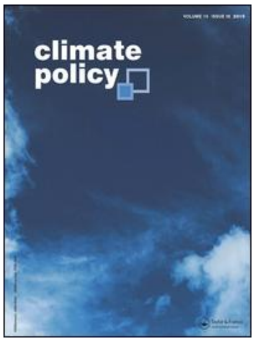

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Correcting course: the emission reduction potential of international cooperative initiatives

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ABSTRACT
This article quantifies the aggregate potential of greenhouse gas (GHG) emissions reductions in 2030 from the assumed full implementation of major international cooperative initiatives (ICIs). To this end, a methodology is proposed to aggregate emission reduction goals of the most significant and potentially impactful global initiatives. We identified the extent to which reductions are additional to national policies, assuming these actions do not displace climate actions elsewhere, and accounted for overlap ranges between the ICIs. The analysis was conducted for 17 initiatives, selected from an original list of over 300 with a series of testing criteria, across eight sectors and ten major emitting economies. These initiatives include cities, regions, businesses, and other subnational and non-state actors, cooperating with each other and sometimes working in partnership with national governments or other international organizations. Our analysis shows that the combined achievement of initiatives' reduction goals could reduce global emissions in 2030 by 18–21 $GtCO_2e$/year in addition to current national policies (total of 60–63 $GtCO_2e$/year), down to 39–44 $GtCO_2e$/year. If delivered fully, reductions from these 17 initiatives would help move the global emissions trajectory within the range of a 2°C-consistent emission pathway by 2030, although a significant gap would remain to reduce emissions to a 1.5°C-consistent pathway.

Key policy insights

- We propose a transparent and robust methodology to aggregate GHG mitigation potential of ICIs, accounting for overlaps between ICIs.
- If major initiatives meet their goals and do not change the course of other existing climate actions, they could make large contributions by 2030 towards global efforts to stay within the range of a below 2°C-consistent emission pathway by 2030. The full suite of existing initiatives beyond those in this analysis could further increase ambition towards achieving the Paris Agreement's temperature goals.
- Cities and regions, businesses and forestry initiatives account for significantly more than half of all possible emission reductions from ICIs; implementation of their goals should be a key policy focus.

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1. Introduction

Since the Paris Agreement solidified a global consensus for an 'all hands on deck' approach to climate change mitigation, non-state (e.g. businesses) and subnational (e.g. cities, states, and regions) actors (NSAs) have become recognized as key contributors – pledging a range of actions, from directly reducing their own greenhouse gas (GHG) emissions, to developing strategies for adaptation and resilience, delivering sustainable development benefits, and providing finance for these activities (Chan & Amling, 2019; Hale, 2016). These actors are also cooperating to collectively achieve systemic impacts throughout entire sectors, and generate sustainable development co-benefits in public health, and job creation (Day et al., 2018; New Climate Economy, 2015; Seto et al., 2014).

Globally, countries are not currently on track to meet the Paris Agreement's goal of limiting global temperature rise to well below 2°C and reaching net-zero emissions in the second half of this century (Climate Action Tracker, 2019; UNEP, 2019a). Targets from a range of NSAs can help implement and reinforce national climate goals. They can also pilot innovative solutions, and potentially address shortfalls in national climate action to narrow the gap between likely emission levels under current policies and those consistent with the Paris Agreement's long-term temperature goals.

International cooperative initiatives (ICIs) have been in the spotlight in recent years for their potential role in reducing GHG emissions (see also UNEP, 2018). ICIs are multi-stakeholder arrangements where NSAs work together across borders, often with national governments and other international organizations (Widerberg & Pattberg, 2015). In addition ICIs can be important vehicles for diffusion of knowledge and resources (Abbott, 2017; Bernstein & Hoffman, 2018; Hermwille, 2018). Decarbonization and adaptation approaches in single areas or actors can spread, catalytically driving larger transformations and affecting government policies (Hale, 2018).

Research quantifying the potential mitigation impact of ICIs demonstrates its potential significance. Blok et al. (2012) first analysed 21 initiatives of NSAs, finding that, together, these initiatives would have the potential to reduce global emissions by 10 $GtCO_2e$/year by 2020. Wouters (2013) analysed a subset of Blok et al.'s initiatives in greater detail. Hsu et al. (2015) assessed 29 NSA targets pledged at the 2014 UN Summit, finding a potential for 2.5 $GtCO_2e$/year emission reductions by 2020, while UNEP (2015) found a remaining mitigation gap of 14 $GtCO_2e$ after accounting for the impact of 15 selected initiatives. Graichen et al. (2017) considered the potential GHG impact from 19 ICIs, finding that initiatives could reduce emissions by 5–11 $GtCO_2e$/year in 2030 beyond countries' national targets. Roelfsema et al. (2018) estimated GHG emission reductions of 5 $GtCO_2e$/year by 2030 from 11 selected initiatives, using an integrated assessment model. To the authors' knowledge, however, there is no peer-reviewed literature to date that has quantified the GHG mitigation goals of ICIs focused on high-emitting economies and assessed their implications on the global emissions gap.

This study quantifies the GHG emission reduction goals of 17 selected ICIs, accounting for overlaps, in ten major emitting economies covering two-thirds (69%) of global emissions (Friedlingstein et al., 2019), and the 'rest of the world' (RoW, consisting of all other regions). This analysis develops criteria to select the most significant and appropriate initiatives to aggregate, as of mid-2019, while utilizing the best available data sources and robust methodologies to quantify their potential GHG emission reductions. The ten economies are Brazil, Canada, China, the European Union (EU28), India, Indonesia, Japan, Mexico, South Africa, and the United States of America (USA). Combined, the ICIs addressed roughly 36–39 $GtCO_2e$ across various sectors. This study serves as a companion paper to Kuramochi et al. (2020), which estimated the aggregate GHG emissions reductions resulting from the full implementation of individual NSA targets (1.2–2.0 $GtCO_2e$/year compared to a current policy baseline in 2030) for the same economies. This analysis employs the same Current National Policies (CNP) baseline scenario as Kuramochi et al. (2020), but uses distinctive datasets, methodologies, and approaches to quantify the potential GHG emission reduction impacts from full implementation of ICI goals. In this article, ICIs are defined as international activities outside the United Nations Framework Convention on Climate Change (UNFCCC) driven by coalitions made up of national governments, companies, non-governmental organizations, academia, international organizations or other non-state and subnational actors (Blok et al., 2012; Roelfsema et al., 2018). The analysis further enhances our understanding of overall NSA contributions to global mitigation by quantifying emissions reductions based on ICI goals, rather than individual actor targets. The results are compared to emission pathways in 2030 consistent with scenarios in the literature limiting warming to 2°C or 1.5°C in 2100, to assess the potential of ICIs to steer the climate back towards reach of the long-term Paris Agreement temperature goals.

2. Data and methods

The aggregation methodology used in our analysis of ICI impacts is based on the previous works described in the Introduction, and further developed by the authors (CDP and We Mean Business, 2016; Data-Driven Yale, NewClimate Institute and PBL, 2018; NewClimate Institute, 2019). All GHG emission figures presented are in terms of 100-year global warming potential (GWP) values from the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC).

2.1. Scenarios investigated

The analysis compared two GHG emission scenarios, which are described below:

(1) The '**Current national policies' (CNP) scenario** details the expected emissions path under current national policies. The CNP scenario projections are taken from Kuramochi et al. (2018) and were originally developed to assess national policy implementation against an NDC (Nationally Determined Contribution) achievement scenario. This CNP scenario considers the main energy and climate policies in place as of mid-2018 and assumes no additional mitigation policy is enacted. Our CNP scenario definition is consistent with that in den Elzen et al. (2019); CNP scenario trajectories reflect all adopted and implemented policies secured in legislative decisions, executive orders, and equivalents. Current implemented policy instruments to achieve future goals are therefore included but announced plans and future strategies are not. This means that the NDC GHG mitigation targets or energy demand and supply targets are not assumed to be implemented. These classifications of policy type are often subject to interpretation and require informed judgement calls. The CNP scenario projections are based on the following distinct modelling approaches: (1) the PBL IMAGE model (Stehfest et al., 2014), and (2) a bottom-up policy impact analysis using existing external baseline scenario projections, as well as land-use sector modelling using the global land-use model GLOBIOM (Havlík et al., 2014) and global forest model G4M (Fricko et al., 2017).

(2) The '**CNP plus initiatives' goals'** scenario assumes mutual implementation of ICI goals and national policies and details the potential GHG emission reductions from ICI goals in addition to the impact delivered by current national policies. This scenario accounts for the total amount of GHG emissions reductions expected from ICI members in their target year. Figure 1 displays various ways of interpreting ICI emission reduction goals. The smallest grey box in the figure, labelled '*current members' potential*,' applies if the current members of an ICI achieve the overarching ICI goal (e.g. halting deforestation by 2030) or member-specific goals agreed with the ICI secretariat (e.g. cities participating in Global Covenant of Mayors have different targets). The larger box, labelled '*initiatives' goals,*' applies if members achieve the ICI's goal, and the ICI also meets explicit goals to increase its membership or ambition. This box represents our interpretation of ICI goals, quantifying explicit targets up to 2030. The largest box, labelled '*global net-zero vision,*' represents an ICI's maximum, idealized impact within a timescale that we consider infeasible, based on current developments. In our analysed scenario, we quantify additional emission reductions from ICI goals on top of CNP (see sections 2.3, supplementary online material (SOM) 2 and 3), and account for overlaps between ICIs (see sections 2.3.2 and SOM 4). We also assume that the ICI goals will be fully implemented and do not change the pace of action elsewhere, as evidence suggests ICI goals are unlikely to have been integrated in national policy planning (see discussion in section 4.2.1). We did not analyse specific actions or implementation barriers to meet these targets.

2.2. Selection of initiatives

Between 2014 and 2019, when the most recent UN Climate Conferences were held (at the time of writing), 190 ICIs were recorded in the Climate Initiatives Platform (Climate Initiatives Platform, 2019), of which 170 remained 'active' in 2019. Sub-national governments and businesses account for the majority of participants, representing almost 40%

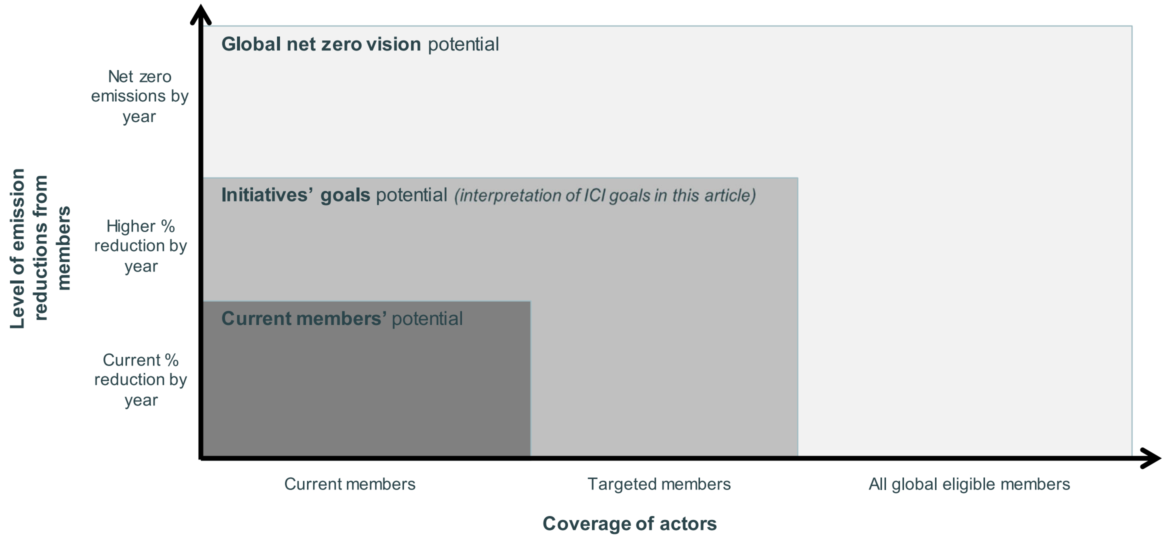


Figure 1. Approaches to defining and selecting ICI targets for emission reduction quantification. Adapted from NewClimate Institute (2019).

of each ICI's membership, with state, international organizations, and research bodies making up the rest (Chan et al., 2018a). While a few ICIs are large, involving hundreds or thousands of participants, most are much smaller.

For this study, we expanded the recorded list of ICIs from the Climate Initiatives Platform with our own research, identifying a list of over 300 that had supported national, subnational and non-state action (see Table S-1). We narrowed the list through a process of tests and filters to establish a representative subset of ICIs to be analysed within the scope of this study.

First, we screened ICIs based on whether they aim to perform **climate change mitigation activities**. Second, ICIs in our selection must also be **transnational** in scope (i.e. involve NSAs from more than two countries). Under this criterion, initiatives involving multiple European countries were eligible, while initiatives whose members fall under the same national jurisdiction were ineligible.

Third, ICIs must possess an ambitious scale in their mitigation operations to be **potentially impactful in reducing global GHGs** for the study to capture the magnitude of ICI goals. To evaluate whether the ICI could be impactful ex-ante, we considered its geographical coverage (does the ICI target geographical regions that contain a meaningful portion of global GHG emissions?) and sectoral coverage (does the ICI target emission intensive sectors particularly relevant for climate mitigation, and does it cover a portion meaningful for global GHG emissions?). ICIs passed this criterion if their mitigation potential was in the order of hundreds of million tonnes of CO_2-equivalent, which we estimated by assessing the emissions coverage of each ICI (see SOM 6) through indicators correlated with emissions (e.g. population, GDP, or energy demand), against its goals. For example, the C40 Cities Climate Leadership Group is included, as its member cities and regions represent 8% of the world's population living across six continents, many of whom live in developed cities with high average emissions per capita (C40, 2019). The RE100 initiative for commercial companies is also selected as its members, in their respective sectors, represent a total of 228 TWh of electricity demand per year, an amount larger than South Africa's (RE100, 2019).

Fourth, we required ICIs to publish **sufficient data** to make emissions reduction quantification possible. For example, Save Food Initiative (Save Food, 2019) to cut global food waste would meet the first three criteria, but was not selected due to limited data on the types of food waste saved, the regions in which it operates, the standards and technology under which the food is produced, or the stage of the supply chain targeted.

Fifth, we screened ICIs for **transparency** in their operations, based on the level of detail in which the ICI describes its operations and theory of change as this adds to an initiative's accountability. The ICI passed this criterion if the theory of change can be clearly conceptualized and if operations have been publicly updated within a year of the analysis.

Sixth, ICIs must achieve a minimal level of output performance according to a **Function-Output-Fit (FOF) analysis** (Chan et al., 2018a; Chan & Amling, 2019). This analysis assesses the initiatives' likelihood of implementation, indicated by progress in producing tangible outputs most relevant to the ICI's function. For instance, if an ICI seeks to reduce emissions by applying new technologies, the building of new installations or infrastructure may indicate progress toward its aim. The higher the FOF score (between 0 and 1), the more likely an ICI might deliver desired behavioural change and/or environmental impacts. For this study, the minimum threshold FOF score was 0.5, meaning that the initiative produces relevant output for at least half of its functions. The FOF scores of our final selection of 17 ICIs, along with further description, are given in SOM 1.2.

As a final test to add to the robustness of our selection of ICIs, we received feedback and agreement on the final ICI selection with the Global Data Community, a working group involved in the tracking the climate action of NSAs and ICIs to support implementation of the Paris Agreement (UNFCCC, 2019). The resulting 17 ICIs assessed in this study represent the final list at the end of the selection process.

2.3. Quantification of potential GHG emissions reduction impact by international cooperative initiatives

The 17 ICIs quantified were categorized into eight sectors: energy efficiency, buildings, transport, renewable energy, industry and business, forestry, non-CO2 GHGs, and cities and regions. The estimated GHG reductions of 'CNP plus ICI goals' were calculated for each of the ten economies as well as for RoW by comparing the ICI goals, in terms of e.g. GHG emissions or energy consumption, to the levels projected for the same indicator under the CNP scenario. In general, we used energy and GHG scenario projections from Kuramochi et al. (2018). However, if more granular energy and emissions projections on a (sub)sector-level were necessary and appropriate, we used energy and GHG scenario projections from other sources (see SOM 3) for our quantifications. We did not use the expected GHG impact estimates reported by the ICIs themselves in our calculations.

Here, we describe the general approach used to quantify potential emissions reduction impacts from initiatives' goals, focusing on those related to energy supply and end-use sectors. Descriptions of each initiative's specific mitigation targets and membership, as well as the detailed methodologies and assumptions used, are given in SOM 2 and 3, including for those initiatives in non-energy sectors. This analysis focuses on overlaps between ICIs (see 2.3.2) and calculates for the additional GHG impact of ICIs (in addition to the CNP baseline) in our quantification methodologies.

2.3.1. Impact quantification in energy supply and end-use sectors

The (sub)sector-level projections from the Current Policies Scenario (CPS) projections of the World Energy Outlook (WEO) 2018 (IEA, 2018) were used when possible, as the baseline against which CO_2 emissions reduction impact of ICIs were calculated. The WEO 2018 CPS projections are similar in terms of assumptions and energy and emission levels to our CNP scenario, and were also used as the basis for developing the CNP scenario projections in Kuramochi et al. (2018) for several economies. For economies not represented individually in WEO 2018, we downscaled global or regional WEO 2018 emissions to the country level using other data sources. Depending on the ICI quantified, other baseline scenarios used include the IEA 2016 Energy Technology Perspectives (ETP) 6 degree scenario (6DS) (IEA, 2016), which assumes an extension of current trends, is consistent with warming of almost 4°C by 2100[1], and includes more sector-specific energy and production data points than our CNP scenario (for a full list, see SOM 3). To convert renewable power generation or electricity savings into emissions savings, we assumed that they displace the need for energy production from conventional fossil fuels (coal, oil, natural gas) and that no carbon leakage occurs. The share and order of which fuel is displaced depends on the initiative quantified. For a list of assumptions used to quantify renewable initiatives, see section SOM 2.4.4.

2.3.2. Quantifying overlaps between initiatives

After calculating the additional emissions reductions of ICI goals compared with national policies for each initiative, we estimated the impact of geographical overlaps between initiatives. Overlap occurs if estimated emissions reductions occur in the same country, sector and for the same GHG emissions, resulting in possible double counting (Hsu, Höhne, et al., 2019b). We build on overlap categorizations of previous work in which aggregation analyses of initiatives were executed and in which 'overlap' concepts have been addressed (Data-Driven Yale, NewClimate Institute and PBL, 2018; Graichen et al., 2017; Hsu, Höhne, et al., 2019b; Roelfsema et al., 2018; Widerberg & Pattberg, 2017). We accounted for three main types of overlaps between initiatives.

Duplicate goals overlap occurs when two ICIs have similar goals, activities or members, and can occur in three ways. *Duplicate members overlap* occurs if one actor is involved in multiple ICIs with similar goals. For example, this occurs if a company, city or sovereign state is committed to two or more initiatives taking similar action. *Encompassing members overlap* occurs when an actor is committed to an initiative but also covers the goals of another smaller actor. For example, this occurs when a region is committed to an initiative, yet cities in that region are also committed to city initiatives. Both overlap types lead to double counting of potential impacts. *Same goal, different actors overlap* occurs in cases where a large pool of emissions is targeted by multiple ICI goals, but the actors of the ICIs are different. For example, this occurs when two ICIs aim to reduce transport-related emissions through similar actions, but one ICI targets cities and the other targets companies. Due to sectoral and geographical overlap, one ICI might claim success of efforts from another ICI. Aggregating both ICI impacts would cause overestimates of overall emission reductions and create difficulties in allocation of reductions to ICIs.

Targeted emissions overlap occurs when ICIs have different goals and activities, but the quantified emission reductions overlap or interact. This can occur in two ways. *Competing targets overlap* occurs when initiatives are addressing the same emissions reductions, but the reductions are not (fully) additional to each other. This could occur between multiple renewable initiatives aiming to reduce fossil fuels in the power generation mix but with different goals (one increases solar while another increases geothermal). Counting the impacts from all ICIs would lead to overestimation in the aggregate results. *Indirect interaction overlap* occurs when ICIs do not address the same emission reductions, but implemented measures interact. For example, implementation of energy efficiency initiatives would reduce fossil fuel use and result in easier attainment of renewable share targets. The extent and impact of overlap differ per target type.

Unspecific target setting overlap occurs when initiatives vaguely define targeted sectors and emissions, thus having potential overlap with sector-specific initiatives. An example is when cities' initiatives have broadly defined emissions reduction goals without indication of targeted implementation activities or sectors. Hence, overlapping sector-specific targets could be double-counted.

As a first step in our method, for ICI results without an estimated emission reduction range in the results, we developed an uncertainty range when accounting for overlaps by using the quantified value as the upper bound and 80% of value as the lower bound. This was based on the average difference between minimum and maximum potential impacts of ICIs for which we found a range in the results. Second, we identified and categorized overlaps according to those described above. We elaborated and utilized a framework decision tree adapted from Smit (2019) (see Figure 2) to identify potential overlaps between any two of the 17 initiatives assessed in this study. The framework was used to develop an overlap matrix to record the results of the potential overlaps (Figure SOM 4.1). We then quantified the overlap rate between initiatives, following the order of the matrix. An overlap rate reflects the share of targeted emissions by a preceding initiative in the matrix that overlaps with the initiative under analysis. The overlap rates were determined case by case, generally based on the share of identical actors (e.g. actors which are involved in two or more initiatives) and similar policy approaches (e.g. when ICIs propose similar policy changes), or emissions coverage in case of *unspecific target setting* overlap. Third, we used the absolute overlap values to correct the ICI reductions additional to national policies for overlap between the ICIs.

In estimating GHG emissions reductions from ICIs in addition to those achieved by national policies, it is assumed that there is no displacement of national climate actions which will be fully implemented. Therefore, we only correct for overlap as described in this section. More information on the overlap matrix, magnitude of overlap categories, and subsequent calculations is given in SOM 4.

3. Results

3.1. GHG emission reductions in 2030

The full list of selected initiatives and quantified emission reduction goals by 2030, in terms of reductions relative to the CNP scenario, is presented in Table 1.

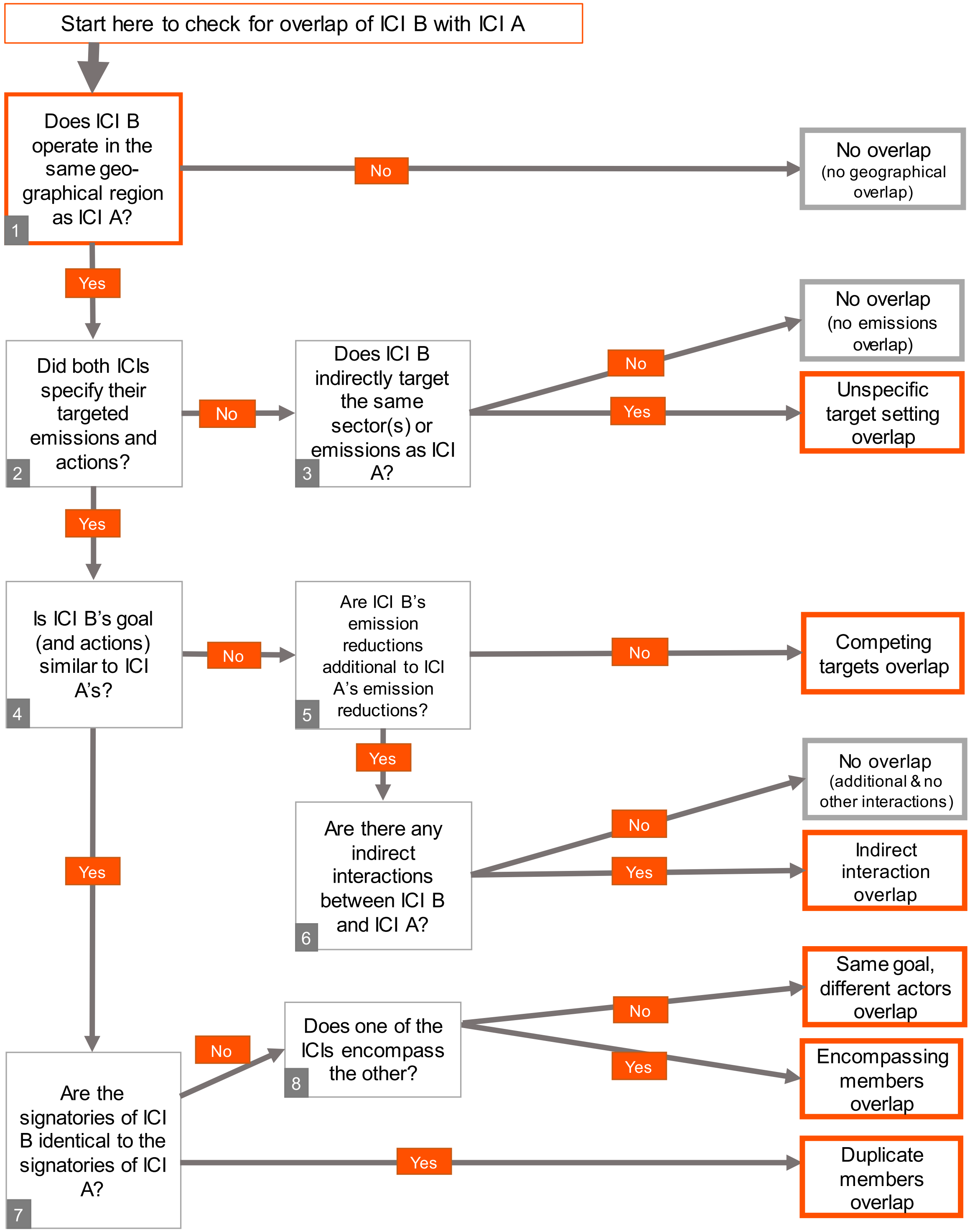


Figure 2. Decision tree for determining overlaps between ICIs (source: adapted from Smit (2019))

After accounting for overlaps, our analysis shows that full implementation of ICIs, if actions do not displace climate action elsewhere, could reduce global GHG emissions in 2030 by 18–21 $GtCO_2e$/year (Figure 3) in addition to the CNP scenario (60–63 $GtCO_2e$/year), which results in global emissions of 39–44 $GtCO_2e$/year. Emission reduction estimates from other sources also reiterate the order of magnitude of the impact of these ICIs. Our calculations assumed that all analysed initiatives meet their goals and that their efforts do not change the pace of action elsewhere. The breakdown of the global potential impact by sector shows that initiatives focused on businesses, forestry, non-CO_2 GHGs, and cities and regions could each potentially deliver GHG emissions reductions of more than 3 $GtCO_2e$/year by 2030. In addition, we present our results in the context of the long-term Paris Agreement temperature goals, by comparing them to global 2°C- (39–46 $GtCO_2e$/year) and 1.5°C- (22–31 $GtCO_2e$/year) compatible emission pathways in 2030 described in section 2.1 (Figure 4).

The Below 2°C and 1.5°C scenarios from the UNEP Emissions Gap Report (2018) are employed in this analysis to compare against our results. These are least-cost mitigation pathways consistent with the Paris Agreement's temperature goals, which have integrated the latest literature including the IPCC Special Report on Global Warming of 1.5°C (IPCC, 2018). We find that emission levels resulting from full implementation of ICI goals and national policies are within the range of a 2°C-consistent pathway by 2030, although there remains a significant gap to reach a 1.5°C-consistent pathway.

Several trends across specific sectors emerge in our analysis.

First, ICIs involving cities and regions can deliver the most significant emissions reductions, as many of these actors, particularly regions, include major economic and population centres that contain ambitious ICI goals. However, while many actors put forward climate mitigation action targets, 58% of the targets do not contain concrete emission reduction action plans. Second, forestry initiatives have large estimated emissions reduction results due to high projected deforestation rates in the CNP scenario and the often ambitious targets of ICIs. For instance, the New York Declaration on Forests aims to end deforestation by 2030. Third, industry and businesses initiatives have ambitious goals, such as adopting 'science-based targets' in line with the Paris Agreement's goal or supplying 100% of their electricity from renewable sources.

There are few active ICIs with potentially high mitigation impacts in emissions intensive energy sub-sectors, such as buildings, industry and transport. Given the importance of the energy sector to global climate change mitigation, implementing ambitious mitigation action in these sub-sectors could have large economy-wide effects.

3.2. Country and regional results

In addition to global results, we have also quantified the potential emissions reductions of ICI goals across ten economies (Figure 5). The differences in results across economies may be due to idiosyncratic country contexts

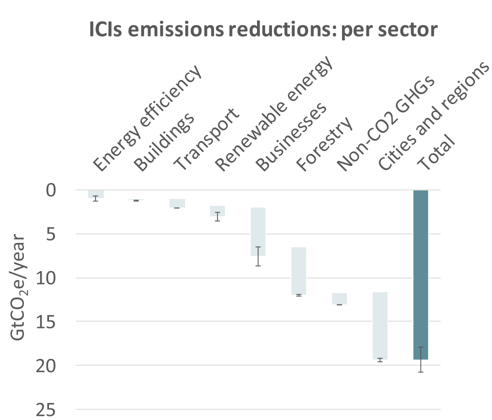


Figure 3. Global potential GHG emissions reductions of ICIs by sector (source: authors)

Table 1. Estimated emission reductions in 2030, if initiatives' goals are fully implemented, without yet accounting for overlaps.

Name of international cooperative initiative	Regions covered	Target(s)	Emissions reduction potential compared to CNP scenario ($GtCO_2e$/year in 2030)	Literature estimate range ($GtCO_2e$/year in 2030; baseline definitions vary) (Source)
Energy efficiency				
United for Efficiency	Global (focus on developing countries)	Members to adopt policies for energy-efficient appliances and equipment	0.6–1.2	1.25 (CIP, 2019b)
Super-efficient Equipment and Appliance Deployment (SEAD) Initiative	Global	Members to adopt current policy best practices for energy efficiency product standards	0.5–1.2	1.7 excluding China (Letschert *et al.*, 2012)
Buildings				
Architecture 2030	Global (focus on North America)	New buildings and major renovations shall be designed to meet an energy consumption performance standard of 70% below the regional (or country) average/median for that building type and to go carbon-neutral in 2030	0.2	N/A
Transport				
Collaborative Climate Action Across the Air Transport World (CCAATW)	Global	Two key objectives: (1) 2% annual fuel efficiency improvement through 2050 (2) Stabilize net carbon emissions from 2020	0.6	0.3 (Roelfsema et al., 2018)
Lean and Green	Europe	Member companies to reduce CO_2e emissions from logistics and freight activity by at least 25% over a five-year period	0.02	N/A
Global Fuel Economy Initiative	Global	Halve the fuel consumption of the light duty vehicle fleet in 2050 compared to 2005	0.5	1.0 $GtCO_2e$/year by 2025 (GFEI, 2018); 0.5 (Roelfsema et al., 2018)
Renewable energy				
European Technology & Innovation Platform for Photovoltaics	Europe	Supply 20% of electricity from solar PV technologies by 2030	0.2–0.5	N/A
Africa Renewable Energy Initiative	Africa	Install additional 300 GW of electricity capacity for Africa by 2030 from clean, affordable and appropriate forms of energy	0.3–0.8	N/A
Global Geothermal Alliance	Global	Achieve a five-fold growth in the installed capacity for geothermal power generation and a more than two-fold growth in geothermal heating by 2030	0.2–0.5	N/A
Business & Industry				
RE100	Global	2,000 companies committed to source 100% of their electricity from renewable sources by 2030	1.9–4.0	N/A
Science Based Targets initiative (SBTi)	Global	By 2030, 2,000 companies have adopted a science-based target in line with a 2°C temperature goal	2.7	N/A
Forestry				
Bonn Challenge / New York Declaration on Forests (NYDF) / Governors' Climate and Forests Task Force (GCFTF)	Global	Two main quantifiable long-term targets: (1) End forest loss by 2030 in member countries (NYDF/GCFTF); (2) Restore 150 million hectares of deforested and degraded lands by 2020 and an additional 200 million hectares by 2030 (NYDF/Bonn)	5.4–5.6	3.8–8.8 (first loss and restoration targets combined) (Wolosin, 2014) 0.7 (Roelfsema et al., 2018)
Non-CO_2 gases				

(*Continued*)

Table 1. Continued.

Name of international cooperative initiative	Regions covered	Target(s)	Emissions reduction potential compared to CNP scenario ($GtCO_2e$/year in 2030)	Literature estimate range ($GtCO_2e$/year in 2030; baseline definitions vary) (Source)
Climate & Clean Air Coalition (HFCs and CH_4)	Global	Members to implement policies that will deliver substantial short-lived climate pollutant (SLCP) reductions in the near- to medium-term (i.e. by 2030)	1.4	3.8 (CIP, 2019a)
Cities and regions				
Under2 Coalition	Global	Local governments aim to limit their GHG emissions by 80–95% below 1990 levels by 2050 (220 members)	4.6–5.0	N/A
Global Covenant of Mayors for Climate & Energy	Global	Member cities have a variety of emission or energy-related targets (>9,000 members)	1.4	1.4 (GCoM, 2018)
C40 Cities Climate Leadership Group[a]	Global	Member cities have a variety of targets, aiming for 1.5°C compatibility by 2050	1.5	Approximately 3.0 (ARUP and C40 Cities, 2016)

[a]From this emissions reduction impact, about 0.67 $GtCO_2e$/year comes from the rest of the world (RoW), i.e. outside of the ten major emitting economies of our focus.

related to environment and geography, such as natural resource endowments (e.g. forestry) or governance and policies (e.g. economic market regulations, industrial structure).

Our results show that ICIs could play an important role in the decarbonization of the world's largest emitters, in addition to current national policies. If ICIs implemented and fully achieved their goals in **China**, they could reduce emissions in 2030 by 2,700–2,800 $MtCO_2e$/year. Initiatives focused on cities and regions account for the largest share of the estimated results (1,860–1,940 $MtCO_2e$/year), given that many of China's largest cities and provinces participate in both domestic and international initiatives. For instance, the Alliance of Peaking Pioneer Cities aims to peak emissions earlier than 2030 (in accordance with China's NDC), while the Under2Coalition and C40 Cities Climate Leadership Network initiatives both have overarching long-term emission goals compatible with Paris Agreement temperature goals.

A similar trend is visible in the **USA**, with cities and regions accounting for a large share (750–880 $MtCO_2e$/year) of the total estimated GHG reductions of ICIs in 2030 (1,300–1,500 $MtCO_2e$/year). Climate action by local governments grew after the announced US withdrawal from the Paris Agreement and federal rollback of major climate policies (Arroyo, 2018). Further, the Climate and Clean Air Coalition has goals that could reduce emissions by around 300 $MtCO_2e$/year by 2030. The lower range of projected emission reductions from ICIs by 2025 (32% below 2005 levels) shows that the ambitions of the ICIs surpass US emission levels expected from its NDC target, findings similar to the 'Bottom-Up' scenario projections in the America's Pledge report (America's Pledge, 2019).

ICIs in the **EU** could reduce emissions in 2030 by 790–1,200 $MtCO_2e$/year. Initiatives focused on renewable energy, non-CO_2 GHGs, and cities and regions account for the largest share of estimated mitigation potential in this region. In particular, the European Technology & Innovation Platform PhotoVoltaics (ETIP-PV), an initiative targeting increased electricity generation from solar energy, has mitigation goals equivalent to emissions reductions of 210–460 $MtCO_2e$/year. As the EU aims to achieve a 32% share of renewable energy in 2030 in line with its NDC, and European countries are now required to develop National Energy and Climate Plans for the period 2020–2030, the large ambition shown by renewable energy initiatives can play a significant role in delivering the EU's climate strategy.

ICIs in **India** could reduce emissions in 2030 by 510–590 $MtCO_2e$/year. Cities and regions, non-CO_2 GHGs, and energy efficiency ICIs make up virtually all (99%) the estimated results. The latter is important for India, as energy demand and population are expected to continue increasing. The room for further expansion of renewable energy initiatives is also large, as India's National Solar Mission aims to increase renewable capacity to 175 GW by 2022 (Indian Ministry of New and Renewable Energy, 2015). The goals included in ICIs would reduce total emission levels significantly beyond India's NDC target.

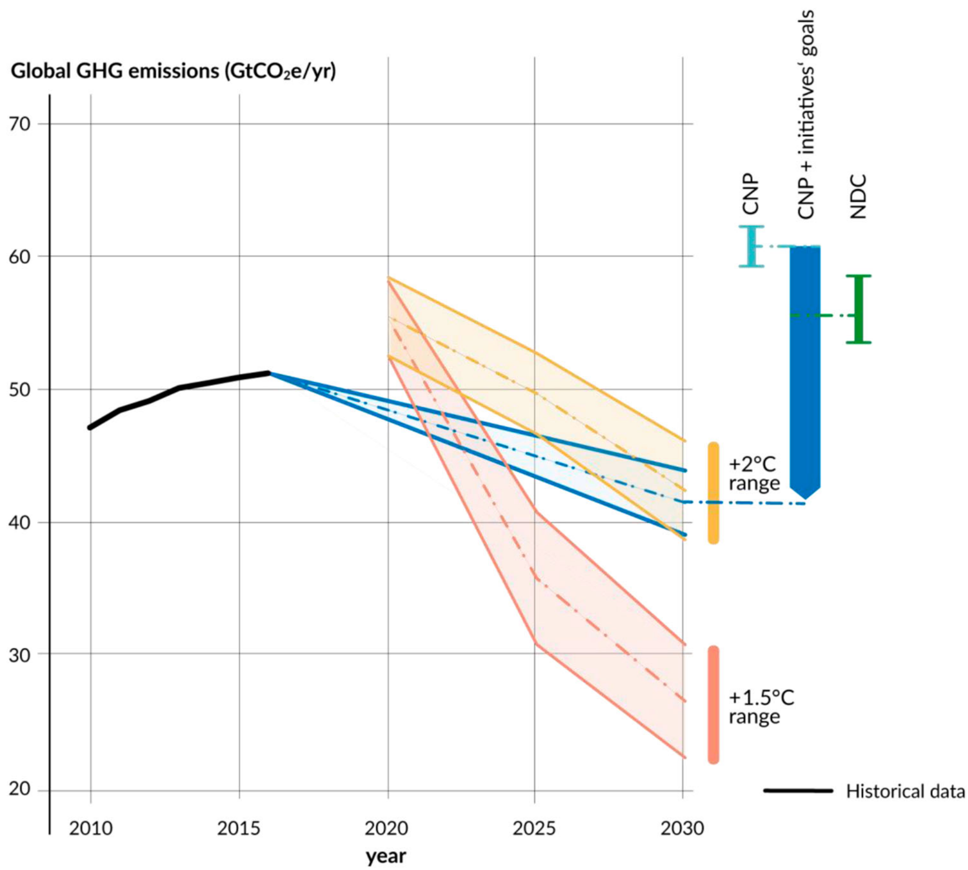
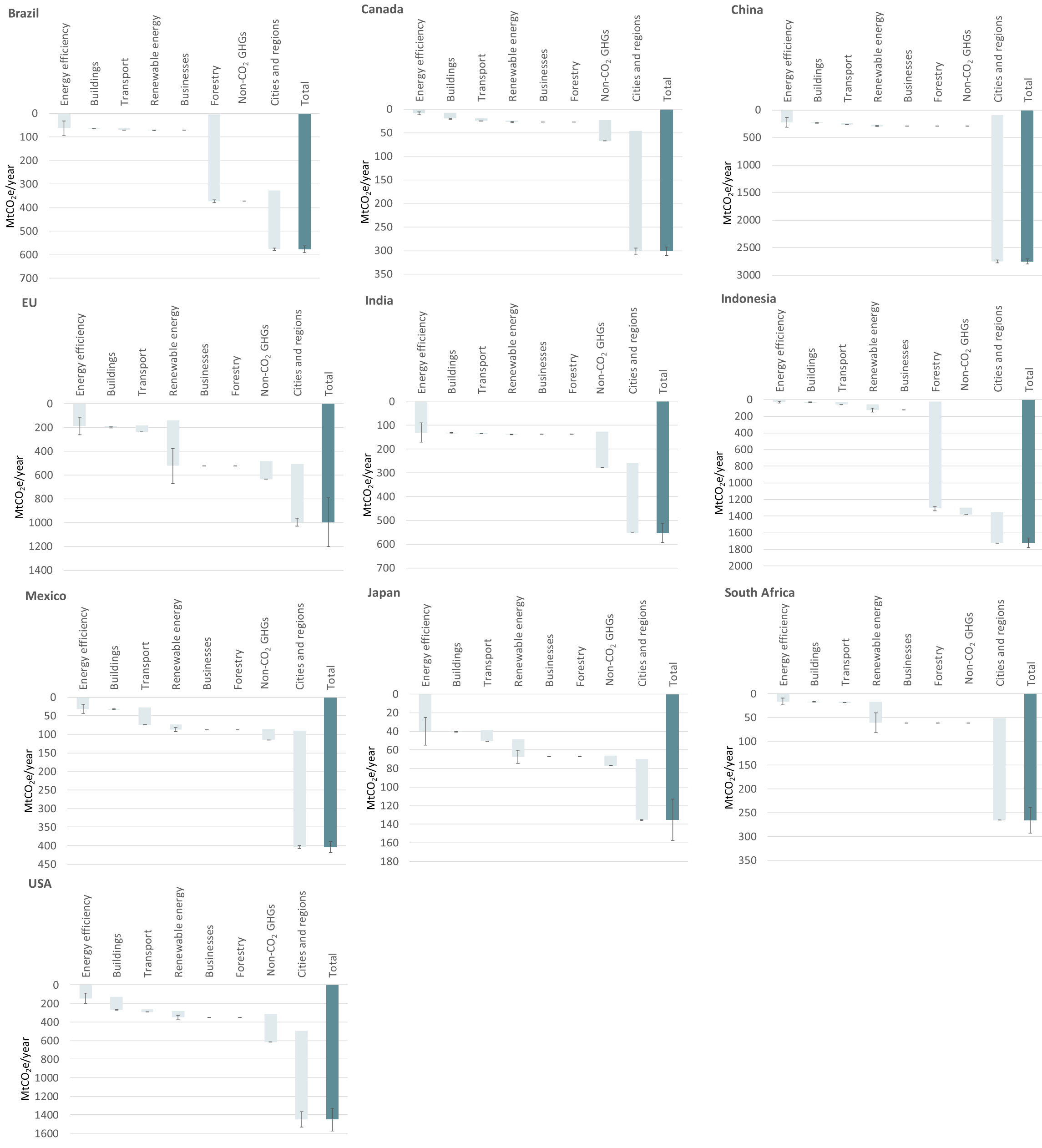


Figure 4. Potential GHG emissions reductions resulting from full implementation of ICIs ('CNP plus initiatives' goals' scenario) up to 2030. Adapted from NewClimate Institute (2019). Data sources: CNP projections from Climate Action Tracker (2018) supplemented with land use, land-use change and forestry (LULUCF) emissions projections adapted from Forsell et al. (2016); NDC (unconditional) scenario projections from Climate Action Tracker (2018); 2°C (in 2100, 66% chance) and 1.5 °C (in 2100, 66% chance) pathways from UNEP (2018), adapted to global warming potentials (GWPs) from the IPCC Fourth Assessment Report based on the 2016 historical data from PRIMAP database (Gütschow et al., 2019). Impact of ICIs: authors.

Initiatives focused on cities and regions also represent the largest results in many other economies analysed. Overall, ICIs in **Canada** could reduce emissions in 2030 by 290–310 $MtCO_2e$/year. Initiatives involving cities and regions and non-CO_2 gases (Climate and Clean Air Coalition) contribute 270–280 $MtCO_2e$/year of this overall mitigation impact. ICIs in **Japan** could reduce emissions in 2030 by 110–160 $MtCO_2e$/year, with cities and regions accounting for approximately half of potential GHG emission reductions. ICIs in **Mexico** could reduce emissions in 2030 by 390–420 $MtCO_2e$/year. Cities and regions make up the largest reductions (290 $MtCO_2e$/year) due to the proportionally high rate of coverage in comparison with other countries. ICIs in **South Africa** could reduce emissions in 2030 by 240–290 $MtCO_2e$/year. These ICIs could help South Africa decrease emissions to the lower end of the range of its NDC target. Cities and regions account for around 200 $MtCO_2e$/year of the estimated results.

In economies with a large forestry sector, initiatives on afforestation and deforestation have considerable emission reduction potential. For **Brazil**, ICIs could reduce emissions in 2030 by 560–590 $MtCO_2e$/year, with forestry initiatives contributing 360–380 $MtCO_2e$/year to this total potential. ICIs in **Indonesia** could reduce emissions in 2030 by 1,700–1,800 $MtCO_2e$/year, with forestry initiatives accounting for 1,260–1,310 $MtCO_2e$/year. We present economy-specific CNP plus initiatives' goals results alongside CNP and NDC emission levels for reference in Table 2. For more details on scenario pathways, see SOM 5.



Note: Country-level results exclude potential impacts from CCAATW, RE100, and SBTi.

Figure 5. Potential GHG emissions reductions of ICIs by sector, per economy (source: authors).
Note: Country-level results exclude potential impacts from CCAATW, RE100, and SBTi.

4. Discussion

4.1. Significance and policy implications

These results show that ICIs have ambitious goals that, if fully implemented in addition to current national policies, have the emissions reduction potential to put the world on track to reach long-term temperature goals consistent with the Paris Agreement. This finding confirms estimates from other literature sources (see Table 1), which find potential emission reductions for our ICIs of the same order of magnitude, and often larger, than the results from this analysis. For each of the ten economies featured in this analysis, the aggregation of ICI goals surpasses – in some cases, greatly so – NDC emission pledges for 2030. For a few economies including the EU, Canada and the USA, ICIs can also deliver impacts consistent with mid-century net-zero CO_2 or GHG emissions goals. It is because of their ambitious mitigation goals, pursuit of sectoral transformational change, and large global emissions coverage (roughly 36–39 $GtCO_2e$) that emissions reduction goals are an order of magnitude larger than those of individual actors' targets (see Kuramochi et al., 2020). However, the ambitious nature of the goals also comes with greater uncertainty on implementation (see section 4.2 on Limitations).

The results have important implications. First, the large results for ICI goals identify the magnitude of emission reductions at stake, suggesting that if ICIs deliver what is promised, they could have prominent roles to play in global mitigation efforts to reach pathways compatible with Paris Agreement goals by 2030. Full implementation of ICI goals in addition to national policies are within the range of a 2°C-consistent pathway by 2030, but there remains a significant gap to reach a 1.5°C-consistent pathway. One reason for this could be that despite the large ICI landscape, fewer ICIs are found in (sub)sectors where emission reductions are difficult or expensive to achieve, yet vital for deep global climate change mitigation, such as in heavy industry. Moreover, although ICI goals can help reach pathways consistent with the Paris Agreement's long-term temperature goals in 2030, this does not necessarily guarantee actual limiting of warming below 2°C or 1.5°C by 2100 (see section 4.2.5).

Second, the mitigation potential demonstrated through ICIs provides quantitative evidence for policymakers of cases where scaled-up non-state and subnational climate action could increase national government policy ambition (Hale, 2018). Third, the development of robust aggregation methods is critical for furthering techniques in ex-ante and ex-post analyses of NSA action, which can increase the overall integrity of NSA action and support their integration into national and international climate governance.

Table 2. Projected GHG emissions in 2030 for economies under the CNP and CNP plus initiatives' goals scenarios.

Country	2016 GHG emissions including LULUCF ($MtCO_2e$/year)	2030 GHG emissions projections including LULUCF ($MtCO_2e$/year)		
		Current national policies (CNP) scenario	CNP plus initiatives' goals scenario (%-reduction to CNP scenario)	[For comparison] Unconditional NDC scenario
Brazil*	1,720	1,560–1,800	1,000–1,210 (36.1–32.7%)	1,180
Canada*	680	610–740	320–430 (48.0–41.7%)	500
China*	12,100–12,600	12,200–14,600	9,520–11,800 (22.1–19.2%)	13,200–16,200
European Union (EU28)*	3,990	2,920–3,540	2,130–2,340 (27.1–34.0%)	3100
India*	2,510–2,620	4,050–4,450	3,540–3,860 (12.6–13.3%)	4,980–6,130
Indonesia*	1,990–2,030	2,820–3,170	1,160–1,390 (59.0–56.1%)	2,100
Japan*	1,250	1,040–1,150	930–990 (10.9–13.8%)	1,020
Mexico*	640–700	690–830	300–420 (56.6–50.2%)	750
South Africa*	560–570	640–750	400–450 (37.3–39.2%)	400–620
United States*	5,790	5,050–5,760	3,730–4,190 (26.3–27.3%)	4,740
Rest of the World (RoW)*	**19,500–20,160**	**25,740–27,930**	**19,570–21,050**	**22,070–22,730**

Note: The CNP scenario does not account for action from ICI goals. The CNP and unconditional NDC scenario is based on Kuramochi et al. (2018). Economy and RoW values are rounded to the nearest 10 and may be thus be minimally unaligned with numbers in the text.

*Ten economies and RoW results do not include results from CCAATW, RE100, and SBTi ICIs. Thus, the sum of ten countries' and RoW do not equal global results, as only the global results include calculations for overlaps of CCAATW, RE100, and SBTi, with other ICIs.

The number of ICIs has been growing annually as the evidence base supporting the case for climate mitigation increases. Mitigation activities in one sector or by one actor can also have multiplier effects and spread to others, potentially driving larger and unforeseen transformations. Furthermore, this study only quantifies 'initiatives' goals' – where ICIs meet increased membership or mitigation goals that are feasible – while the delivery of ICIs' 'global net-zero cvision' goals would lead to larger estimated reductions. While these points reinforce that the ambition of ICIs is great, they also underline the scale of effort required to enable the successful realization of ICI goals. Together, our results identify ICIs as a highly relevant and future priority area for both academics and policymakers.

4.2. Limitations

4.2.1. Changing the course of action elsewhere

One important assumption made in this study is that ICI sectoral action does not alter other actions captured in the CNP scenario. For ICIs to be integrated in national policy planning and change the course of action elsewhere, effective coordination would be required between national governments, ICI secretariats and implementing actors. Hsu, Brandt, et al. (2019a) showed this is not the case between governments and NSAs. This unlikelihood is further compounded by ICIs being transnational in impact, voluntary in scope, and displaying poor tracking and monitoring. Thus, we conclude with our assumption that ICI actions are currently not captured by government and do not change the course of others' actions.

4.2.2. Selection and coverage of ICIs

The full universe of ICIs is under-represented in this study as our research uncovered more than 300 ICIs with links to climate mitigation or adaptation, but only focused on 17. While the omission of some ICIs from this study is indicative of minimal estimated GHG reductions, other ICIs undertaking actions only indirectly affecting emissions (e.g. activism, knowledge-sharing) could also have considerable impacts. Another example is the exclusion of finance sector initiatives, such as the UN-convened Net Zero Asset Owner Alliance (UNEP, 2019b), which is aimed at shifting portfolios to help economic sectors align with Paris Agreement emissions goals. However, various assumptions used in the calculations could also overestimate ICI mitigation contributions and resulting GHG emissions are not guaranteed (see below).

4.2.3. Data methods and assumptions

For this assessment, many decisions and assumptions were made during ICI quantifications (see SOM 2). In general, our approach was to be conservative and insert an uncertainty range to ensure our results were robust. Where ICI goals were vague or not deemed feasible based on the literature, we chose to quantify less ambitious explicitly stated goals to avoid inflating results (e.g. we quantify ETIP-PV's 20% share of EU electricity generation in 2030 goal, rather than 600 GW by 2025). In filling data gaps, we utilize the full range of literature values to show fair results (e.g. when fossil fuels are displaced or removed in the energy mix, we present a minimum/maximum range depending on whether gas is removed before coal or vice versa). For the evolution of trends, we also make conservative assumptions in case of uncertainty (e.g. for RE100 actors without an explicit target year, we assume they achieve their goals in 2050, beyond the time horizon of our analytical results). While granular data and assumptions can always be challenged, we conclude that our results capture the order of magnitude of ICI emissions reduction goals.

4.2.3.1. Calculating overlaps between initiatives. While applying the overlap analysis, we stay conservative while maintaining a systemic and traceable approach. For ICIs where we assume lower bounds, our method decreases the estimated emissions impact of our results. While our overlap matrix and decision tree has not been previously discussed in the literature, we believe it is a robust exploration of a novel approach. This is justified by an extensive review of academic literature on NSA and good practices (see section 2.3.2). Our methodologies and results should not be immutable and could be further calibrated as more data becomes available.

4.2.4. Likelihood of full implementation of ICI goals

While this article has demonstrated the emissions reduction potential of our selected ICI goals, there remains uncertainty as to their implementation. One factor concerns the ambitious nature of the goals and results from the international and large-scale efforts connecting diverse sets of actors, working in diverse sectors and targeting transformational change. Support and mobilization of actors at all levels – from the international, national, local, and private sector communities – are critical to building an enabling policy environment for ICIs (e.g. Pereira et al., 2017; Reo et al., 2017; Westman & Broto, 2018; Widerberg et al., 2019). Another factor relates to progress tracking and data availability. The majority of ICIs do not establish strong practices in monitoring, reporting, and verification (Chan et al., 2018b; Graichen et al., 2017; Pattberg et al., 2012) and for those that do, ex-post evidence of successful implementation and evaluation of large-scale mitigation-focused ICIs is scarce and the evidence case for ICI impact is cautious (e.g. Steffen et al., 2019). The New York Declaration on Forests, which has 2020 goals of halving global deforestation (Goal 1) and increasing forest cover by 150 Mha (Goal 5), has reported in its five-year assessment report that achievement of 2020 goals is 'likely impossible'; since 2000, the global rate of gross tree cover loss has nearly doubled instead of decreasing, and only 18% of Goal 5 has been achieved (NYDF, 2019). For the Science Based Targets initiative, only 43% of member companies had approved targets by January 2020 (Leone, 2020; SBTi, 2019). While most countries' actions currently fall short of their NDC targets (Climate Action Tracker, 2019), a similar statement can be made for ICIs relative to their own goals.

4.2.5. Uncertainty in temperature outcomes

The implications of results presented are consistent with the latest science on estimated temperature outcomes at the point of analysis (IPCC, 2018; UNEP, 2018), suggesting full implementation of ICI goals could bring global emission levels to a range consistent with a 2°C pathway in 2030 (42 $GtCO_2e$/year in 2030). However, while this range implies a 66% chance of limiting warming to 2°C relative to pre-industrial levels in 2100, it also implies a 90% chance of staying below 2.4–2.6°C. There are also other known sources of uncertainty in projecting long-term temperature outcomes (e.g. Lowe & Bernie, 2018; Matthews et al., 2017; Tokarska & Gillett, 2018). Thus, this study primarily emphasizes the order of magnitude of emission reductions while limiting discourse on long-term temperature outcomes.

4.3. Areas of further research

The discussion in this article offers several suggestions for further research. The development and adoption of an effective standardized approach for ICIs to report quantitative and qualitative indicators is critical to fill data gaps, further advancing quantification methodologies across the wider landscape of ICIs and enabling comprehensive progress tracking. A significant emphasis on extracting best practices and lessons learned is important to generate contextual recommendations to policymakers and actors for enabling fulfilment of ICI goals. Methodological exploration to assess the likelihood of full ICI implementation is another priority, as robust assessments could give policymakers the confidence to integrate ICI actors in climate planning processes, and ICI goals in target-setting.

5. Conclusions

This article presents a comprehensive analysis of the potential GHG emissions reductions that could be achieved from full implementation of the goals of selected ICIs, where cities, regions, businesses, and other subnational and non-state actors work together, often in partnership with national governments and other organizations. We find that the combination of current national polices and 17 initiatives could reduce global GHG emissions in 2030 by 18–21 $GtCO_2e$/year below a CNP scenario (60–63 $GtCO_2e$/year), resulting in global emissions of 39–44 $GtCO_2e$/year. If all initiatives meet their goals and their efforts do not change the course of action elsewhere, they could steer global emissions levels to reach an emissions pathway consistent with limiting global warming to 2°C (in 2100, 66% probability) by 2030.

Through ICIs, a range of actors – including cities, regions and companies – demonstrate the potential for national governments to implement more ambitious policies than those in place currently, and more ambitious pledges than current NDCs. The efforts of ICIs can also serve as examples to help spur greater economy-wide impacts through the spillover of actions to other sectors and actor groups. While the level of ambition is evidently high in the global ICI landscape, progress on actual implementation is largely unknown and in a few visible cases, slower than could be expected. To fully deliver ICI goals, collaboration is needed involving a diversity of institutions and stakeholders from different countries, levels of governance, sectors, and branches of civil society. It is therefore crucial that national governments further leverage and enhance cooperation with these initiatives if they are to correct the course of global emissions and accelerate efforts toward long-term carbon neutrality.

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Note

1. ETP scenarios give cumulative CO_2 emissions from energy and industry sectors to 2050, which can be extended to 2100. The 6DS scenario leads to IPCC Representative Concentration Pathways (RCP) scenarios between RCP 6 and RCP8.5, which indicate approximately 4°C increase by 2100 from pre-industrial levels. These RCP scenarios include post-2050 emissions for all sources of GHG emissions.

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References

Abbott, K. W. (2017). Orchestrating experimentation in non-state environmental commitments. *Environmental Politics*, *26*(4), 738–763. https://doi.org/10.1080/09644016.2017.1319631

America's Pledge. (2019). *Accelerating America's Pledge: Going all-in to build a prosperous, low-carbon economy for the United States*. https://www.bbhub.io/dotorg/sites/28/2019/12/Accelerating-Americas-Pledge.pdf

Arroyo, V. (2018). The global climate action summit: Increasing ambition during turbulent times. *Climate Policy*, *18*(9), 1087–1093. https://doi.org/10.1080/14693062.2018.1516957

ARUP, & C40 Cities. (2016). *Deadline 2020: How cities will get the job done. ARUP, C40 Cities*. http://www.c40.org/researches/deadline-2020.

Bernstein, S., & Hoffman, M. (2018). The politics of decarbonization and the catalytic impact of subnational climate experiments. *Policy Sciences*, *51*(2), 189–211. https://doi.org/10.1007/s11077-018-9314-8

Blok, K., Höhne, N., van der Leun, K., & Harrison, N. (2012). Bridging the greenhouse-gas emissions gap. *Nature Climate Change*, *2*(7), 471–474. https://doi.org/10.1038/nclimate1602

C40. (2019). *C40 Cities*. Retrieved September 1, 2019, from https://www.c40.org/about

CDP and We Mean Business. (2016). *The business end of climate change*. CDP, We Mean Business Coalition. https://newclimate.org/2016/06/28/the-business-end-of-climate-change/

Chan, S., & Amling, W. (2019). Does orchestration in the global climate action agenda effectively prioritize and mobilize transnational climate adaptation action? *International Environmental Agreements: Politics, Law and Economics*, *19*(4), 429–446. https://doi.org/10.1007/s10784-019-09444-9

Chan, S., Ellinger, P., & Widerberg, O. (2018b). Exploring national and regional orchestration of non-state action for a < 1.5°C world. *International Environmental Agreements: Politics, Law and Economics*, *18*(1), 135–152. https://doi.org/10.1007/s10784-018-9384-2

Chan, S., Falkner, R., Goldberg, M., & van Asselt, H. (2018a). Effective and geographically balanced? An output-based assessment of non-state climate actions. *Climate Policy*, *18*(1), 24–35. https://doi.org/10.1080/14693062.2016.1248343

CIP. (2019a). *CCAC: Phasing down climate potent HFCs /HFCs initiative*. http://climateinitiativesplatform.org/index.php/CCAC:_Phasing_Down_Climate_Potent_HFCs_/_HFCs_Initiative.

CIP. (2019b). *Climate initiatives platform: Super-efficient equipment and appliance deployment (SEAD) initiative*. http://climateinitiatives-platform.org/index.php/Super-efficient_Equipment_and_Appliance_Deployment_(SEAD)_Initiative.

Climate Action Tracker. (2018). *Some progress since Paris, but not enough, as governments amble towards 3°C of warming*. NewClimate Institute, Ecofys, Climate Analytics. https://climateactiontracker.org/documents/507/CAT_2018-12-11_Briefing_WarmingProjectionsGlobalUpdate_Dec2018.pdf

Climate Action Tracker. (2019). *Warming projections global update: Governments still showing little sign of acting on climate crisis*. https://climateactiontracker.org/documents/698/CAT_2019-12-10_BriefingCOP25_WarmingProjectionsGlobalUpdate_Dec2019.pdf

Climate Initiatives Platform. (2019). *Climate initiatives platform*. http://climateinitiativesdatabase.org/index.php/Welcome

Data-Driven Yale, NewClimate Institute and PBL. (2018). *Global Climate Action from cities, regions, and businesses*. Data-Driven Yale; NewClimate Institute; PBL. http://bit.ly/yale-nci-pbl-global-climate-action

Day, T. (2018). *Opportunity 2030: Benefits of climate action in cities. Quantifying the benefits of city-level measures in buildings, transport and energy supply*. NewClimate Institute. https://newclimate.org/wp-content/uploads/2018/03/C40_Opportunities_2030_report.pdf.

den Elzen, M., Kuramochi, T., Höhne, N., Cantzler, J., Esmeijer, K., Fekete, H., Fransen, T., Keramidas, K., Roelfsema, M., Sha, F., van Soest, H., & Vandyck, T. (2019). Are the G20 economies making enough progress to meet their NDC targets? *Energy Policy*, *126*(October 2018), 238–250. https://doi.org/10.1016/j.enpol.2018.11.027

Forsell, N., Turkovska, O., Gusti, M., Obersteiner, M., Elzen, M. den, & Havlik, P. (2016). Assessing the INDCs' land use, land use change, and forest emission projections. *Carbon Balance and Management*, *11*(1), 26. https://doi.org/10.1186/s13021-016-0068-3

Fricko, O., Havlik, P., Rogelj, J., Klimont, Z., Gusti, M., Johnson, N., Kolp, P., Strubegger, M., Valin, H., Amann, M., Ermolieva, T., Forsell, N., Herrero, M., Heyes, C., Kindermann, G., Krey, V., McCollum, D. L., Obersteiner, M., Pachauri, S., … Riahi, K. (2017). The marker quantification of the shared socioeconomic pathway 2: A middle-of-the-road scenario for the 21st century. *Global Environmental Change*, *42*, 251–267. https://doi.org/10.1016/j.gloenvcha.2016.06.004

Friedlingstein, P. (2019). Global carbon budget 2019. *Earth System Science Data*, *11*, 1783–1838. https://doi.org/10.5194/essd-11-1783-2019

GCoM. (2018). *Implementing climate ambition. Global covenant of mayors 2018 global aggregation report*. https://www.globalcovenantofmayors.org/wpcontent/uploads/2018/09/2018_GCOM_report_web.pdf.

GFEI. (2018). *The global fuel economy initiative: Delivering climate action*. Global Fuel Economy Initiative.

Graichen, J., Healy, S., Siemons, A., Höhne, N., Kuramochi, T., Gonzales-Zuñiga, S., Sterl, S., Kersting, J., & Wachsmuth, J. (2017). *International climate initiatives - A way forward to close the emissions gap? Initiatives' potential and role under the Paris agreement. Final report*. 31. German Federal Environment Agency, German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

Gütschow, J., Jeffery, L., & Gieseke, R. (2019). The PRIMAP-hist national historical emissions time series (1850-2016) V 2.0. GFZ Data Services. http://dataservices.gfz-potsdam.de/pik/showshort.php?id=escidoc:3842934

Hale, T. (2016). "All hands on deck": The Paris agreement and nonstate climate action. *Global Environmental Politics*, *16*(3), 12–22. https://doi.org/10.1162/GLEP_a_00362

Hale, T. (2018). *Catalytic cooperation. BSG Working Paper Series 2018/026*. Oxford, UK. https://www.bsg.ox.ac.uk/sites/default/files/2018-09/BSG-WP-2018-026.pdf

Havlík, P., Valin, H., Herrero, M., Obersteiner, M., Schmid, E., Rufino, M. C., Mosnier, A., Thornton, P. K., Böttcher, H., Conant, R. T., Frank, S., Fritz, S., Fuss, S., Kraxner, F., & Notenbaert, A. (2014). Climate change mitigation through livestock system transitions. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(10), 3709–3714. https://doi.org/10.1073/pnas.1308044111

Hermwille, L. (2018). Making initiatives resonate: How can non-state initiatives advance national contributions under the UNFCCC? *International Environmental Agreements: Politics, Law and Economics*, *18*(3), 447–466. https://doi.org/10.1007/s10784-018-9398-9

Hsu, A., & Brandt, J. (2019a). Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs). *Climate Policy*, *20*(4), 443–457. https://doi.org/10.1080/14693062.2019.1624252

Hsu, A., Höhne, N., Kuramochi, T., Roelfsema, M., Weinfurter, A., Xie, Y., Lütkehermöller, K., Chan, S., Corfee-Morlot, J., Moorhead, J., Hale, T., Setzer, J., Weber, C., Höhne, N., Roelfsema, M., Weinfurter, A., Xie, Y., Chan, S., Gordon, D. J., … Hultman, N. E. (2019b). A research roadmap for quantifying non-state and subnational climate mitigation action. *Nature Climate Change*, *9*(1), 11–17. https://doi.org/10.1038/s41558-018-0338-z

Hsu, A., Moffat, A. S., Weinfurter, A. J., & Schwartz, J. D. (2015). Towards a new climate diplomacy. *Nature Climate Change*, *5*(6), 501–503. https://doi.org/10.1038/nclimate2594

IEA. (2016). *Energy technology perspectives 2016. Towards sustainable urban energy systems*. Paris, France: International Energy Agency. http://www.iea.org/etp/etp2016/

IEA. (2018). *World energy outlook 2018*. Paris, France: International Energy Agency. https://www.iea.org/weo2018/

Indian Ministry of New and Renewable Energy. (2015). New solar energy policy. http://pib.nic.in/newsite/pmreleases.aspx?mincode=28

IPCC. (2018). *Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,*. Geneva, Switzerland: Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Citation.pdf

Kuramochi, T. (2020). Beyond national climate action: The impact of region, city, and business commitments on global greenhouse gas emissions. *Climate Policy*, *20*(3), 275–291. https://doi.org/10.1080/14693062.2020.1740150

Kuramochi, T., Fekete, H., Luna, L., de Villafranca Casas, M. J., Nascimento, L., Hans, F., Höhne, N., van Soest, H., den Elzen, M., Esmeijer, K., Roelfsema, M., Forsell, N., Turkovska, O., & Gusti, M. (2018). *Greenhouse gas mitigation scenarios for major emitting countries. Analysis of current climate policies and mitigation commitments: 2018 update*. NewClimate Institute, PBL Netherlands Environmental Assessment Agency and International Institute for Applied Systems Analysis. https://newclimate.org/2018/12/05/greenhouse-gas-mitigation-scenarios-for-major-emitting-countries-analysis-of-current-climate-policies-and-mitigation-commitments-2018-update/.

Leone, F. (2020). *Science based targets initiative reports on progress towards low-carbon economy, international institute for sustainable development*. Retrieved February 7, 2020, from http://sdg.iisd.org/news/science-based-targets-initiative-reports-on-progress-towards-low-carbon-economy/

Letschert, V., Desroches, L.-B., Ke, J., & McNeil, M. (2012). Estimate of technical potential for minimum efficiency performance standards in 13 major world economies. *Lawrence Berkeley National Laboratory (LBNL)*, *5724-E*(July). http://ies.lbl.gov/publications/estimate-technical-potential-minimum-

Lowe, J. A., & Bernie, D. (2018). The impact of Earth system feedbacks on carbon budgets and climate response. *Philosophical Transactions of the Royal Society A*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5897833/

Matthews, H. D. (2017). Estimating carbon budgets for ambitious climate targets. *Current Climate Change Reports*, *3*(1), 69–77. https://doi.org/10.1007/s40641-017-0055-0

New Climate Economy. (2015). *Seizing the global opportunity: Partnerships for better growth and a better climate. The 2015 new climate economy report*. The Global Commission on the Economy and Climate.

NewClimate Institute. (2019). *Global climate action from cities, regions and businesses: Impact of individual actors and cooperative initiatives on global and national emissions. 2019 edition*. NewClimate Institute, Data-Driven Lab, PBL Netherlands Environmental Assessment Agency, German Development Institute/Deutsches Institut für Entwicklungspolitik (DIE), Blavatnik School of Government, University of Oxford.

NYDF. (2019). *Protecting and restoring forests: A story of large commitments yet limited progress - five-year assessment report*. https://forestdeclaration.org/images/uploads/resource/2019NYDF_ES.pdf

Pattberg, P. H., Biermann, F., Chan, S., & Mert, A. (2012). *Public-private partnerships for sustainable development: Emergence, influence and legitimacy*. Edward Elgar Publishing.

Pereira, G. V. (2017). Increasing collaboration and participation in smart city governance: A cross-case analysis of smart city initiatives. *Information Technology for Development*, *23*(3), 526–553. https://doi.org/10.1080/02681102.2017.1353946

RE100. (2019). *RE100 progress and insights - annual report*. http://media.virbcdn.com/files/5c/aa8193f038934840-Dec2019RE100ProgressandInsightsAnnualReport.pdf

Reo, N. J., Whyte, K. P., McGregor, D., Smith, P., & Jenkins, J. (2017). Factors that support Indigenous involvement in multi-actor environmental stewardship. *AlterNative: An International Journal of Indigenous Peoples*, *13*, 58–68. https://doi.org/10.1177/1177180117701028

Roelfsema, M., Harmsen, M., Olivier, J. J. G., Hof, A. F., & van Vuuren, D. P. (2018). Integrated assessment of international climate mitigation commitments outside the UNFCCC. *Global Environmental Change*, *48*, 67–75. https://doi.org/10.1016/j.gloenvcha.2017.11.001

Save Food. (2019). *Save food initiative*. Retrieved February 7, 2020, from https://www.save-food.org/

SBTi. (2019). *Raising the bar: Exploring the science based targets initiative's progress in driving ambitious climate action*. https://sciencebasedtargets.org/wp-content/uploads/2019/12/SBTi-Progress-Report-2019-FINAL-v1.2.pdf

Seto, K. C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G. C., Dewar, D., Huang, L., Inaba, A., Kansal, A., Lwasa, S., McMahon, J. E., Müller, D. B., Murakami, J., Nagendra, H., & Ramaswami, A. (2014). Human settlements, infrastructure and spatial planning. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, & A. Adler (Eds.), *Climate change 2014: Mitigation of climate change. Contribution of working Group III to the Fifth Assessment Report of the Intergovernmental Panel on climate change* (pp. 927–977). Cambridge University Press.

Smit, S. S. (2019). *Addressing overlaps in non-state and subnational climate action aggregation analyses: Bridging the gap, or counting chickens before they hatch?* https://dspace.library.uu.nl/bitstream/handle/1874/393829/Smit_6236308_SD_EM_MasterThesis_Overlaps_Final.pdf.

Steffen, B., Schmidt, T. S., & Tautorat, P. (2019). Measuring whether municipal climate networks make a difference: The case of utility-scale solar PV investment in large global cities. *Climate Policy*, *19*(7), 908–922. https://doi.org/10.1080/14693062.2019.1599804

Stehfest, E., van Vuuren, D., Kram, T., Bouwman, L., Alkemade, R., Bakkenes, M., Biemans, H., Bouwman, A., den Elzen, M., Janse, J., Lucas, P., van Minnen, J., Müller, C., & Prins, A. (2014). *Integrated assessment of global environmental change with IMAGE 3.0 - model description and policy applications*. PBL Netherlands Environmental Assessment Agency.http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2014-integrated

Tokarska, K. B., & Gillett, N. P. (2018). Cumulative carbon emissions budgets consistent with 1.5°C global warming. *Nature Climate Change*, *8*(4), 296–299. https://doi.org/10.1038/s41558-018-0118-9

UNEP. (2015). *Climate commitments of subnational actors and business*. United Nations Environment Programme. http://apps.unep.org/publications/pmtdocuments/-Climate_Commitments_of_Subnational_Actors_and_Business-2015CCSA_2015.pdf.pdf

UNEP. (2018). *Emissions gap report 2018*. United Nations Environment Programme. https://www.unenvironment.org/resources/emissions-gap-report-2018

UNEP. (2019a). *Emissions gap report 2019*. United Nations Environment Programme. https://doi.org/10.18356/ff6d1a84-en

UNEP. (2019b). *UN-convened net-zero asset owner alliance*, *UNDEP finance initiative*. Retrieved June 10, 2020, from https://www.unepfi.org/net-zero-alliance/

UNFCCC. (2019). *Global data community commits to track climate action*. Retrieved July 27, 2020, from https://unfccc.int/news/global-data-community-commits-to-track-climate-action

Westman, L., & Broto, V. C. (2018). Climate governance through partnerships: A study of 150 urban initiatives in China. *Global Environmental Change*, *50*(November 2017), 212–221. https://doi.org/10.1016/j.gloenvcha.2018.04.008

Widerberg, O., & Pattberg, P. (2015). International cooperative initiatives in global climate governance: Raising the ambition level or delegitimizing the UNFCCC? *Global Policy*, *6*(1), 45–56. https://doi.org/10.1111/1758-5899.12184

Widerberg, O., & Pattberg, P. (2017). Accountability Challenges in the transnational Regime Complex for climate change. *Review of Policy Research*, *34*(1), 68–87. https://doi.org/10.1111/ropr.12217

Widerberg, O., Pattberg, P., & Brouwer, L. (2019). Hybrid accountability in cooperative initiatives for global climate governance. In S. Park & T. Kramarz (Eds.), *Global environmental governance and the accountability Trap* (pp. 121–142). Massachusetts Institute of Technology.

Wolosin, M. (2014). *Quantifying benefits of the New York declaration on forests. Climate advisers*. https://www.climateadvisers.com/wp-content/uploads/2014/09/Quantifying-Benefits-of-the-New-York-Declaration-on-Forests-09232014.pdf.

Wouters, K. (2013). *Wedging the gap - an analysis of the impact of existing large-scale bottom-up initiatives for greenhouse gas emission mitigation in 2020* [MSc thesis].Utrecht, the Netherlands: Utrecht University.