) project that India will reduce emissions farther than required by the intensity target with current policies, but it is uncertain what emission level would be reached under all three targets combined, also because emission projections highly depend on future economic growth (e.g, Dubash et al., 2018).

In 2018 the National Electricity Plan was published (CEA, 2018). The NEP indicates that while 48.3 GW of end-of-life plants are expected to close by 2022, another 94.3 GW will be added by 2027. There is a risk, however, of at least some of this capacity becoming stranded assets. The projections in the National Electricity Plan is in stark contrast to its draft version (Central Electricity Authority, 2016), which forecast that no new coal-fired power capacity would be required during the period 2022–2027 following a capacity addition of around 50 GW for the period 2017–2022.

The NDC communicated by the **United States** in 2016 committed to reduce GHG emissions by 26–28% below 2005 levels in 2025. Independent studies (Table 1) indicate that the U.S. is not on track to meet the 2025 NDC targets with existing policies (excluding the Clean Power Plan). In June 2017, President Donald Trump announced that the U.S. intends to withdraw from the Paris Agreement and would cease implementation of the NDC. On August 4th, 2017, the US notified the UN Secretary General that it intends to "exercise its right to withdraw" from the Paris Agreement. The earliest that U.S. withdrawal can take effect is in 2020, four years after the Paris Agreement entered into force. Legally, the US NDC is still in place until that time, although the Trump Administration has made clear that the target will not be implemented at the federal level. Fransen and Levin (2017) analysed seven studies (Chai et al., 2017; Climate Action Tracker, 2017; Climate Advisers, 2017; ClimateInteractive, 2017; Hafstead, 2017; Rhodium Group, 2017a; b) and estimated that 2025 emissions under the new Administration's policies will range from 5.6 to 6.8 $GtCO_2e$/year, in contrast to 5.0–6.6 $GtCO_2e$/year under the previous Administration's policies. All these scenarios show emissions in 2025 higher than the U.S. target. However, these projections highly depend on how quickly policies are reversed or revised, and what will replace them. In addition, many states, cities and companies have stepped up in response to Trump's announcement on the Paris Agreement, pledging to support the agreement and to take action on climate change. The additional impact of action by these subnational and non-state actors, however, may counter some of the effect of the new Administration's policies (Data Driven Yale, NewClimate Institute, PBL, 2018; Kuramochi et al., 2017b).

Argentina presented a revised and more ambitious NDC relative to its INDC (Government of Argentina, 2016). This new NDC includes an unconditional absolute emissions target of 483 $MtCO_2e$/year by 2030 and a conditional target of 369 $MtCO_2e$/year by 2030, both including land use land use change and forestry emissions (LULUCF). The lower emission projections resulting from the revised NDC is partly due to the updated methodologies for quantifying the historical emissions data in the land use sector. The Climate Action Tracker (CAT, 2018a) concludes that under current policies the emissions projections would still rise significantly by about 50% above 2010 levels, and Argentina would need to implement additional mitigation actions to meet its revised NDC targets.

Australia committed to a 26–28% reduction of GHG emissions by 2030 below 2005 levels, including LULUCF. Official projections indicate that emissions are expected to reach 570 $MtCO_2e$/year in 2030 (Government of Australia, 2017), in contrast to the NDC projections of 429–440 $MtCO_2e$/year. Independent analyses (CAT, 2018a; Kitous et al., 2017; Kuramochi et al., 2017a; Reputex, 2016) confirm that Australia's emissions under current policies are expected to fall short of achieving its NDC targets for 2030. The main policies include the Emissions Reduction Fund and linked safeguard mechanisms, which the Government of Australia considers to be a key policy measure, and the National Energy Productivity Plan that aims to improve energy productivity by 40% by 2030.

Brazil has put forward an absolute emissions target of 1.3 $GtCO_2e$/year by 2025 and an indicative target of 1.2 $GtCO_2e$/year by 2030, which are equivalent to 37% and 43% below 2005 emissions levels including LULUCF. Actions to achieve the targets focus mainly on the forest sector and on increasing the share of biofuels and renewable electricity in the Brazilian energy mix. Two independent studies (PBL and JRC) suggest that if all implemented policies are successful (including the enforcement of the Brazilian Forest Code, biofuel policy updates and renewable power capacity targets) emission projections are likely to be in line with the NDC targets; however, two other studies (CAT, 2018a; Rochedo et al., 2018) project higher emissions, taking into account the recent reversal in progress towards reducing deforestation, and show the opposite. Uncertainty nevertheless remains about the future of emissions. For example, LULUCF emissions were reduced by 86% between 2005 and 2012 through successful policies in the LULUCF sector, i.e. the enforcement of the Brazilian Forest Code and efforts to reduce deforestation in the Amazon and Cerrado regions (Ministry of Science and Technology of Brazil, 2016), but recent data and analyses suggest that the decreasing trend in deforestation has slowed down or even stopped (SEEG, 2017). In fact, the recent political crisis in the country has forced government to concede reversals in environmental regulation in exchange for political support, which could potentially result in higher deforestation emissions (Rochedo et al., 2018).

Canada's NDC commits to emissions reductions of 30% from the 2005 level by 2030. Government projections indicate that emissions are expected to reach 742 $MtCO_2e$/year by 2030, in contrast to the targeted level of 523 $MtCO_2e$/year (excluding LULUCF) (Environment and Climate Change Canada, 2017). The main current policies are a fuel efficiency standard for passenger vehicles and carbon standard for newly built coal-fired power plants. Independent studies show that Canada is not achieving its NDC target under current policies by a large margin. Canada has recently proposed a plan to price carbon pollution that would require individual provinces either to place a direct price on carbon or to adopt a cap and trade system. This planned policy was not included in the analysis.

Indonesia's NDC includes an unconditional target of 29% below BAU and a conditional 41% reduction below BAU with sufficient international support by 2030, both including LULUCF. A significant share of Indonesia's emissions originates in the LULUCF sector, due to deforestation, peatland destruction, and land-use change. GHG emissions from LULUCF are expected to increase over time, driven by continued expansion of large scale oil palm plantations, but there are large uncertainties in the emission projections. Independent analyses covered in Table 1 show that Indonesia is close to on track to achieving its unconditional NDC, with overall GHG emissions showing an increase compared to 2010 levels.

Japan aims to reduce its GHG emissions by 26% below 2013 levels by 2030 under its NDC. Recent independent analyses show that Japan is roughly on track to meet its NDC with current policies (such as the renewable feed-in tariff scheme and the 2014 Basic Energy Plan). Japan's NDC also sets a power generation mix target, with 26% coal, 27% gas, 20–22% nuclear and 22–24% renewables. However, there is

still a great deal of uncertainty regarding the future role of nuclear and coal power, as it is not yet fully clear when nuclear capacity will be replaced and by which energy carriers.

Mexico in its NDC aims to reduce its GHG emissions by between 22% (unconditional) and 36% (conditional) from BAU by 2030. Mexico has also set a goal of generating 35% of its electricity from clean energy sources[5] by 2024. Mexico's new Energy Transition Law provides overarching strategies and goals with regard to clean energy, energy efficiency and GHG emissions reductions (Government of Mexico, 2015). Under current policies, Mexico is roughly on track to meet the unconditional NDC target, but additional mitigation actions are needed to meet the conditional NDC target (Kuramochi et al., 2017a).

Republic of Korea committed under its NDC to reduce its GHG emissions by 37% below BAU by 2030. Recent independent analyses indicated that the emissions projections under current policies would exceed the NDC emission level. Main current policies considered here are renewable energy targets for 2020 and 2030 and the national emissions trading system (ETS). The Roadmap to Achieve the National GHG reduction target for 2030 has been published in 2016, which specifies the emissions projections, reduction targets and major emissions reduction plans for eight sectors (The Government of the Republic of Korea, 2017).

The new government that took office in May 2017 announced plans to implement new policies to increase renewable electricity and reduce reliance on coal power. Following this, a new 15-year "Plan for Electricity Supply and Demand" was released, which confirms the intention to shift electricity generation away from coal and nuclear towards more renewables (CAT, 2018b; Ministry of Trade Industry and Energy, 2018). CAT (2018a) estimates that such policies could bring Republic of Korea considerably close to meeting its NDC.

Russia's INDC aims to limit its GHG emissions to 70–75% of 1990 levels by 2030. Independent estimates of the INDC emission level vary significantly, mainly due to different interpretations of the accounting of LULUCF emissions. The projected emission levels under current policies in 2030 are below the lower end of Russia's INDC range.

Saudi Arabia's NDC aims to achieve emission reductions of up to 130 $MtCO_2e$ annually by 2030 through actions and plans that also contribute to economic diversification and adaptation. The country has not yet defined a baseline, which the NDC states will be determined based on weighted combinations of two scenarios, which differ in terms of their assumptions regarding the allocation of oil: produced for either domestic consumption or export. The independent studies (JRC and CAT) project that Saudi Arabia is not on track to meet its NDC target. Given the uncertainties around the NDC target and the lack of data availability we conclude that it is not possible to determine whether Saudi Arabia is on track.

South Africa's NDC consists of a 'peak, plateau and decline' GHG emissions trajectory, which gives a range of 398–614 $MtCO_2e$/year between 2025 and 2030, reaching a peak between 2020 and 2025 and a plateau for the following decade, before starting to fall. The current policies projection includes the Integrated Resource Plan for electricity, the most important policy affecting South Africa's GHG emissions. All studies agree that South Africa's GHG emissions under current policies are above the NDC emissions range by a margin of 50 $MtCO_2e$/year to nearly 400 $MtCO_2e$/year in 2030.

Turkey's INDC sets an economy-wide GHG emission reduction target of up to 21% below BAU by 2030 (about 900 $MtCO_2e$/year). The current policies projection includes renewable energy targets. The independent studies show a wide range of emissions projections (525–1000 $MtCO_2e$/year). This large range means the INDC could be either easily achieved (based on the emissions projections under current policies by PBL and JRC), or expected to be achieved (based on government estimates reflected in the projection of CAT, 2018a).

[5] Includes renewables, nuclear, carbon capture and storage-equipped fossil fuel power as well as efficient combined heat and power.

4. Understanding the required reduction efforts of the G20 members collectively

Our assessment indicates that current policies of G20 members collectively fall short of achieving the unconditional NDCs (Table 3). G20 economies will likely need to implement additional policies to together reduce further 2030 GHG emissions by about 2.5 $GtCO_2e$ to achieve all the unconditional NDCs, and by about 3.5 $GtCO_2e$ to achieve all the conditional NDCs.

Fig. 2 presents the additional effort needed, and shows that the main contributions would need to come from Australia, Canada, the Republic of Korea, South Africa and in particular the United States. These four countries also have the largest additional reduction effort as a percentage of the current policies estimates (between 20% and 25%). For the United States, linear interpolation between the NDC target year (2025) and the 2050 long-term target (83% reduction below 2005 levels) was assumed to estimate the 2030 target —it should be noted that the required additional emissions reductions would halve if the 2030 target remained at the same level as for 2025, instead of progressing linearly towards its 2050 target as assumed in our analysis (and in many studies assessed in Rogelj et al. (2016) and UNEP (2017) for the global NDC scenarios). In addition, emission target levels of three NDCs (India, Russia and Turkey) are projected to be above the estimated current policy scenario levels, as illustrated in Fig. 2. These countries are thus expected to overachieve their NDC targets under their current policies by about 1 $GtCO_2e$. For the gap mentioned above, we have not assumed that his overachievement offsets the underachievement of other targets and assumed that these countries will follow their current policies trajectory rather than that implied by their NDCs.

We also compared 2030 emissions for the G20 under current policies and NDCs with those based on 2 °C pathways. The 2030 emissions levels the G20 for the 2 °C pathways are calculated based on the aggregated greenhouse gas emissions levels of all individual G20 members projected (median estimate) by 450 ppm CO_2e scenarios (van Soest et al., 2017). The delayed 450 ppm CO_2e scenarios are based on global emission scenarios from Integrated Assessment Models from various projects, such as: AMPERE (Kriegler et al., 2015; Riahi et al., 2015) and LIMITS (Tavoni et al., 2015), that assume limited action until 2020 and global least-cost emission reduction pathways starting from 2020 and consistent with a greater than 66% chance of limiting global warming in 2100 to below 2 °C above pre-industrial levels. The G20 emission levels in 2030 for 2 °C pathways are estimated at 27 (range: 23–31) $GtCO_2e$ (about 20% below 2010 levels), which is about 13.5 $GtCO_2e$ lower than the median estimate for the current policies (about 40.5 $GtCO_2e$, or 8% above 2010 levels).

5. Understanding the mitigation efforts of the NDCs

The previous sections assessed whether G20 members, individually and collectively, need to implement additional policies to meet their NDC targets. This section presents high-level decarbonisation indicators to enhance understanding of the progress of G20 economies toward their NDCs. This is done by examining changes in these indicators relative to 2010, and decoupling of emissions in terms of population and GDP on the basis of a few indicators that have been proposed in the literature (Peters et al., 2017). We do not attempt to indicate the level of ambition of the NDC targets. Assessing whether the magnitude of change in GHG emission-related indicators as a result of NDCs is ambitious and fair in the light of Paris Agreement's long-term goal requires explicit benchmarking across alternative normative indicators of effort-sharing, which is beyond the scope of this study. However, a number of recent peer-reviewed studies attempt this task using a range of effort-sharing allocations according to different equity principles (CAT, 2018a; Höhne et al., 2018; Pan et al., 2017; Robiou du Pont et al., 2017), using similar IPCC AR5 effort-sharing categories (Höhne et al., 2014).

Table 3
Total greenhouse gas emissions for the G20 as a group in 2030 ($GtCO_2e$/year) under different scenarios (average and 10th to 90th percentile range).

Scenario	G20 total emissions in 2030[a]
Current policy	40.5 (35.5–46.0)
Unconditional NDCs	38.0 (36.0–39.0)
Conditional NDCs	37.0 (35.0–39.0)
G20 emission level based on 2 °C pathways (more than 66% chance of meeting 2 °C in 2100, global least-cost from 2020)[b]	27.0 (23.5–31.5)

[a] G20 emissions in 2010 and 2015 were 32.0 and 35.2 $GtCO_2e$, respectively (Appendix A).
[b] the emission projections of individual G20 members are based on the cost-optimal 450 ppm CO_2e scenarios, as described in van Soest et al. (2017).

Cross-cutting information regarding national emissions (relative to various base years), emissions per GDP and emissions per capita for G20 economies is summarised in Fig. 3. The projections of the latter two indicators are influenced by many factors. The per capita GDP and population growth will generally result in an increase in emissions, while energy intensity improvements in the global economy and reductions of carbon intensity in energy production will generally result in a decrease in emissions.

Fig. 3a illustrates the wide range of likely per capita emissions in 2030. It also illustrates a general trend that countries starting from a lower base level in 2015 tend to increase more by 2030. For example, Australia and Canada, with high expected 2030 per capita emissions, are among those (including the EU28) with the highest decline relative to 2015 for the current policy scenario. Argentina, Russia and Saudi Arabia show an increase in per capita emissions despite having a high expected per capita emission level in 2030. Saudi Arabia has the highest expected per capita emissions in 2030, reaching almost eight times the per capita emission levels of India, and four times those of the EU28. India, with low levels of per capita emissions in 2015, has the highest increase in per capita emissions relative to 2015, together with Argentina and Turkey.

Fig. 3b illustrates the change in emissions by 2030 compared to 2015 levels. Current policies do not prevent emissions from increasing from 2015 to 2030 for 12 of the 16 G20 economies. The highest decrease compared to 2015 levels are in the EU28 and Brazil, whereas India, Turkey and Saudi Arabia shows the highest increases. It indicates that the various G20 economies have had different phases of rapid emissions increase.

Fig. 3c shows the emissions intensity of the GDP, expressing the extent to which current policies lead to a decoupling of economic growth and emissions. In total, decoupling is projected to be about 20–40% for 12 of the 16 G20 economies. Only Turkey and Russia have a below 5% and 1% decrease in emissions per GDP, and for Saudi Arabia and South Africa it is an increase of about 15% and 2% (see Fig. 3c). The largest reductions are projected for countries with the highest emission intensities in 2015, such as China and EU28.

Fig. 3a and Fig. 3c combined show that Saudi Arabia and South Africa are projected to continue increasing both emission intensity per unit GDP and emissions per capita under current policies by 2030 from 2015 levels. Together with Russia, which showed little change in emission intensity per unit GDP, these major fossil fuel-producing countries are projected to continue with the current economic structure at least up to 2030.

Fig. 3d shows the change in IPAT/Kaya indicators (emissions, population, GDP per capita and emissions intensity) by 2030 compared to 2015 levels for the current policies. The per capita GDP and population growth (in particular for China, India and Indonesia) result in an increase in emissions, while decrease in emission intensity of GDP lowers the emissions. However, for many G20 economies this lowering effect is not enough to prevent emissions from increasing from 2015 to 2030 under current policies.

6. Discussion

6.1. Interpretation of the results

Regarding the findings of this study, a country being on track to meet its NDC does not necessarily mean that it will undertake more stringent action on mitigation than a country that is not on track. We identified three main reasons for this.

First, the NDC targets differ in their ambition levels. A country that is not on track to meet its NDC target may have set itself a very ambitious target or a country being on track to meet its target may indicate that it set a relatively unambitious target. A number of recent studies have analysed the level of ambition and fairness of the NDC targets using a range of effort-sharing allocations according to different metrics and equity principles (CAT, 2018a; Höhne et al., 2018; Pan et al., 2017; Robiou du Pont et al., 2017). In addition, NDCs are also nationally determined and heterogeneous by nature, so a fair comparison of progress across countries is not always straightforward.

Second, the current policy scenario projections presented in this study only account for existing policies at least through 2016, and thus our findings should not be interpreted as the likelihood of countries' meeting their NDC targets. It has only been three years since countries formulated their NDCs. It is not surprising to see a gap between the mitigation targets and current policy trajectories if countries pledged something above what they would have achieved anyway. The gap may close in the years to come as countries adopt additional policies and strengthen the implementation of existing policies.

Third, countries have different policy-making approaches. Some countries use their pledges or targets as a device to drive more ambitious policies, while others use them merely to formalise the expected effect of existing measures.

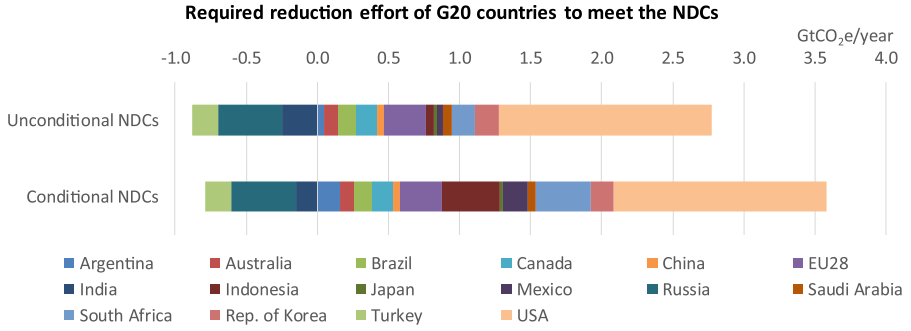

Fig. 2. Projected emission reduction ($GtCO_2e$/year) relative to the current policy scenario to achieve NDC targets in G20 members in 2030. (Calculation for USA based on extrapolated indicative 2030 target.).

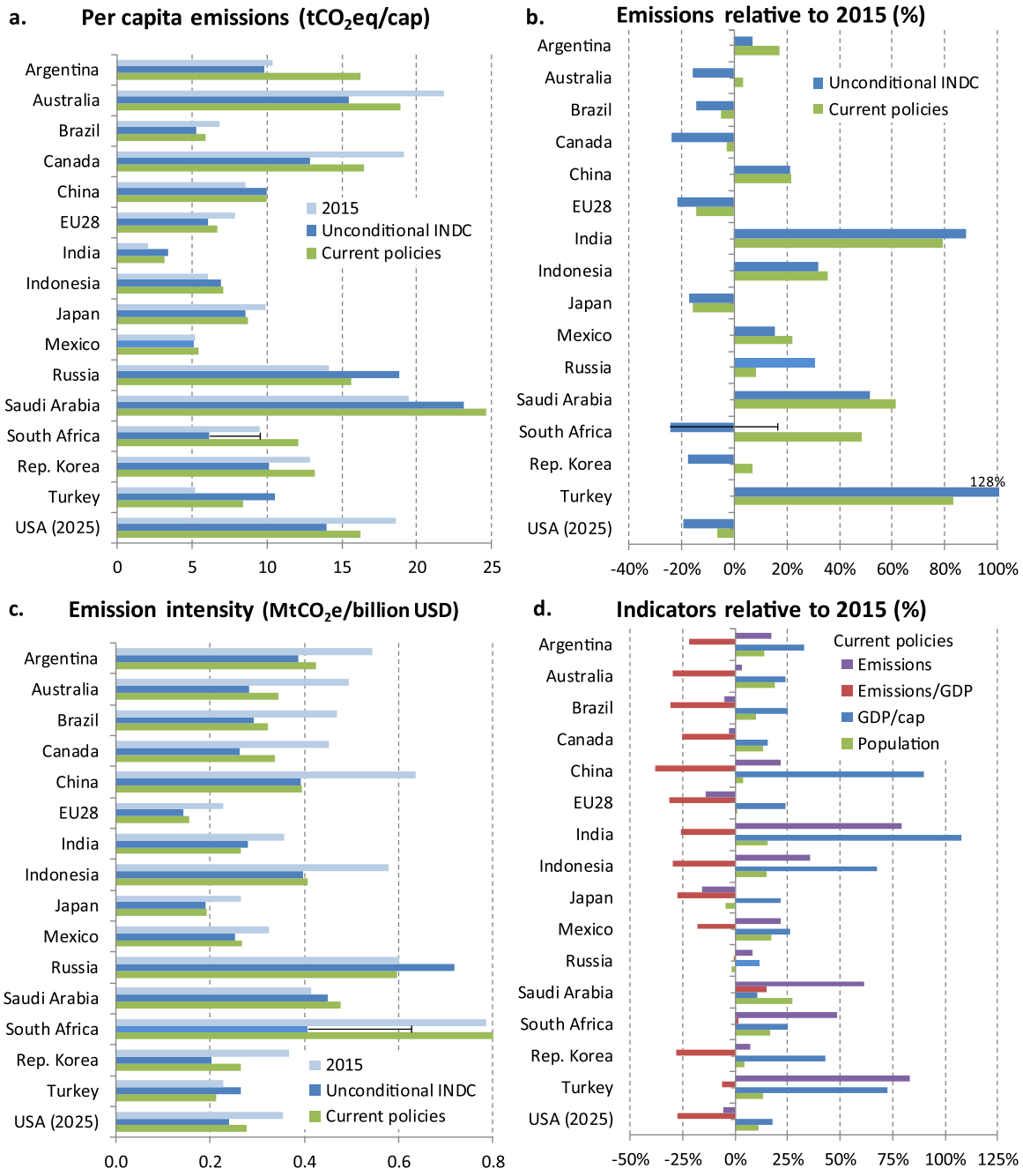

Fig. 3. Per capita greenhouse gas emissions for the unconditional NDCs and current policy scenario for G20 members (a), emissions relative to 2015 levels (b), emission intensity of the economy (i.e. emissions per unit of real GDP (US$$_{2010}$$)) (c), and their drivers, population, GDP per capita and emission intensity (current policies), based on the Kaya decomposition (d) for the year 2030 (current policies). Bars show the median estimate, with the median emission estimates as shown in Fig. 1. Note: South Africa's NDC is based on an emission trajectory with an emissions range of 398–614 $MtCO_2e$.

6.2. Methodological limitations

There are some important methodological limitations related to the reported emission levels from the current policies and the full implementation of the NDCs, which are largely attributable to the uncertainties surrounding these emissions projections resulting from current policies, the differences in the nature and characteristics of NDCs and climate policies across countries.

First, and arguably most importantly, projections are subject to uncertainty associated with factors including macroeconomic trends, such as changes in GDP and population trends, and the future technological development, as well as the impact of each country's climate policy action. This information is provided in this study as a range of projections from different models and literature sources (Table 1), which consider the best current estimates of projected economic trends and current policy approaches, including policies at least through 2016. The ranges do not reflect the full uncertainty range associated with the aforementioned factors. This would require a systematic analysis of the impact of the key uncertainties, including such socioeconomic conditions, on the current policies emission trajectories at a country level, which is not available in the current literature. Rogelj et al. (2017) have done such a systematic uncertainty analysis for the emissions outcomes of NDCs, and found that uncertainties in socioeconomic developments are the dominant driver, accounting for more than half of the uncertainty. (Part of this uncertainty results from some NDCs being expressed as emissions intensity improvements.)

Second, besides the impact of socioeconomic factors on quantifying NDC target emission levels, there is also an uncertainty in the NDC target emission levels when the NDCs include non-GHG targets such as energy mix targets or forest sink targets, as observed for China and India. A relatively large number of assumptions have to be made to translate such targets into GHG emission terms, as well as to assess whether these non-GHG targets result in additional emissions reductions beyond the GHG emission targets also set under their NDCs.

Third, interpretation and coverage of current policies may differ between studies. Current policy trajectories reflect all adopted and implemented policies, 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, while individual executive orders to implement such plans or strategies would qualify. Ultimately, however, these definitions may be interpreted differently in the underlying studies. In addition, studies may differ in the coverage of effective national climate and energy policies, and/or translation of policies to model parameters is done differently because of model structure. This assessment is bound by the interpretations and coverage of policies as used by individual research groups.

Fourth, countries are implementing policies in various areas to a varying degree; the stringency of a current policy package considerably differs across countries. With regard to the coverage of key policy areas, for example Höhne et al. (2018) show that the EU and the US cover more sectors and thematic areas with policies that are considered to be good practice for reducing GHG emissions than China does. With regard to policy implementation, we provide an example of renewable energy targets, which have been set by many countries and are to be achieved by national support policies. For some countries, in particular the non-OECD countries, there is not enough information about the implementation status. For some countries, the studies have assumed a full implementation of those targets without limited evidence of concrete support policies, in some cases by considering other factors (e.g. historical trends and projections from other studies), but this has the risk of overestimating the emissions reductions. Although beyond our research scope, it is important to assess and compare the stringency and comprehensiveness of the existing policy package in future work.

7. Conclusions and policy implications

In this paper, we analysed the G20 members' progress towards the greenhouse emissions targets outlined in their nationally determined contributions (NDCs) under the Paris Agreement. The assessment shows that for many G20 economies, NDC implementation would result in lower emissions than the current policy scenario, or in other words, that additional policies will have to be implemented to meet the NDC target (barring the use of offsets or unpredicted macroeconomic shifts, as mentioned above). For other countries, the NDC target emission levels were found to be above current policy scenario projections. (We do not assess the ambition levels of NDC targets; this could be done by applying different equity-based effort sharing approaches to global emission pathways consistent with achieving 2 °C or 1.5 °C.)

After careful consideration of the caveats and limitations described in Section 6, we come to the following conclusions. Altogether, recent studies assessed here suggest that six G20 members (China, India, Indonesia, Japan, Russia and Turkey) are on track to achieve or overachieve their unconditional 2030 targets under current policies.

Uncertainty about the future emissions projections makes it difficult to determine whether Brazil, Mexico and Saudi Arabia are on track to meet their NDCs. Better data and more national studies are necessary to track progress adequately. The number of studies analysing whether countries are on track to achieve their NDC targets is still limited in literature, whereas from a policy perspective it becomes more and more important to look at the implementation of the NDCs.

The seven remaining G20 economies (Argentina, Australia, Canada, EU28, South Africa, Republic of Korea and the United States) need to adopt enhanced and new climate and energy policies as their projected reductions by the target year fall short of meeting the reductions targeted in their NDCs, according to government and independent estimates. These policies could focus on further decarbonisation of energy supply and the improvement of energy efficiency (such as increasing energy efficiency in the industry, buildings and transport sectors, increasing investments in renewable energy technologies and reducing the use of coal), and/or mitigation in the non-energy sector (such as afforestation, reducing methane emissions arising from oil and gas production and reducing hydrofluorocarbon or HFC emissions).

Many countries (including G20 economies) have already successfully implemented a wide range of climate and energy policies (such as renewable energy, efficiency standards in transport and appliances, afforestation and reforestation) that reduce greenhouse gas emissions (e.g., Fekete et al., 2015; Roelfsema et al., 2018). G20 economies could adopt or strengthen these policies, as relevant, as they already have proven to be successful today at reasonable costs. This would help them to meet or go beyond their current commitments.

Some of the economies that are not on track based on our results are planning to implement new measures (like the reform of the ETS for the EU28, the Plan for Electricity Supply and Demand for the Republic of Korea), which once implemented, would further reduce future emissions.

Progress on reducing GHG emissions relative to historical levels also varies for the G20 economies. Current policies are projected to impact emissions, but do not prevent emissions from continuing to increase through 2030 (above 2010 levels). This is the case in many G20 economies (Argentina, Australia, China, India, Mexico, Republic of Korea, Saudi Arabia, South Africa and Turkey). Emissions under current policies in the remaining G20 economies are projected to remain stable, approximately at current levels, or to decrease.

The per capita emission projections under current policies also show a wide range across G20 economies, with the highest per capita emissions in 2030 for Saudi Arabia, Australia, Argentina, the United States and Canada. For many G20 economies there is a decoupling of economic growth and greenhouse gas emissions under current policies, except for Saudi Arabia and South Africa, and to a lower extent Russia. In general, differences in per capita emissions and emission intensity start to decrease (with some exceptions), but these levels are still well above the global average level needed to be compatible with the Paris Agreement temperature goals of 1.5 °C or 2 °C.

For meeting the climate objectives of the Paris Agreement, it is essential that G20 economies adopt enhanced and new policies that go beyond the current NDC targets, so that their combined mitigation effect leads to global emission levels that are needed to limit global warming to well below 2 °C and possible to below 1.5 °C. Sub-national actors such as cities and regional governments may take further action, and non-state actors can also help to overachieve NDCs.

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Appendix A. Historical emissions data sources

Historical greenhouse gas (GHG) emissions data was taken from latest inventories, many of which have been submitted to the UNFCCC in 2017. For Annex I Parties of the G20 (Australia, Canada, the European Union, Japan, the Russian Federation, Turkey and the United States) and the European Union, the GHG emissions data for 1990–2015 submitted via the Common Reporting Format 2018 to the UNFCCC (2018a) was used.

For historical emissions in non-Annex I Parties of the G20, for many countries the GHG emissions data was taken from the UNFCCC GHG database (UNFCCC, 2018a), in which the GHG inventory data reported in most recent Biennial Update Reports (BURs) submitted to the UNFCCC (2018c) are compiled (Table 4). For Brazil, the emissions inventory from Sistema de Estimativa de Emissões de Gases de Efeito Estufa (SEEG, 2017) was used. For Indonesia, the emissions data were directly taken from the first biennial report for the year 2000 and 2012, used as is, and the data of 1990–1994 from UNFCCC (2018a). Table 4 also gives the time series of data and latest reported year, which clearly shows that not always the emissions data for the year 1990, 2010 and 2015 (needed for Fig. 1) was available. Therefore, the emissions data was extrapolated from the last reported year up to 2015 using growth rates of GHG emissions (excluding LULUCF) of the EDGAR database (Olivier et al., 2017). For LULUCF emissions the same approach was used using the data of FAO (FAOSTAT, 2018). For the historical data, the data was extrapolated from the most recent data. For example, for China we obtained the greenhouse gas emissions China's BUR1 for 2012 (UNFCCC, 2017), and the EDGAR data was used in a similar way to extrapolate from 2012 to 2010.

Table 4
Data sources for historical GHG emissions in non-Annex I countries (UNFCCC, 2018a).

Country	GHG emissions including LULUCF	
	Source	Last reported year
Argentina	BUR1, BUR2 and UNFCCC (2018a) for 1990 – 2012	2012
Brazil	SEEG (2017)	2015
China	BUR1 / UNFCCC (2018a) for 1994, 2000 and 2012	2012
India	BUR1 / UNFCCC (2018a) for 1994, 2000 and 2010	2010
Indonesia	UNFCCC (2018a) for 1990 – 1994, BUR1 for 2000 and 2010	2012
Republic of Korea	UNFCCC (2018a) for 1990 – 2014	2014
Mexico	UNFCCC (2018a) for 1990 – 2012	2012
Saudi Arabia	BUR1 for 2010 and 2012	2012
South Africa	BUR1, BUR2 and National Inventory reports for 2000 – 2012	2012

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