Methodology for quantifying the potential impact of international cooperative initiatives

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List of Abbreviations

ACI	Airport Carbon Accreditation
AREI	African Renewable Energy Initiative
ASEAN	Association of South East Asian Nations
ATAG	Air Transport Action Group
A2030	Architecture 2030 initiative
bcm	billion cubic meters
C40	Cities Climate Leadership Group
CAT	Climate Action Tracker
CCAC	Climate and Clean Air Coalition
CCATW	Collaborative Climate Action Across the Air Transport World
COP-21	21st Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPS	Current Policies Scenario from the IEA World Energy Outlook
CSAM	Central South America
CSP	Concentrated Solar Power
DOE	U.S. Department of Energy
EPA	U.S Environmental Protection Agency
ETIP	European Technology & Innovation Platform
ETP	IEA's Energy Technology Perspectives
EWI	European Wind Initiative
FAO	Food and Agriculture Organization of the United Nations
GCFTF	Governors' Climate and Forests Task Force
GCoM	Global Covenant of Mayors
GFEI	Global Fuel Economy Initiative
GGA	Global Geothermal Alliance
GHG	Greenhouse gas
GPFLR	Global Partnership of Forest Landscape Restoration
GW	Gigawatt
GWP	Global Warming Potential
ha	hectare
HFCs	Hydrofluorocarbons

ICAO	International Civil Aviation Organization
ICCT	International Council on Clean Transport
ICI	International Climate Cooperative Initiative
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
(I)NDC	(Intended) Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ITF	International Transport Forum of the OECD
lge	litres of gasoline equivalent
LULUCF	Land-use, land-use change and forestry
MEPS	Minimum Energy Performance Standard
Mha	Mega hectare (ha x 10^6)
$MtCO_2e$	Megatons of CO_2 equivalent
MWh	Megawatt hours
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organisation
NOAA	U.S. National Oceanic and Atmospheric Administration
NPS	New Policies Scenario from the IEA World Energy Outlook 2
NYDF	New York Declaration on Forests
OECD	Organization for Economic Co-operation and Development
PV	Photovoltaic
RE	Renewable Energy
RoW	Rest of World
SAR	IPCC's Second assessment Report
SDS	Sustainable Development Scenario from the IEA World Energy Outlook
SEAD	Super-efficient Equipment and Appliance Deployment Initiative
SBT	Science-based target initiative
SEII	Solar Europe Industry Initiative
SLCP	Short-lived climate pollutant
SSI	U.S. SunShot Initiative
TWh	Terawatt hours
UN	United Nations

UNGC	United Nations Global Compact
U4E	United for Efficiency Initiative
UNFCCC	United Nations Framework Convention on Climate Change
WEO	World Energy Outlook
WMO	World Meteorological Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

1. Introduction

The *Global climate action from cities, regions, and businesses* report determines the global impact of both individual and international cooperative initiatives (ICIs) on national and global greenhouse gas emissions by 2030. It also shows to what extent individual and ICI climate commitments exceed current national policies' emission reductions, and how this relates to the "well below 2° C" temperature limit goal that was secured in the Paris Agreement. The mitigation impact of individual commitments from cities, regions and companies, and the mitigation impact of ICIs were calculated separately and are not meant to be aggregated or combined. A separate appendix describes the methodology used to calculate the mitigation impact of individual commitments from cities, regions, and companies.[1] This appendix describes the methodology used to determine the mitigation impact of ICIs.

ICIs bring numerous national, regional and local governments, businesses, and civil society partners together, often across national boundaries, to address climate change. This document provides a detailed overview of the methodology used to quantify the potential impact of ICIs on national and global GHG emissions, including:

- The process and criteria for selecting initiatives to include in this study;
- The methodology used to quantify the emission reduction potential of selected initiatives; and
- The approaches used to account for overlaps between different initiatives.

We first selected initiatives to quantify and analysed their potential impact on greenhouse gas emissions in the eight different thematic areas they operate in, such as forestry, buildings, and transport, using the initiative's target. We identified and removed overlaps from actors with targets in more than one initiative; for instance, when a city or region had made an emission reduction commitment through several initiatives, only the most ambitious goal was factored into the calculation, to avoid counting the same commitment several times.

We then distributed the emission reduction impacts of these selected initiatives to 9 high-emitting countries and the EU, including Brazil, China, the European Union (EU), India, Indonesia, Japan, Mexico, Russia, South Africa and the United States of America (US), and to the 'Rest-of-the-World' (RoW). During this step of the analysis, we identified overlaps where initiatives target the same emissions. For instance, separate initiatives that focus on promoting wind and solar energy would both replace emissions from fossil fuel electricity generation. We also identified initiatives with goals that could span many sectors – such as city or regional initiatives that aim to reduce overall emissions without specifying the sector(s) in which these reductions will occur. We accounted for overlaps with initiatives that target sectors, such as energy, buildings, transport, and energy efficiency, that will likely overlap with these municipal and regional efforts.

Once the overlaps were accounted for, the emission reductions that could be collectively achieved through the ICI activity in these 10 high-emitting countries and the RoW were aggregated into a global

[1] Several of ICIs, including the Global Covenant of Mayors for Climate and Energy, and theUnder2 Coalition, are included as data sources for both the analysis of individual commitments by cities, states, and regions and the analysis of ICIs. However, the analysis of individual commitments analyzes the specific commitments already made by each city, state, and region, while the ICIs analysis analyzes the overarching aspirational goals of these initiatives.

total (Figure 1, illustrative purpose only). Major emission reductions potential from ICIs were found in the US, EU and China.

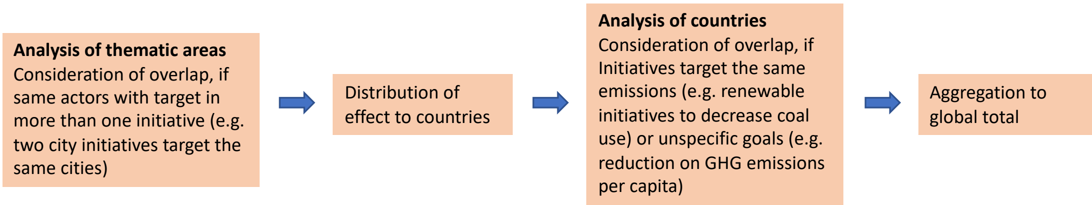

Figure 1. An illustration of the steps of the analysis

This document begins with a description of the initiative selection process chapters describing the eight thematic areas the analyzed initiatives operate in. The chapters list and describe all the initiatives considered within a thematic area and provide descriptions of the initiatives and the study's approach to quantifying their emissions reductions. These chapters also describe any assumptions made to quantify the initiatives' impact. The document's final chapter summarizes and explains the overlap quantification.

Throughout the analysis, we consider several different scenarios, or representations of what a future climate might look like, based on different policy decisions or actions:

As a starting point, we use a **"Current national policies" scenario**, which considers currently implemented federal/national policies. Global emissions in this scenario amounted to 49 $GtCO_2e$ in 2014 and are projected to increase to 56 to 59 $GtCO_2e$ by 2030, including LULUCF emissions (CAT, 2018). Historical emissions data and emissions projections under current policies are taken from the Climate Action Tracker (CAT) and supplemented with historical land-use, land-use change and forestry (LULUCF) and agricultural sector emissions from the International-Institute for Applied Systems Analysis (IIASA). The global analysis of LULUCF and agricultural sector used also projections from Blok et al. (2017).

The **"Current national policies plus initiatives' goals" scenario** is the main scenario in this analysis and builds upon the "current national policies scenario." In addition to considering currently implemented national policies, it accounts for the quantifiable goals of a carefully selected subset of international cooperative initiatives (see chapter 2 for more details). In this scenario, ICIs are assumed to fully achieve their pledged targets. We did not further analyze specific policies, actions or implementation barriers to meet these targets.

To conduct a sensitivity analysis, we also investigated the **"NDCs plus initiatives' goals"** scenario. This scenario includes the impact of currently implemented national and federal policies, in addition to the proposals countries have made under the Paris Agreement (often called Nationally Determined Contributions, or NDCs), also taken from (Kuramochi *et al*>, 2017). These scenarios assume the full implementation of both conditional NDC commitments – those that countries have only pledged to take if they receive financial and/or technical support – and unconditional NDCs – actions countries plan to take regardless of outside help – by 2030.

Table 19 in the annex lists all data sources for the construction of the current national policies and NDC scenarios in the eight different areas.

In the current analysis, the base year is determined by the most recent year for which data is available (usually 2017) and the time horizon is 2030. All greenhouse gas (GHG) emission values are expressed using the global warming potential (GWP) values from the second assessment report (SAR) of the Intergovernmental Panel on Climate Change (IPCC, 1995) to ensure consistency with our baseline scenarios.

"Key countries" refers to the set of countries included in the overall non-state and subnational aggregation analysis (see the full report, *Global Climate Action of Cities, Regions, and Business* and *Methodology for Quantifying the Impact of Individual Climate Commitments*) and comprise the following countries: the European Union (EU), China, Brazil, Japan, South Africa, the United States of America (USA), Russia, Mexico, India and Indonesia.

2. Selection of initiatives

In consultation with experts in non-state and subnational action, we selected 59 initiatives from an initial list of more than 300 initiatives that support national, subnational and non-state action, drawn from the Climate Initiatives Platform, and supplemented by our own research (see Table 1) for further analysis and quantification. This selection was done based on the following criteria:

- The initiative is likely to have a significant impact on GHG emissions.
- The initiative has a quantifiable target.

Table 1: Initially shortlisted international cooperative initiatives (ICIs)

Name of initiative	Sector
2030 Architecture Challenge	Buildings
Airport Carbon Accreditation (ACI)	Transport
Alliance for Responsible Atmospheric Policy	Non-CO2
American Business Act on Climate Pledge	Industry & Business
below50	Transport
C40 Cities Climate Leadership Group (C40)	Cities & Regions
Global Covenant of Mayors for Climate & Energy	Cities & Regions
C40 Clean Bus Declaration	Cities & Regions
Carbon Neutral Cities Alliance	Cities & Regions
Carbon Pricing Leadership coalition	Industry & Business
Caring for Climate	Industry & Business
Climate Alliance	Cities & Regions
Under2 MoU	Cities & Regions
Climate Mayors	Cities & Regions
EP100	Industry & Business
Covenant of Mayors for Climate & Energy	Cities & Regions
En.lighten Initiative	Energy Efficiency
Super-efficient Equipment and Appliance Deployment (SEAD) Initiative	Energy Efficiency
European Alliance to Save Energy (EU-ASE)	Energy Efficiency
United for Efficiency (U4E)	Energy Efficiency
Bonn Challenge	Forestry
Global Buildings Performance Network (GBPN)	Buildings
Governors Climate and Forests Task Force (GCFTF)	Forestry
New York Declaration on Forests	Forestry
Global Methane Initiative	Non-CO2
Go 100%	RE
Powering past coal alliance	Fossil fuels
Initiative 20x20	Forestry
LCTPi Renewables	RE

Life Beef Carbon Initiative	Agriculture
Low Carbon Technology Partnerships (LCTPi)	Industry & Business
Low-Carbon Sustainable Rail Transport Challenge	Transport
Science-based emission reduction target	Industry & Business
We Are Still In	Industry & Business
Remove commodity-driven deforestation from all supply chains by 2020	Industry & Business
Renewable Energy Buyers Alliance (REBA)	RE
RE100	Industry & Business
SIDS Lighthouses Initiative	RE
Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants	Non-CO2
Zero Routine Flaring by 2030	Non-CO2
Africa Renewable Energy Initiative	RE
Taxi4SmartCities	Transport
The Global Alliance for Clean Cook stoves	Non-CO2
Ultra-Low CO2 Steelmaking (ULCOS)	Industry & Business
European Wind Initiative (EWI)	RE
Solar Europe Industry Initiative (SEII)	RE
United States Climate Alliance	Cities & Regions
SunShot Initiative 2030	RE
Vehicle Fuel Efficiency Accelerator	Transport
US Wind Program	RE
Zero Deforestation Commitments from Commodity Producers and Traders	Forestry
Global Geothermal Alliance	RE
Collaborative Climate Action Across the Air Transport World	Transport
Balikpapan Challenge	Forestry
EV100	Industry & Business
Sustainable Energy 4 All	RE, Energy Efficiency
Mitigating SLCPs from the Municipal Solid Waste Sector	Non-CO2
Global Fuel Economy Initiative (GFEI)	Transport
Public Transport Declaration on Climate Leadership (UITP)	Transport

In a second step, we narrowed this list of 59 initiatives further, by evaluating it against the following criteria:

- High likelihood of implementation, indicated by recent reporting, and other regular updates.
- If various initiatives cover the same topic area, we chose the one with the most ambitious target.

A discussion of the selected initiatives, and the methodology used to quantify their emission reduction potential, follows in the sections below.

3. Forestry

Bonn Challenge/The New York Declaration on Forests (afforestation/ reforestation focus)

Description

The Bonn Challenge was launched in 2011 and aspires to restore 150 million hectares of degraded and deforested lands by 2020. In addition, the New York Declaration on Forests (NYDF) endorsed at the UN Climate Summit in 2014 raised the Bonn Challenge's ambition by calling for restoration of an additional 200 million hectares by 2030. The NYDF is endorsed by over 190 entities, including more than 50 governments, and covers all selected key countries from our study except for Russia, China, India and South Africa[2].

The Bonn Challenge is coordinated by the Global Partnership of Forest Landscape Restoration (GPFLR). The GPFLR is a network of governments, international organizations and civil society, and aims to catalyze and reinforce a network of diverse examples of restoration of degraded and deforested lands that delivers benefits to local communities and to nature.[3]

Quantification

As there is a large uncertainty in global forest carbon emissions (Blok et al. 2017), and the methodology to determine emission reductions through afforestation/ reforestation is complex, we make use of the values reported in Wolosin (2014), that compared several assessments of the quantitative impact of the NYDF. As the NYDF has a more ambitious reforestation target than the Bonn Challenge, we only look at NYDF reforestation values here.

Results from the Wolosin meta study indicate that the NYDF could help to sequester between 1.6 (lower bound) to 3.4 (higher bound) $GtCO_2e$/year by 2030, compared to the current national policies scenario.

Global LULUCF emissions were assumed to increase from 3.15 $GtCO_2e$/year in 2015 to 3.49 $GtCO_2e$/year in 2030 under the current national policies scenario, based on Blok et al. (2017). Country-level GHG emissions projections were taken from Kuramochi et al. (2017).

The global potential impact of the initiative on GHG emissions was assumed to be achieved by the countries that signed the NYDF, including through voluntary action by subnational and/ or non-state actors. The total emissions reduction impact was distributed over the key countries that signed the NYDF, plus the "Rest-of the World" (RoW), based on the most recent (2010) historical data on afforestation and reforestation from the Food and Agriculture Organization of the United Nations (FAO).[4] For this, we assumed that countries with historically high afforestation and reforestation rates are likely to have higher potential to contribute to achieving the goals of the Bonn Challenge / NYDF. Specifically, we calculated the share of afforestation/reforestation rates (in Mha/year) of each of our key countries in the global total afforested/reforested area and used these rates to split the total target of the initiative (in Mha to be reforested/restored) across the respective countries, plus the RoW. In

[2] https://nydfglobalplatform.org/endorsers/
[3] http://www.bonnchallenge.org/
[4] FAO data on afforestation and reforestation is available here: http://www.fao.org/forest-resources-assessment/current-assessment/country-reports/en/

addition, to determine the country-specific potential emissions reduction impact, we applied a weighting factor to account for the difference in carbon content of the respective forest areas.

In the absence of afforestation/ reforestation rates forecasts, we assumed that that country-specific historical afforestation and reforestation rates remain unchanged until 2030. Therefore, this initiative only results in additional impact at the country level if it would go *beyond* historical trends.

Governors' Climate and Forest Task Force/ The New York Declaration on Forests (deforestation focus)

Description

The Governors' Climate and Forests Task Force (hereinafter, "GCF Task Force") is a subnational collaboration between 38 states and provinces from Brazil, Indonesia, Ivory Coast, Mexico, Nigeria, Peru, Spain, Colombia, Ecuador and the United States, established in 2008. The GCF Task Force aims to advance jurisdictional programs designed to promote low emissions rural development and REDD+, and link them with emerging GHG compliance regimes and other pay-for-performance opportunities.

In addition, the NYDF pursues a similar goal, i.e. striving to halve the rate of forest loss (deforestation) by 2020 and completely end forest loss by 2030.

Quantification

The NYDF has a more ambitious reforestation target than the GCF Task Force, therefore we only quantified the NYDF deforestation target. We again refer to the emissions reduction potential values reported in Wolosin (2014).

The Wolosin study indicates that the NYDF could help avoid between 2.2. to 4.1 $GtCO_2e$/year by 2030. We adopt the use of declining baseline estimations to characterize global forest trends, as those are more in line with recent changes in deforestation and more recent studies such as IIASA and Blok et al. (2017). The declining baseline estimations are based on a set of base case models in IPCC WG3 Chapter 6 that suggest that net forest emissions may fall by about 25 percent through 2030 with no interventions. The Wolosin study thus assesses the impact of the NYFD on the full range of estimates by adjusting from a strictly historical baseline, to a baseline that declines by 12.5 percent by 2020 and by 25 percent by 2030. These estimates were used to represent our current national policies scenario.

For country-specific potential values, we used the deforestation rate (ha/yr) for each country that is a member of the NYDF to determine that country's percent share of deforestation. The impact of the initiative in different countries also depends on the carbon value of the forests within those countries. As carbon values of forests heavily depend on the climate zone where a country is positioned in, we further applied a weighting factor to obtain a weighted share of the emissions impact of deforestation. Weighted deforestation rates were used to calculate the minimum and maximum emission savings through participation in the NYDF for some selected key countries plus the RoW, compared to the range of declining baseline estimations. In addition, we applied a cap on the potential emission reductions by the initiative by comparing the calculated emission reduction in each country with estimated emissions from LULUCF in 2030 (Kuramochi et al. 2017). We thus assumed that the final emission reductions from the initiative cannot go beyond the estimated LULUCF emissions in 2030.

Results

Table 2 – Global emission reduction potential from Forestry ICIs

Initiative	2020 impact	2030 impact

Bonn Challenge/NYDF	0 $MtCO_2e$	1,600-3,400 $MtCO_2e$
GCFTF/NYD	0 $MtCO_2e$	2,200-4,100 $MtCO_2e$

Notes on NDC sensitivity analysis

There were no emissions projections available for the LULUCF sector consistent with the current national policies scenario used for the analysis. We hence assumed roughly 1 $GtCO_2e$/year smaller emissions reductions in 2030 compared to current national policies scenario for the afforestation and deforestation targets combined. This value was derived by multiplying the difference between current national policies scenario projections and NDC scenario projections for all sectors globally (around 4 $GtCO_2e$/year in 2030) by the current share of the LULUCF sector in global total GHG emissions (around a fourth).

4. Cities and Regions

C40 Cities Climate Leadership Group (C40)

Description

C40 is a network of megacities committed to addressing climate change. It was founded in 2005 by the Mayor of London in collaboration with representatives from 18 other megacities. Today, the C40 Cities Climate Leadership Group connects more than 90 of the world's largest cities, representing 650 million people and one quarter of the global economy. C40 is focused on "tackling climate change and driving urban action that reduces GHG emissions and climate risks, while increasing the health, wellbeing and economic opportunities of urban citizens"[7]. The network carries two explicit goals: 1) to have every C40 city develop a climate action plan before the end of 2020 (Deadline 2020), which is "deliver action consistent with the objectives of the Paris Agreement"[5] and 2) to have cities achieve emissions neutrality by 2050[6].

Driven by the fact that almost all member cities report climate change to be a risk to their communities, about 14,000 concrete actions to reduce GHG emissions, including energy audits, installation of efficient lighting, tree-planting and creation of green space, and climate risks have been taken by this network. Furthermore, C40 cities represent 2.4 GtCO2e/year in 2017 (C40, 2017) and have committed to help implement the Paris Agreement goal of limiting global average temperature rise to 1.5 °C above the pre-industrial average.[7]

Quantification

The quantification consisted of two steps: 1) first, we calculated the emissions reduction impact of individual city commitments, scaled up to C40's long-term overarching goal of emissions neutrality by 2050, and then 2) compared this aggregated emissions reduction impact with the counterfactual current national policies scenario.

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[5] https://resourcecentre.c40.org/join-deadline-2020
[6] https://resourcecentre.c40.org/climate-action-planning-framework-home
[7] https://www.c40.org/about

In the first step, we calculate the C40 cities 2015 base year emissions based on historical data and WEO current policy scenario growth rates, both within and beyond our key countries. We assumed that an individual city's emissions can be approximated by using ratio of the city population relative to the country population to determine the city's share of the total country's emissions. Thus, we assume that the city inhabitants have the same average CO_2e emissions per capita as the country average. We also assumed that the cities' commitments would apply to the population under the mayor's jurisdiction; therefore, we mostly collected data on the cities' population (at the time of the target's base year) from the C40 website. Additional data on historical city populations was compiled from the United Nations, national census bureaus, and other sources which are given in Table 3.

In the next step, after establishing city base year emissions data, we assume that the cities first implement their explicit pre-2050 targets in a linear reduction fashion, before linearly implementing C40's overarching 2050 emission neutrality goals.

We acknowledge that the assumption using a city's population and national average per capita emissions as a proxy for the city's emissions can be challenged on different grounds. According to existing estimates of city emissions, significant discrepancies can exist between city-level per-capita emissions and the country average[8]. There is no general rule for this, as city-level per-capita emissions can be higher than the country average (such as in the case of Rotterdam compared to the Netherlands' national average), roughly at the same level (such as in the case of Athens), or lower (such as in Stockholm). Due to this lack of a consistent relationship between city and national emissions, as well as a lack of detailed city-level data (especially for non-recent base years, such as 1990), we have used this simplified approach.

We downscaled countries' emissions pathways, or Current Policies Scenarios (CPS) to the city level, using the cities' population and assuming all cities have the same average per capita emissions in the country. Once the Current Policies Scenario (CPS) emission pathways were downscaled to the city level, we then compared the potential emission reduction that would be achieved through the city-level CPS' and the cities' targets, respectively. In this way, the additional emissions reduction contribution from cities was estimated for both 2020 and 2030. Those contributions were then added up back to the country level.

We estimated that the cities located in our key countries of this study represent around 86% of the total impact of the C40 initiative.

As the C40 initiative and Under2MOU have reduction targets for cities and regions, some of the cities' targets might overlap with their regions' targets. In the case that a city has pledged a less ambitious target than its corresponding region, we only take the most ambitious target into account in order to avoid double counting. In the case where a city is represented by multiple initiatives (i.e. it makes commitments in both C40 and Global Covenant of Mayors for Climate and Energy), we chose to use only one commitment, and chose the one which accounts for a larger city boundary in the country (i.e. a larger population served, or larger share of emissions covered). Emissions reductions targets coming from other sectors such as transport, renewables, and buildings could also contribute to achieving the cities' and regions' targets. These potential overlaps and our approach to avoiding the double counting of these emissions reduction is discussed in the section on country-level overlaps in chapter 11.

Table 3: Population data sources used in the quantification of the C40 initiative

[8] World Bank (2011), Representative GHG Baselines for Cities and their Respective Countries, http://siteresources.worldbank.org/INTUWM/Resources/GHG_Index_Mar_9_2011.pdf

Country	Data sources [9]
USA	United States Census Bureau; UN data; C40 cities; World Bank Indicators
Indonesia	C40 Cities; UN data, World Bank Indicators
India	Not needed as no quantified city targets available
Brazil	United Nations, Department of Economic and Social Affairs, Population Division; C40 Cities; World Bank Indicators
China	Not needed as there are no quantified targets available that stretch beyond 2015
Japan	Tokyo Metropolitan Government; UN data; C40 cities; World Bank Indicators
Russia	C40 Cities; World Bank Indicators; World Population Review; UN data
EU	Eurostat; C40 Cities; World Bank Indicators
Mexico	World Bank Indicators; CDP Cities data, UN data
South Africa	World Bank Indicators; Johannesburg Econ Review; World Population Review
RoW	C40 Cities; Carbon*n* Climate Registry; CDP; Compact of Mayors; Global Covenant of Mayors; Wikipedia

Under2MOU

Description

The Under2MOU, or Memorandum of Understanding on Subnational Global Climate Leadership, is an initiative that brings together subnational governments committed to ambitious climate action. The Under2MOU originated from a partnership between the state of California (in the USA) and the state of Baden-Württemberg (in Germany).

Each signatory commits to reduce their GHG emissions trajectory to the levels consistent with the Paris Agreement's goal to limit temperature rise below two degrees Celsius (2°C), i.e., to 80-95% below 1990 levels or to below 2 tCO_2e per capita by 2050. As of 11 June 2018, a total of 205 governments over six continents had signed or endorsed the Under2MOU. Together, they represent more than 1.3 billion people and nearly 40% of the global economy.[10]

In addition to the main objective of supporting the delivery of Paris Agreement's goals to keep global warming below 2°C, the Under2MOU also aims to offer an opportunity for states, regions, and cities to share ideas and best practices on how to reduce GHGs and promote renewable energy.

Quantification

For the quantification of the potential impact of the Under2MOU initiative, we first listed the signatory regions within our key countries and established their 2015 base year emissions based on historical data and WEO current policy scenario growth rates. Our quantification of Under2MOU evaluates the

[9] United States Census Bureau (http://www.census.gov/); UN data (http://data.un.org/); C40 cities (http://www.c40.org/cities); World Bank Indicators (http://data.worldbank.org/indicator); United Nations, Department of Economic and Social Affairs, Population Division (http://www.un.org/en/development/desa/population/); Tokyo Metropolitan Government (http://www.metro.tokyo.jp/ENGLISH/ABOUT/HISTORY/history03.htm); Eurostat (http://ec.europa.eu/eurostat/data/database); interpolation used between years when a specific year's population was not available.
[10] http://www.under2coalition.org/sites/default/files/under2_annual_report_2017.pdf

potential mitigation impact of the initiative, with an aspirational membership goal of 250 signatories by 2020 (there are currently 128 signatories). The only exception here is for Mexico, where we do not apply the scale up factor and keep the current membership. This is because the initiatives' current regional coverage of emissions in the country is already significant and near doubling the regional coverage is unrealistic. This method differs from our approach to quantifying the mitigation impact of C40 and Global Covenant of Mayors for Climate and Energy (GCoM), as our quantifications of the latter two initiatives currently evaluate current membership impacts only. If a participating region has not submitted an Annex with a clear emissions reduction target as part of their Under2MOU pledge, the analysis was based on the Under2MOU's general target (80-95% reduction below 1990 levels by 2050). This is an ambitious assumption particularly for cities that expect significant growth. We assume the emission reduction rate to decrease linearly between the start year and 2020/2030, unless the region had stated intermediate goals for those years.

Similar to the methods applied for the C40 quantification, we assume that regional emissions can be approximated by multiplying the share of the region in the country's population by the country's overall emissions. In other words, we assume that regions' inhabitants have the same average emissions per capita as the country average.

We then compare the regions' emissions reduction targets with their current policy emissions pathways (CPS) to estimate the additionality of their Under2MOU commitments. We assumed that the signatory regions will follow an emissions pathway (CPS) at the same rate as their country's CPS. For Indonesia and Mexico, the countries' CPS is assumed to follow the same emissions pathway as their global region's CPS trajectory (e.g. – Southeast Asia for Indonesia, Central America for Mexico). We downscaled the country's CPS to a subnational region level using the regions' population and assuming all regions have the same average per capita emissions in the country.

Once the CPS' were downscaled, we compared the potential emissions reduction that would be achieved through the CPS and the Under2MOU. In this way, the additional emissions reduction contributions from cities were estimated for both 2020 and 2030. Those contributions were then added up back to the country level. Since our evaluation of Under2MOU includes the potential impact of aspirational membership goals, the final estimated emission reduction impacts were scaled up, by assuming that additional members have the same average impact as current members. The initiative's membership is assumed to remain constant, at 250 members, from the period between 2020 and 2030.

Finally, based on population shares, we estimated that the regions we assessed that fall within the 10 key countries of this study represent around 87% of the total impact of this initiative. Impacts in the regions outside our key countries of interest are calculated based on the same methods described above, using the regions' respective country or global region CPS projections to evaluate the additionality of their Under2MOU commitments. Regions that are not represented within the World Energy Outlook (WEO) country/region classifications are separated into OECD or non-OECD countries and follow those emissions projections. Table 4 shows the sources used to collect population data for each region, by country.

As both the C40 initiative and Under2MOU gather reduction targets from cities and regions, some of the cities' targets might overlap with their regions' targets. In the case that a city has established a less ambitious target than its corresponding region, we only accounted for the most ambitious target, in order to avoid double counting. Additionally, emissions reductions targets coming from other sectors such as transport, energy efficiency, renewable energy, non-CO_2 and buildings, would contribute to achieving the cities'/regions' targets. These potential overlaps and our approach to avoiding double counting these emissions reductions is discussed in the section on country-level overlaps in chapter 11.

Table 4: Population data sources used in the quantification of the Under2MOU initiative

Country	Data sources [11]
USA	Under 2 MoU Region's Annex; United States Census Bureau; World Bank Indicators
Indonesia	UN data; World Bank Indicators. There is no existing population data for the specific Under2MOU regions from Indonesia. Thus, we make assumptions about these regions' share of the population of the larger region they are based in, based on historical UN data. We assume that East Kalimantan and West Kalimantan have consistent population shares of 23% and 31%, respectively, of the whole Kalimantan region, and that South Sumatra has a population share of 14.5% of the whole Sumatra region.
India	World Bank Indicators; UN Data
Brazil	Under 2 MoU Region's Annex; Brazil's Population Census 2010; UNFCCC emissions summary for Brazil
China	C40 Cities; UN Data; World Bank Indicators
Japan	Under 2 MoU Region's Annex; World Bank Indicators
Russia	(No Under2MOU actors)
EU	Under 2 MoU Region's Annex; World Bank Indicators; City Population
Mexico	Mexico Population Census 2010
South Africa	Under 2 MoU Region's Annex; World Bank Indicators

Global Covenant of Mayors for Climate and Energy

Description

The Global Covenant of Mayors for Climate and Energy (GCoM) was launched in June 2016 through the joining of the EU Covenant of Mayors, comprised of more than 7,000 local and regional authorities voluntarily committing to meet and exceed the EU 20% CO_2 reduction objective through energy efficiency and renewable energy, and the Compact of Mayors, a coalition of major global cities around the world committing to reduce local greenhouse gas emissions, enhance resilience to climate change, and track their progress transparently. GCoM's members share a long-term vision of promoting and supporting voluntary action on climate change towards a low-carbon society.

As of June 2018, there were 9,120 signatories accounting for more than 772 million inhabitants, or approximately 10.5% of the total global population. Signatories identify appropriate commitments, and

[11] Under 2 MoU Region's Annex (http://under2mou.org/?page_id=238); United States Census Bureau (http://www.census.gov/); World Bank Indicators (http://data.worldbank.org/indicator); Brazil's Population Census 2010 (http://noticias.uol.com.br/censo-2010/populacao/); UNFCCC emissions summary for Brazil (https://unfccc.int/files/ghg_data/ghg_data_unfccc/ghg_profiles/application/pdf/bra_ghg_profile.pdf); interpolation used between years when a specific year's population was not available.

pledge to communicate these transparently to their citizens, and then develop inventories and climate action plans to achieve their goals.[12]

Quantification

For the quantification of GCoM's impact on GHG emissions, we first took the initiative's overall estimate of its percentage emission reduction from the GCoM Impact website.[13] This quantification includes assumptions for cities that have "committed to commit" but have not yet define a reduction target. We then converted this percentage to absolute GHG emissions reductions for all global GCoM regions (i.e., North America, East Asia, Europe), using base year emissions also taken from the same website. In the same way as for C40 and Under2MOU, we assume population as a proxy for emissions and assume per capita emissions to be equal across individual regions. We then downscale GCoM's regional impacts to the city level for our key countries. This allows us to split the percentage of GCoM's emission reduction impact to key countries.

The next step was to compare this emission reduction with a counterfactual scenario, the current policy scenario. Again, as in the case of the C40 and Under2MOU initiatives, we compared the GCoM city targets with their corresponding national CPS to estimate the additionality of their GCoM commitments to the scenario. We assume that the signatory cities will follow an emissions pathway (CPS) at the same rate as their country's CPS. For Indonesia and Mexico, the countries' CPS is assumed to follow the same emissions pathway as their global region's CPS trajectory (e.g., Indonesia will follow the same emissions pathway as Southeast Asia; Mexico will follow the same emissions pathway as Central America). We assume that per capita emissions in the subnational signatories as the same as their country's average per capita emissions.

We then compared the potential emissions reduction that would be achieved through the CPS and the GCoM. In this way, the additional contribution to emissions reduction from cities was estimated for both 2020 and 2030. Finally, based on population shares, we estimated that the regions assessed for the 10 key regions of this study represent approximately 38% (in 2020) and 34% (in 2030) of the total impact of this initiative in their respective years. All the population data collected for each city (which also make up both country and region populations) was retrieved from the GCoM Impact website and database.

Results

Table 5 – Global emission reduction potential from Cities/Regions ICIs

Initiative	2020 impact	2030 impact
C40	270 $MtCO_2e$	820 $MtCO_2e$
Under2MOU	1,800-2,000 $MtCO_2e$	5,100-5,500 $MtCO_2e$
GCoM	850 $MtCO_2e$	1,280 $MtCO_2e$[14]
Total impact (accounting for overlaps between Cities/Regions ICIs)	2,500-2,630 $MtCO_2e$	6,270-6,600 $MtCO_2e$

[12] https://www.globalcovenantofmayors.org/participate/
[13] http://impact.globalcovenantofmayors.org (accessed July 2018)
[14] This value is the outcome of our calculations and differs slightly from the original value of impact of the Global Covenant of Mayors as we adapted our own methodology to establish the baseline.

5. Buildings

Architecture 2030 initiative

Description

Buildings are a major source of global demand of energy and materials that produce by-product greenhouse gases (GHG). Slowing the growth rate of GHG emissions and then reversing it is the key to addressing climate change and keeping global average temperature below 2°C above pre-industrial levels.

Architecture 2030 is a non-profit organization established in 2002 with the mission to rapidly transform the global built environment from a major contributor of GHG emissions to a central part of the solution to the climate crisis.[15] To accomplish this, Architecture 2030 (A2030) has set the following goals:

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% below the regional (or country) average/median for that building type.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet an energy consumption performance standard of 70% of the regional (or country) average/median for that building type.

The fossil fuel reduction standard for all new buildings and major renovations shall be increased to:

- 80% in 2020, relative to the regional (or country) average/median for that building type.
- 90% in 2025, relative to the regional (or country) average/median for that building type.
- Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate).

To achieve the targets, A2030 explains that innovative sustainable design strategies, generating on-site renewable power and/or purchasing (20% maximum) renewable energy may be used.

Quantification

A2030's potential impact is given by the relative reduction of thermal energy in buildings from 2015 to 2020 or 2030, respectively.

To calculate a counterfactual scenario, to estimate the additionality of initiative's energy saving potential in comparison to national policies, we assumed that the thermal energy demand of buildings develops as projected in the Current Policies Scenario (CPS) of the IEA World Energy Outlook (WEO) 2017. For the NDC sensitivity analysis, we used instead WEO's 2017 New Policies Scenario (NPS). The thermal energy demand of buildings is approximated by the sum of coal, oil, and gas use in WEO 2017.

To translate the thermal energy savings into emission savings, we assumed that saving thermal energy reduces either the coal, oil or gas consumption of buildings. The emissions intensity of buildings for coal, oil and gas is used to determine the emissions of fuel consumption by multiplying it with total final energy consumption. Uncertainty ranges were calculated by assuming different fossil fuels are replaced by renewables. In the maximum reductions scenario, we assume that reductions

[15] http://architecture2030.org/about/

come from coal first, then oil, then gas. In the minimum reductions scenario, we assume that reductions come from gas first, then oil, then coal.

The potential impact of major renovations was calculated by assuming demolition rates of 2% per year (/yr) for non-OECD countries, 1%/yr for OECD countries and 1.5%/yr for the RoW (based on ETP 2016). Floor area renovated that is “A2030 compatible” (i.e. meets the target of the initiative) was assumed equal to new floor area built, based on our interpretation of the A2030 initiative.

Our estimates suggest that A2030’s potential global energy savings range from a minimum of 569 MtCO_2e/year in 2020 to a maximum of 2,174 MtCO_2e/year in 2030, compared to CPS.

The same procedure is applied to derive the additional potential impact by region. To this end, we analogously assumed that the local share of additional saving potential is given by the difference of the national reduction in the A2030 scenario and WEO’s 2017 CPS. For Mexico, buildings' energy use in Central South America (CSAM) is adjusted based on Mexico's buildings energy consumption in 2015 from the IEA World Energy Balances. For Indonesia, final emissions are adjusted based on a similar factor of buildings energy use in Indonesia in 2015 to energy use in ASEAN.

Results

Table 6 – Global emission reduction potential from Buildings ICIs

Initiative	2020 impact	2030 impact
Architecture 2030	570-890 MtCO_2e	1,870-2,170 MtCO_2e

6. Energy Efficiency

Super-Efficient Equipment and Appliance Deployment Initiative (SEAD)

Description

The Super-Efficient Equipment and Appliance Deployment (SEAD) Initiative is a government-led multinational collaboration between Australia, Brazil, Canada, the European Commission, Germany, India, Indonesia, Japan, South Korea, Mexico, Russia, South Africa, Sweden, the United Arab Emirates, the United Kingdom, and the United States.

This initiative seeks to transform international markets for highly efficient appliances and equipment. Through its activities and projects, the SEAD Initiative is engaging governments and the private sector to measure the potential of appliance and equipment efficiency. If all SEAD governments were to adopt current policy best practices for product energy efficiency standards, 2000 TWh of electricity consumption (roughly twice the annual consumption in Japan) could be saved annually by 2030.[16] Letschert et al. (2012) estimated that realizing the SEAD Initiative’s goal will save consumers more than US$1 trillion between 2010 and 2030.

Quantification

We have calculated the global and regional saving potentials that would result from applying best-practice policies to appliances' energy efficiency, based on results from the BUENAS model

[16] http://www.superefficient.org/About-Us/What-Is-the-SEAD-Initiative

developed by McNeil et al. (2012). SEAD's goal is assumed to be the reduction of electricity use in buildings in the BUENAS business-as-usual scenario, by 2000 TWh from 2015 to 2030, which estimates the technical potential for minimum efficiency performance standards. The additionality of this saving potential was then determined by comparing the BUENAS scenario to the WEO's CPS 2017, and then to the WEO's NPS 2017 (for the sensitivity analysis).

The energy demand of appliances was approximated by the electricity demand of buildings in WEO 2017, and we have assumed that the demand shares of all SEAD countries, which are not disaggregated in WEO 2017, stay constant within the corresponding world regions. In addition, we assumed that the electricity demand of buildings from the WEO 2017 already contains savings of the best practice scenario/ results from the BUENAS model (ibid), and savings in 2020 are estimated by linear interpolation between 2015 and 2030.

To quantify the emissions reduction impact, we assumed that saving electricity reduces either generation from coal or gas power plants. And the emission intensity of power generation for coal-fired and gas-fired electricity is given by the CO_2e emissions from total power generation from coal and gas divided by total electricity generated through coal and gas fired power generation respectively. Our estimates show that the SEAD's potential global energy savings range from 70 to 150 $MtCO_2$e/yr in 2020 and between 379 to 790 $MtCO_2$e/yr in 2030.

In order to derive the additional potential impact by country, we split the global total energy saving potential of 2,000 TWh according to the national energy saving potential (TWh) provided by Letschert (2012). This study also contains savings for China, but China is only an observer, rather than a formal member of the SEAD initiative, and thus is not included in the estimates. Then, the country-specific additional saving potential is given by the difference of that regional reduction and the regional reduction in the CPS. Emission intensity values for gas and coal generation of electricity are calculated for each key country using WEO 2017 (IEA 2017), except for Mexico where emission factors are based on the CAT analysis (Climate Action Tracker 2018) and Indonesia where we calculated the emissions intensity based on Indonesia's share in total ASEAN energy use and assuming that this share remains constant.

United for Efficiency (U4E)

Description

U4E is a global initiative supporting developing countries and emerging economies to move their markets to energy-efficient appliances and equipment.

U4E builds on the success of the en.lighten initiative, which accelerates the transition to efficient lighting worldwide. It broadens the scope to six high-efficiency product categories (five for which data is provided), such as commercial, industrial and outdoor lighting, residential refrigerators, room air conditioners, electric motors, distribution transformers, and information and communication technologies.

U4E focuses primarily on developing countries and emerging economies, where electricity demand is expected to more than double by 2030. The initiative claims to have the potential to achieve 1.25 GtCO2e emissions reductions annually by 2030.[17]

U4E is an official partner of SEAD and mostly supplementary as the two initiatives include different types of countries (developed and developing countries respectively, with some degree of overlap).

Quantification

Energy efficient appliances and equipment reduce electricity consumption. Saving electricity reduces either generation from coal or gas plants. The emission intensity of power generation for coal and gas is given by the CO_2 emissions from its total use in power generation divided by total electricity generated.

Total global savings were already quantified by the initiative itself. Energy savings (TWh) for each of the key countries were also calculated by the initiative. To quantify the corresponding emissions reductions, we multiplied the savings potential with the global emissions intensity of coal-fired electricity (maximum emission reduction potential) and gas-fired electricity (minimum emission reduction potential). And the emission intensity of power generation for coal-fired and gas-fired electricity is given by the CO_2e emissions from total power generation from coal and gas divided by total electricity generated through coal and gas fired power generation respectively. Power generation and emissions develop as in WEO's CPS 2017 (or as in WEO's NPS 2017 for the sensitivity analysis). Emission intensity values for gas and coal generation of electricity in each key country are calculated using WEO 2017 (IEA 2017), except for Mexico where emission factors are based on the CAT analysis (Climate Action Tracker 2018) and Indonesia where we calculated the emissions intensity based on Indonesia's share in total ASEAN energy use and assuming that this share remains constant.

U4E quantifies the potential thermal energy savings from the initiative by product and country, based on reductions relative to the "Policy scenario" which broadly corresponds to the IEA WEO's Current Policies Scenario and is defined as: *Policy scenario – Assumes minimum energy performance standards (MEPS) are implemented in the year 2020 at a level equivalent to the current day best MEPS.*

The initiative does not provide global potential emissions reductions relative to an NDC scenario nor any data that would have allowed us to calculate an NDC scenario. We thus had to use the emission reduction potential calculated under the WEO CPS, as our global result under the NDC as well.

Results

Table 7 – Global emission reduction potential from Energy Efficiency ICIs

Initiative	2020 impact	2030 impact
SEAD	70-150 $MtCO_2e$	370-790 $MtCO_2e$
U4E	1,250 $MtCO_2e$	1,250 $MtCO_2e$

7. Non-CO2

[17] https://united4efficiency.org/

The Climate and Clean Air Coalition (CCAC)

Description

The Climate and Clean Air Coalition (CCAC) targets the "implementation of policies […] that will deliver substantial short-lived climate pollutant (SLCP) reductions in the near- to medium-term (i.e. by 2030)" (CCAC 5-Year Strategic Plan).[18] SLCPs include methane (CH_4), HFCs, black carbon and tropospheric ozone.

For the timeframe up to 2030, the CCAC claims that global action to reduce SLCPs would save around 2.5 million lives by cutting indoor and outdoor air pollution, as well as increase crop yields by around 52 million tonnes each year (UNEP & WMO 2011).

Quantification

The quantification is focused on CH_4 and HFCs, as these types of SLCPs are usually included in GHG emission scenarios. As black carbon is not explicitly accounted for under the Paris Agreement, we have excluded the latter.

Methane (CH4)

We assumed that the CCAC targets a reduction of CH_4 emissions in line with the "CH_4 + BC group 1 and 2 measures" scenario from UNEP (2011), as the measures considered in this scenario are referenced in the CCAC's Annual Report 2016-2017 (CCAC 2017). Specifically, we assumed a reduction target of 26% in 2030, compared to the 2005 level, and assume that this target is reached linearly over time, starting from 2015. Historical and projected CH_4 emission data was retrieved from the EPA database (US EPA 2012). The target then translates to a CH_4 emission level of 5.1 $GtCO_2e$ in 2030. EPA non-CO_2 projections are used as baseline (Current National Policies scenario) for future CH4 emission development (Ibid). The comparison of CCAC target and the current national policy scenario then shows a reduction of 3.5 $GtCO_2e$ beyond this baseline in 2030.

We split the potential impact between the ten investigated countries according to their share of global CH_4 emissions in 2005 (reference level), again using data from the EPA database.

For the sensitivity analysis, we calculated and applied the % reduction between emissions projections under a CPS and those under current pledges, both based on Climate Action Tracker (CAT) data, to derive an NDC scenario for methane emissions. The reductions are then calculated by the difference between the CCAC target for methane emissions and the NDC scenario.

HFCs

For HFCs, we assumed that the CCAC targets a phase-down pledged in the Kigali Amendment, with linear reductions between phase-down steps. As the Kigali Agreement has already been adopted, CCAC has already achieved this part of the initiative. However, the Kigali Amendment figures are not yet part of the current national policies scenario used in the analysis, and therefore still needed to be calculated here.

The emissions reduction estimates for both individual countries and global totals were taken from Fekete et al. (submitted); the historical emissions dataset up to 2013 were developed using the PRIMAP (Gütschow et al. 2017) and EDGAR (EU JRC & PBL 2014) databases, and future growth rates are based on the reference scenario reported in U.S. EPA (US EPA 2012). The HFC emissions

[18] http://www.ccacoalition.org/en/resources/ccac-five-year-strategic-plan

reductions were calculated in CO_2 equivalent terms using the Global Warming Potentials (GWPs) from the IPCC Fourth Assessment Report (AR4); we estimate the choice of GWPs would not affect our conclusions. Global emission reductions from the Kigali Amendment include all F-gases, thus going beyond HFCs. This leads to an over estimate of around 10%. We estimated a global reduction potential of 360 $MtCO_2e$/year by 2030 compared to the Current National Policy scenario.

To estimate future HFC emissions under the NDC scenario on a global and country level, HFC emissions of a country under the CPS (based on U.S. EPA data) was multiplied by the reduction rate of global GHG emissions under the NDC scenario compared to the CPS. If a country's NDC does not apply to non-CO_2 GHG emissions (e.g., as is the case in China), we assumed the same emissions projections as under the CPS. We then compared the new NDC scenario to emission projections under the Kigali Amendment, which is equal to the applying the CCAC's HFC goal.

Zero Flaring Initiative

Description

The "Zero Routine Flaring by 2030" initiative, introduced by the World Bank, brings together governments, oil companies, and development institutions who recognize the flaring situation to be unsustainable from both a resource management and environmental perspective, and who agree to cooperate to eliminate routine flaring no later than 2030. This initiative is endorsed by 27 governments and 34 companies.[19] Routine flaring of gas takes place during normal oil production operations in the absence of sufficient facilities or amenable geology to re-inject the produced gas, utilize it on-site, or dispatch it to a market.

Quantification

We used historical data for gas flaring (expressed in billion cubic meters: bcm) published by the U.S. National Oceanic and Atmospheric Administration (NOAA) and the World Bank on the Zero Flaring Website (GGFR 2017). The baseline scenario projections were taken from U.S. EPA (EPA 2012). EPA provides emissions data which combines emissions from both flaring and venting. This data was used to determine the growth rate to project emissions from gas flaring in 2020 and 2030.

To quantify the initiative's emission reduction potential, we calculated the difference between projected emissions from flaring under the Current National Policies scenario, based on EPA data, and a linear reduction from total flaring emissions in 2016 to zero emissions from flaring in 2030. We used the same approach also for our selected countries and RoW region. Our analysis resulted in a potential to reduce emissions by 425 MtCO2e/year by 2030 globally.

To derive the emission reduction potential under an NDCs plus initiatives' goals scenario, we used a similar approach to the one used for the CCAC initiative (see above). The main difference was that we constructed an NDC scenario for flaring and venting specifically (based on U.S. EPA data), rather than for all non-CO2 gases and using the information contained in countries' NDCs.

Results

Table 8 – Global emission reduction potential from Non-CO2 ICIs

Initiative	2020 impact	2030 impact

[19] http://www.worldbank.org/en/programs/zero-routine-flaring-by-2030#4

CCAC	1,200 $MtCO_2e$	3,800 $MtCO_2e$
Zero Routine Flaring	120 $MtCO_2e$	425 $MtCO_2e$

8. Transport

Global Fuel Economy Initiative (GFEI)

Description

The Global Fuel Economy Initiative (GFEI) works to secure real improvements in fuel economy, and the maximum deployment of vehicle efficiency technologies across the world. This includes light and heavy-duty vehicles, and the full range of technologies, including hybrid and fully electric vehicles. The Initiative promotes these objectives through shared analysis, advocacy, and through in country policy support, and tools.

GFEI is a partnership of the International Energy Agency (IEA), United Nations Environment Programme (UNEP), International Transport Forum of the OECD (ITF), International Council on Clean Transportation (ICCT), Institute for Transportation Studies at UC Davis, and the FIA Foundation – which hosts the secretariat.[20]

The initiative has two main goals:

- Improve Light Duty Vehicle fuel economy by 50% by 2030 for new vehicles, and 2050 for all vehicles (2005 baseline). Goal is expressed in litres of gasoline equivalent per 100 km for entire fleet.
- Improve Heavy Duty Vehicle fuel consumption by 35% by 2035 for new vehicles (2015 baseline)

In our analysis, we focus on the first goal exclusively.

Quantification

Quantification of the impact of the GFEI initiative was done with the TIMER energy model. This model forms part of the integrated assessment model IMAGE 3.0 (Stehfest et al. 2014). It describes future energy demand and supply for 26 global regions (including some large countries, such as the US and China), and assesses the implications of energy system trends for all major greenhouse gases and air pollutants. This model simulates long-term energy baseline and mitigation scenarios (Van Vuuren et al., 2014) on the global and regional levels. The investments into different energy technologies are calculated by a multinomial logit function that accounts for relative differences in costs and preferences (technologies with lower costs gain larger market shares). The model is built up from different modules, including energy demand modules for transport, industry, buildings and modules for energy supply, industrial processes and emissions.

Efficiency of new cars is an input to the TIMER transport model (Girod et al. 2011), and the default setting was changed to represent the GFEI target. Manufacturing costs were changed accordingly. Two variants were calculated:

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[20] https://www.globalfueleconomy.org/

1. For each IMAGE region, average fuel economy is set to 4.2 litres of gasoline equivalent/ kilometer (lge/km) by 2030 for new cars, representing a 50% improvement relative to 2005 according to GFEI (2016)
2. For each IMAGE region, average fuel economy is set to 50% of 2005 level

GHG emission reductions were compared to the current policies scenario from Kuramochi et al. (2017), that includes implemented policies from large major emitting countries.

Collaborative Climate Action Across the Air Transport World (CAATW)

Description

In order to enable the world to benefit from the rapid connectivity advantages of air transport, the sector has committed itself to a pathway of sustainable growth encompassing all areas of the commercial industry and governments working in partnership through the International Civil Aviation Organization (ICAO). The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was adopted at the 39th session of the ICAO Assembly in 2016. The aim is to address any annual increase in total CO_2 emissions from international civil aviation above 2020 levels and contribute to the industry's commitment to carbon neutral growth from 2020.

ICAO's participants include 191 member states, and the cross-industry Air Transport Action Group (ATAG), which represents over 1,860 airports, 258 international airlines, and 80 air traffic management organizations. They have 2 main goals[21]:

- 2% annual fuel efficiency improvement through 2050
- Stabilise net carbon emissions from 2020 onwards

Quantification

We assumed that international aviation emissions develop as projected by ICAO (2013)[22]. This serves as our current national policy scenario.

Given the high uncertainty over the future usage of CORSIA, potential emission reductions were then calculated by comparing projected emissions under the carbon neutral growth target with the projected emissions (maximum impact) from international aviation, assuming CORSIA is not being used, and a scenario where the emission growth would be completely offset (minimum impact).

We assume no change for the sensitivity analysis as international airline emissions are not included in NDCs.

Results

Table 9 – Global emission reduction potential from Transport ICIs

Initiative	2020 impact	2030 impact
GFEI	70-150 $MtCO_2e$	340-600 $MtCO_2e$
CAATW	0 $MtCO_2e$	550 $MtCO_2e$

[21] https://www.icao.int/environmental-protection/Documents/CorsiaBrochure_8Panels-ENG-Web.pdf
[22] https://www.icao.int/Meetings/a38/Documents/WP/wp026_en.pdf

9. Industry and business

RE100

Description

RE100 is an initiative of companies, with 125 members as of June 2018 that have committed to source 100% of their electricity from renewable sources by a certain individual target year and have overarching initiative goals of securing 3,000 member companies by 2030. The work of RE100 is supported by a Steering Committee and a Technical Advisory Group.

Quantification

Our quantification of the impact of RE100 builds upon general information provided in the Annual Report 2016,[23] the Progress and Insights Report January 2018[24] and on company-specific data provided by CDP. From this, we retrieved total and renewable electricity consumption by RE100 members in 2017.

The RE100 has overarching initiative goals of achieving 1,000 company members by 2020 and 3000 company members by 2030, as taken from the Business End of Climate Change report.[25] We also assume that companies reach their RE targets linearly over time and that their total electricity consumption grows at the same rate as projected for global electricity generation in the Current Policies Scenario (CPS) of IEA's World Energy Outlook 2017 (or as in the corresponding NPS for the sensitivity analysis). Companies without defined renewable energy targets were assumed to have a target of 100% renewable, since they are signatories of RE100. Companies without defined target years are assumed achieve the renewable target in 2050, which is a conservative estimate. Further, we assumed that without the initiative, the RE share of RE100 members would have grown at the same rate as the global RE share in the CPS.

To project the total electricity demand of RE100 companies for the 1,000 and 3,000 members, we took the average energy consumption per company from the current membership group and scaled this up for all membership targets. We approximated the RE share for the 1,000 and 3,000 companies' energy demand by assuming them to be equal to the average RE shares for the current membership group, projected for 2020 and 2030.

By comparing the RE share of each company with targeted membership, and the share projected by the CPS, we estimated the additional renewable electricity use from the RE100 goals. We then translated this additional RE use into a range of GHG emission reductions. For the lower limit of the range, we assumed that RE replaces gas-fired electricity, while the replacement of coal-fired electricity was assumed for the upper limit. Emission factors for gas- and coal-fired electricity were taken from the CPS.

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[23] http://media.virbcdn.com/files/f9/d6e716c56a9b3312-RE100AnnualReport2016_v17.pdf
[24] https://www.theclimategroup.org/sites/default/files/re100_annual_report.pdf

For 2020 and 2030, we have performed company-specific calculations for companies whose target year is beyond the year of analysis (either 2020 or 2030), again assuming a linear increase of their RE share. For the few companies who have not published their target year yet, we have conservatively assumed that those companies will achieve 100% RE in 2050. For 2020, we have estimated an additional RE use of 959 TWh, which translates to a potential impact of 468 to 965 $MtCO_2e$/year. The result for 2030 is an additional RE use of 2,300 TWh/year, or GHG reductions of 1,100 to 2,300 $MtCO_2e$/year.

We did not attempt to break down the impact of RE100 into reductions for different countries.

Science based targets (SBT) initiative

Description

The Science Based Targets initiative is a collaboration between CDP, World Resources Institute (WRI), the World Wide Fund for Nature (WWF), and the United Nations Global Compact (UNGC) and one of the We Mean Business Coalition commitments.

Targets adopted by companies to reduce GHG emissions are considered “science-based” if they are in line with the level of decarbonization required to keep global temperature increase below 2 degrees Celsius compared to pre- industrial temperatures, as described in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5).

The initiative’s overall aim is that by 2020, science-based target setting will become standard business practice and corporations will play a major role in driving down global greenhouse gas emissions comprising 2,000 companies by 2030. Embedding science-based targets as a fundamental component of sustainability management practices is crucial in achieving this.[26]

Quantification

Our quantification adopted the approach and calculations tool developed for the “The Business End of Climate Change” report (CDP & We Mean Business 2016). We first quantified the potential impact of the SBT initiative and started from the most ambitious plan of the initiative for 2030, i.e. sign-up of 2,000 companies by 2030. Then, we translated the goal into different variables (e.g. coverage of production in a sector or improvements in emissions per activity) that fed into the calculation tool. To estimate the expected coverage of GHG emissions per sector, we used a range of information sources.

We assumed that the sign-up rate increases linearly from current date (May 2018) membership to the pledged percentage in 2030. All companies signed up for the SBT will linearly decrease their carbon intensity per unit output towards 2050 to the level consistent with the 2°C pathway, while production develops as under the baseline. The 2050 targets were calculated based on the 6°C Scenario (6DS) of the IEA Energy Technology Perspectives (ETP) 2015 (IEA 2015) as done with ETP 2014 in Krabbe et al. (2015). The 6DS is broadly consistent with the World Energy Outlook Current Policies Scenario. Direct and electricity related emissions only, plus emissions from car use were covered. For emissions from purchased or acquired electricity, steam, heat, and cooling (scope 2 emissions), the decarbonisation targets were recalculated with baseline electricity CO2 emission factors to avoid double counting of emissions reductions in the power sector.

[26] http://sciencebasedtargets.org/about-the-science-based-targets-initiative/

For the NDC scenario, we used the 4°C Scenario (4DS) from the IEA ETP 2015 (IEA 2015) which takes into account recent pledges made by countries to limit emissions and step up efforts to improve energy efficiency. This scenario is broadly consistent with the World Energy Outlook New Policies Scenario.

Results

Table 10 – Global emission reduction potential of Industry and Business ICIs

Initiative	2020 impact	2030 impact
RE100	330-680 $MtCO_2e$	780-1,610 $MtCO_2e$
SBT	40 $MtCO_2e$	1,100 $MtCO_2e$

10. Renewable Energy

Given that the methodology to quantify emission reduction potentials from initiatives targeting renewable energy is nearly identical for all of the below initiatives, we describe the detailed methodology only once, and highlight any changes where relevant.

This chapter thus starts with a description of the initiatives, followed by a section on quantification.

European Wind Initiative

Description

The European Wind Initiative (EWI) sets out an ambitious target for wind energy to account for a 20% share of total EU electricity consumption by 2020 (33% by 2030). The objective is to make onshore wind the most competitive energy source by 2020, with offshore following by 2030. The European Wind Energy Technology Platform estimates that the levelized cost of energy can be reduced up to 50% for offshore wind energy and up to 20% for onshore compared to 2008 over the next 20 years.[27]

Solar Europe Industry Initiative (SEII)

Description

The Strategic Energy Technology plan was a European initiative and was originally launched in 2006 with the objective to accelerate the development and deployment of low carbon technologies. The SEII was established by the European Photovoltaic Industry Association (now SolarPower Europe) in 2006 to underpin the implementation of the SET plan in the photovoltaic sector. The vision of the SEII was to "establish PV as a mainstream clean, sustainable and competitive energy technology providing up to 12% of the European electricity demand by 2020, up to 20% in 2030 and 30% in 2050."[28] In order to

[27] http://www.windplatform.eu/fileadmin/ewetp_docs/Documents/reports/TPWind_SRA.pdf
[28] http://www.aie.eu/files/Directives_EU/Solar%20europe%20Industry%20Initiative-%20DRAFT%20SUMMARY%20IMPLEMENTATION%20PLAN%202010-2012.pdf

achieve these objectives, the initiative aims to co-ordinate R&D efforts in order to bring down the cost of solar PV to increase usage of the technology.

In September 2015, the European Commission announced a new integrated strategic energy technology plan, which is based upon 10 actions structured around the research and innovation priorities of the Energy Union Strategy. To reflect the establishment of new governance structures, the SEII was merged with the European Photovoltaic Technology Platform (a network of academics, member state representatives and industry) to form the European and Technology Innovation Platform (ETIP) in January 2016.[29]

SunShot Initiative (US)

Description

The SunShot Initiative (SSI) was established by the U.S. Department of Energy (DOE) in February 2011, with the aim to drive down the cost of solar electricity to $0.06 per kilowatt-hour or $1 per watt (not including incentives). In order to achieve this goal, the SSI funds collaborative research between private companies, universities, state and local governments, not for profit organizations and national laboratories across five program areas: photovoltaics (PV), concentrating solar power (CSP), soft costs (or balance of systems costs), systems integration, and technology to market. In late 2017, it was announced that the utility-scale solar target had been met three years ahead of schedule. Nevertheless, the initiatives will continue to aim for lower solar power generation costs.[30]

Wind Program (US)

Description

The U.S. Department of Energy (DOE) published a report in 2008, which assessed the technical feasibility of generating 20% of the nation's electricity demand via wind energy by 2030.[31] The Wind Program, established by DOE, aims to accelerate the deployment of wind power technologies by removing barriers, lowering costs and improving performance.[32]

In order to achieve this aim, the initiative collaborates with national laboratories, industry, universities and other federal agencies to conduct common research and development activities through competitively selected, directly funded and cost-shared projects. The Wind Program supports the deployment of wind energy in the U.S. by investing in improvements to wind plant design, technology development and the identification of high quality wind resources.[33]

African Renewable Energy Initiative

Description

African countries together pledged its support for renewables during the 21st Conference of Parties (COP-21) meeting in Paris by establishing the African Renewable Energy Initiative (AREI). The

[29] http://www.eupvplatform.org/set-plan.html
[30] http://energy.gov/eere/sunshot/about-sunshot-initiative
[31] http://energy.gov/eere/wind/20-wind-energy-2030-increasing-wind-energys-contribution-us-electricity-supply
[32] http://energy.gov/eere/wind/about-doe-wind-program
[33] Ibid.

Initiative is led by the African Union's commission, the New Partnership for Africa's Development (NEPAD)'s Agency, the African Group of Negotiators, the African Development Bank, UN Environment, and the International Renewable Energy Agency (IRENA).[34] The overall goals of the AREI are to achieve the following:

- Help achieve sustainable development, enhanced well-being, and sound economic development by ensuring universal access to sufficient amounts of clean, appropriate and affordable energy;
- Help African countries leapfrog to renewable energy systems that support their low-carbon development strategies while enhancing economic and energy security.[35]

Global Geothermal Alliance

Description

The Global Geothermal Alliance (GGA), supported by the International Renewable Energy Agency (IRENA), was launched at COP-21 through coordination efforts from the geothermal industry, policymakers and stakeholders worldwide. GGA is a coalition that calls for governments, businesses, and other actors to increase geothermal capacity in both electricity generation and heat generation worldwide. GGA has set goals to increase installed capacity for geothermal power generation by five-fold and geothermal heating by two-fold by 2030, but also has general goals to enhance the dialogue, cooperation and coordination of international and domestic actions related to all phases of geothermal energy deployment.[36]

As of June 2018, GGA has 44-member countries and 31 partner organizations that range from development banks to academic organizations.

Quantification for the abovementioned renewable energy initiatives

The current national policy projections for renewable energy generation and total electricity generation (solar, wind etc., depending on the initiative) were taken for the years 2020 and 2030 from the IEA WEO 2017 Current Policies Scenario (and from WEO's NPS 2017 for the sensitivity analysis). Electricity generation and emission values for 2020 under CPS were approximated by linearly extrapolating from future 2025-2040 projections to the period 2020-2030. The additional renewable energy generation in TWh was then calculated by the difference between the targets set under the respective renewable energy initiative for both 2020 and 2030 (as a share of total electricity generation corresponding to the WEO CPS 2017) and the expected level of renewable energy generation assumed under the WEO CPS 2017 (as a share of the total electricity generation). We then estimated a range of GHG impacts depending upon whether renewables displace gas-fired electricity first, and then coal-fired electricity (low estimation) or coal-fired electricity first, followed by gas-fired electricity (high estimation). For this we used emission factors derived from the WEO 2017 data.

For the following initiatives, we slightly deviated from the above-mentioned approach:

- **AREI:** We assumed that the share of AREI's capacity increase by energy source would follow the same trend as WEO's CPS 2017. For 2030, we follow the same methodology, with the exception that capacity values and continental renewable

[34] http://newsroom.unfccc.int/lpaa/renewable-energy/africa-renewable-energy-initiative-increasing-renewable-energy-capacity-on-the-african-continent/
[35] http://www.arei.org/wp-content/uploads/2016/01/summary_eng.pdf
[36] http://www.globalgeothermalalliance.org/

shares are taken from the WEO's Sustainable Development Scenario (SDS) instead of the CPS. This is because while we could agree with the CPS trend for hydro that implies a large proportion of African renewable generation in 2020 (86%), we find the estimated share of African renewable generation in 2030 (72%) implausible given that hydro capacity installation will not continue to expand significantly in the medium term while wind and particularly, solar PV, will. We find the SDS renewable shares in 2030 more plausible, with hydro, wind, and solar PV taking 42%, 13%, and 45% of electricity generated by renewables respectively. We calculate the additional electricity generated in 2030 by the different renewable energy sources under SDS with the same method used in 2020 for CPS. After this calculation, we compared the renewable energy generated by energy source from the scenarios (CPS for 2020, SDS for 2030) and the additional renewable energy generated by AREI targets to ascertain additionality.
We also assumed throughout this quantification that the three renewable technologies make up 100% of growth in renewable energy generated through AREI since they are the most technologically advanced and economically efficient renewable technologies. Furthermore, projected growth in other renewable technologies are negligible aside from geothermal, which is captured within our GGA quantification below.

- **GGA:** For geothermal heating, base year (2014) values were ascertained from Lund and Boyd (2015), while future business-as-usual projections of 2020 and 2030 capacity were interpolated with the 2050 geothermal heat capacity projections from the Geothermal Roadmap (IEA 2011). This projection was used due to the lack of CPS data regarding geothermal heat capacity. To derive country-specific emission reduction potentials for our key countries, we took the country specific estimates of installed geothermal capacity for 2020 and 2030 (in GW) and derived the percentage share for each country in the total expected global growth of geothermal capacity. The percentage shares were then multiplied by the GGA's overall emissions savings in 2020 and 2030. We have assumed that the emission factor for each country is equal to that of the global level when displacing other energy sources with geothermal energy since country-specific emission factors for geothermal were not available. However, the application of country-specific emission factors are unlikely to have a significant impact on our aggregated results and is captured within the uncertainty range.

The specific data used for the quantification is given in the below tables.

Table 11: Parameter descriptions, values, units and sources used in the quantification of the EWI

Description	Value	Unit	Source
Total electricity generation EU (2020)	3353	TWh	IEA WEO 2017 Current Policies Scenario
Total electricity generation EU (2030)	3574	TWh	
EU electricity generation from wind (2020) –CPS	460	TWh	
EU electricity generation from wind (2030) – CPS	622	TWh	
Emission factor coal (2020)	1.03	tCO_2 / MWh	
Emission factor gas (2020)	0.43	tCO_2 / MWh	
Emission factor coal (2030)	1.00	tCO_2 / MWh	
Emission factor gas (2030)	0.41	tCO2 / MWh	

Table 12: Parameter descriptions, values, units and sources used in the quantification of the SEII

Description	Value	Unit	Source
Total electricity generation EU (2020)	3353	TWh	IEA WEO 2017 Current Policies Scenario
Total electricity generation EU (2030)	3574	TWh	
EU electricity generation from solar PV (2020) – CPS	138	TWh	
EU electricity generation from solar PV (2030) – CPS	160	TWh	
Emission factor coal (2020)	1.03	tCO_2 / MWh	
Emission factor gas (2020)	0.43	tCO_2 / MWh	
Emission factor coal (2030)	1.00	tCO_2 / MWh	
Emission factor gas (2030)	0.41	tCO_2 / MWh	

Table 13: Parameter descriptions, values, units and sources used in the quantification of the SSI

Description	Value	Unit	Source
Total electricity generation USA (2020)	4464	TWh	IEA WEO 2017 Current Policies Scenario
Total electricity generation USA (2030)	4892	TWh	
USA electricity generation from wind (2020) – CPS	123	TWh	
USA electricity generation from wind (2030) – CPS	214	TWh	
Emission factor coal (2020)	0.92	tCO_2 / MWh	
Emission factor gas (2020)	0.40	tCO_2 / MWh	
Emission factor coal (2030)	0.91	tCO_2 / MWh	
Emission factor gas (2030)	0.38	tCO_2 / MWh	

Table 14: Parameter descriptions, values, units and sources used in the quantification of the US Wind Program

Description	Value	Unit	Source
Total electricity generation USA (2020)	4464	TWh	IEA WEO 2017 Current Policies Scenario
Total electricity generation USA (2030)	4892	TWh	
USA electricity generation from wind (2020) – CPS	346	TWh	
USA electricity generation from wind (2030) – CPS	427	TWh	
Emission factor coal (2020)	0.91	tCO_2 / MWh	
Emission factor gas (2020)	0.40	tCO_2 / MWh	
Emission factor coal (2030)	0.91	tCO_2 / MWh	
Emission factor gas (2030)	0.38	tCO_2 / MWh	

Table 15: Parameter descriptions, values, units and sources used in the quantification of AREI

Description	Value	Unit	Source
Total renewable electricity capacity of hydro, wind, and solar Africa (2020)	46	GW	IEA WEO 2017 CPS and SDS
Total renewable electricity capacity of hydro, wind, and solar Africa (2030)	118	GW	
Total Africa renewable electricity generation from hydro, wind, and solar (2020) – CPS	166	TWh	
Total Africa renewable electricity generation from hydro, wind, and solar (2030) – SDS	337	TWh	
Emission factor coal (2020)	1.04	tCO_2 / MWh	
Emission factor gas (2020)	0.46	tCO_2 / MWh	
Emission factor coal (2030)	0.97	tCO_2 / MWh	
Emission factor gas (2030)	0.42	tCO_2 / MWh	

Table 16: Parameter descriptions, values, units and sources used in the quantification of GGA

Description	Value	Unit	Source
Total geothermal power generation capacity (2020) - CPS	13	GW	IEA WEO 2017 CPS/ /
Total geothermal power capacity (2030) - CPS	26	GW	IEA WEO 2017 CPS
Total geothermal heat capacity (2014) - BAU	70	GW	Lund and Boyd (2015)
Total geothermal heat capacity (2050) - BAU	184	GW	Geothermal Roadmap
Emission factor coal (2020)	1.01	tCO_2 / MWh	IEA WEO 2017 CPS
Emission factor gas (2020)	0.49	tCO_2 / MWh	IEA WEO 2017 CPS
Emission factor coal (2030)	0.96	tCO_2 / MWh	IEA WEO 2017 CPS
Emission factor gas (2030)	0.45	tCO_2 / MWh	IEA WEO 2017 CPS

Results

Table 17 – Global emission reduction potential of Renewable Energy ICIs

Initiative	2020 impact	2030 impact
EWI	90-220 $MtCO_2e$	230-560 $MtCO_2e$
SEII	110-270 $MtCO_2e$	160-610 $MtCO_2e$
SunShot Initiative	20-90 $MtCO_2e$	200-610 $MtCO_2e$
US Wind Program	0 $MtCO_2e$	180-430 $MtCO_2e$
AREI	20-40 $MtCO_2e$	360-820 $MtCO_2e$
Global Geothermal Alliance	0 $MtCO_2e$	125-270 $MtCO_2e$

11. Quantification of overlaps between ICIs

This section explains the methods of quantifying the overlaps between initiatives. We calculated these overlaps on a country-level basis for most initiatives, and globally for the remaining initiatives.

Introduction

After calculating both the global level and country level emission reduction potential relative to the current national policies scenario for each initiative (as detailed in the previous sections), possible overlaps among initiatives within each country were analyzed. This resulted in a range of emission reduction potentials that correspond to different overlap percentages between initiatives.

In this range, the lower bound of reductions corresponds to the highest possible overlaps between initiatives, i.e. a situation where initiatives do the "least additional work while still reaching their respective targets". The upper bound corresponds to assuming the initiatives are completely "additional" to each other, i.e. achievements from one initiative do not diminish ambition of another.

Overall, the types of overlaps that we have considered can be roughly grouped into one of three categories, which are explained in more detail below. Table 18 provided an overview of the different types of overlaps that were calculated across the initiatives.

One significant type of potential overlap that has not been taken into account is that of initiatives with emission-trading schemes. For example, for renewable power initiatives in the EU, whose power sector falls under the ETS, we assume that reduction in emissions from initiatives' actions would not result in the sale of emission allowances to someone else (e.g. that the allowances are cancelled, or that the ETS cap is lowered in response to additional renewable power production). This is consistent with our general assumption that the enhanced ambition of initiatives does not reduce ambition elsewhere (in this context, buying emission credits falls under the latter). In addition, we do no assume that pledged initiative targets would lead to carbon leakage, i.e. transfer of production to countries with lower climate ambition.

Table 18: Types of overlaps considered and the instances in which specific calculations were made in the country-level analysis.

Type of overlap	For which initiatives	Overlaps with	Applied in countries
Same actors with target in more than one initiative (same sector)	Under2MOU	C40, GCoM	Worldwide (wherever applicable)
	SEAD	U4E	Brazil, India, Indonesia, Mexico, Russia, South Africa
Initiatives targeting the same emissions (same sector)	US Wind Program	SunShot Initiative	USA
	EWI	SEII	EU
	Bonn Challenge	NYDF (reforestation part)	Worldwide (wherever applicable)
	Global Forest Challenge	NYDF (deforestation part)	Worldwide (wherever applicable)
Targets that are not sector specific (overlap between city initiatives with different sectors)	C40, GCoM and Under2MOU	US Wind Program, SSI, GGA SEAD, A2030, GFEI, CCAC (F-gases only)	US
		SEAD, GGA, A2030, GFEI, CCAC (F-gases	Brazil, India, Japan, Mexico, Russia

		only)	
		U4E, GGA, A2030, GFEI, CCAC (F-gases only)	China
		SEAD/ U4E, GGA, A2030, GFEI, CCAC (F-gases only)	Indonesia, South Africa
		EWI, SEII, GGA, SEAD, A2030, GFEI, CCAC (F-gases only)	EU

Same actors with targets in more than one initiative

This type of overlap may occur when one non-state and/or subnational actor is participating in one or more initiative in the same sector. For example, this often occurs when cities set an emission reduction target under the C40 initiative and/or GCoM, while their corresponding regions simultaneously sets a reduction target under the Under2MOU; or when certain companies are subscribed to more than one business initiative. Such overlaps are thus not subject to uncertainty; we do not have to calculate a range of possible reductions assuming varying degrees of overlap, as there is complete certainty that this overlap is definite.

We have taken out the effect of this potential double-counting by checking for each country (or on the global level for the business initiatives) which instances of multiple memberships occur and selecting the most ambitious commitment. For example, if a city is found to be part of both the C40 and the Under2MOU initiative, and its target is not substantially more ambitious under the C40, then its potential for reduction is counted in the Under2MOU because this one has a larger coverage (regions instead of cities).

Initiatives targeting the same emissions

This type of overlap occurs when different initiatives in the same sector have: targets that overlap directly, as they are expressed in the same metric; targets that aim to achieve the same goal (through undefined means); or targets that could potentially compete with each other.

The renewable energy initiatives in the United States and the European Union are examples of such kinds of overlap. In both cases one initiative targets a certain percentage of power generation to come from solar by 2020 or 2030, and the other a certain percentage of power generation to come from wind power. While these targets are in principle complementary, quantifying their potential impact is only possible by taking into account the potential competition between the two. For instance, the upper range of reduction of the European Wind Initiative on its own could be calculated by assuming the wind power replaces first coal, then oil and then gas in the power mix. The same can be done for the SSEI. But the sum of the two upper bounds of EWI and SEII is not equal to the upper bound of the two initiatives together, because they would then be replacing more coal than exists in the power mix. So, the fact that the two can compete in “replacing fossil fuels” impacts their potential maximum impact when both are assumed to be implemented.

Targets that are not sector specific

Another type of overlap we consider is between city initiatives and all other types of initiatives (in other sectors). Various cities and regions have set “NDC-style” emission reduction pledges under the C40 and Under2MOU initiatives, respectively, usually expressed in a percentage reduction to be achieved by a certain target year and relative to a certain base year. While some cities go into more detail on how this is implemented, for others there is a broad range of activities that could help cities achieve their targets, i.e. sustainable energy deployment, better building standards, etc. Thus, other initiatives in relevant sectors, if implemented, could simultaneously contribute to cities/regions reaching their own targets.

To estimate the overlaps involved, we have estimated that city/region initiatives can overlap by:

1) Initiatives in the sustainable energy sector, e.g. the wind and solar programs in the EU and US;
2) Initiatives in the buildings sector, i.e. A2030;
3) Initiatives in the non-CO2 sector, i.e. f-gases;
4) Initiatives targeting energy efficiency, i.e. SEAD and U4E;
5) Initiatives in the road transport sector, i.e. GFEI.

In cases where there is potentially significant overlap between cities/region initiatives and other sector initiatives (US, EU, Russia, Japan), we applied the simple assumptions of either no additional effect or 50% additional effect to derive an uncertainty range. For the remaining countries where other quantified sector initiatives do not have large overlaps with cities/regions initiatives, overlaps are calculated by subtracting the impacts of buildings, transport, renewables, and energy efficiency initiatives from the cities/regions impact. Due to overall larger uncertainties in commitment implementation, we did not apply a sophisticated overlap calculation as for individual actor commitments.

We assumed there is no overlap between other initiatives. For example, we assumed no overlap between energy efficiency initiatives and the Architecture2030 initiative, as the latter reduces or avoids emissions by reducing thermal energy demand while the former targets electricity consumption/ appliances.

12. Appendix

Table 19: Data sources – Current national policies scenario and NDC scenarios per action area

Action area/ sector	Current national policies scenario	Nationally determined contribution scenario
Forestry	Global: Blok et al. (2017); Country-specific: Kuramochi et al. (2017) + historical data on afforestation and reforestation from the FAO	Not available consistent with the current policy scenario. We hence assumed roughly 1 $GtCO_2$ difference in 2030 compared to current policies scenario (Difference between current policy and NDC of all sectors globally is around 4 $GtCO_2$, applying the same proportion as the size of the forestry sector, around a fourth of global emissions, yields in 1 $GtCO_2$)
Cities & Regions	IEA's World Energy Outlook (2017) (Current Policies Scenario)	UNFCCC (I)NDC submissions
Buildings	IEA's World Energy Outlook (2017) (Current Policies Scenario)	IEA's World Energy Outlook (2017) (New Policies Scenario)
Energy Efficiency	IEA's World Energy Outlook (2017) (Current Policies Scenario); for U4E only: 'Policy Scenario' as provided by the initiative	IEA's World Energy Outlook (2017) (New Policies Scenario); for U4E only: Same as for CPS as no data available to construct an NDC scenario
Non-CO2	CCAC: CH_4 emissions: EPA database (US EPA 2012); HFC emissions: The historical emissions dataset up to 2013 was developed using the PRIMAP (Gütschow et al. 2017) and EDGAR (EU JRC & PBL 2014) databases, and future growth rates are based on the reference scenario reported in U.S. EPA (US EPA 2012); Zero flaring initiative: U.S. EPA (US EPA 2012) – Emissions from Natural Gas & Oil Systems	CCAC: CH_4 and HFC emissions – NDC scenario based on % reduction between emissions projections under a CPS and those under current pledges (global, then applied to all countries), based on Climate Action Tracker (CAT) data; if a country's NDC does not apply to non-CO_2 GHG emissions (e.g., as is the case in China), we assumed the same emissions projections as under the CPS; Zero flaring initiative: Same as for CCAC but country-specific NDC scenario for flaring and venting (based on U.S. EPA data), using the information contained in countries' NDCs
Transport	GFEI: Kuramochi et al. (2017); CAATW: ICAO (2013)	GFEI: Additional calculations with TIMER model. Two scenarios 1) improving vehicle efficiency for new cars by 50% relative to 2005, 2) setting 2030 efficiency for new cars to 4.2 lge/100km based on GFEI (2014) report. CAATW: Same as CPS (as emissions from international air travel are not included in NDCs)
Industry & Business	RE100: IEA's World Energy Outlook (2017) (Current Policies Scenario) SBTi: IEA ETP 2015, 6DS (IEA 2015)	RE100: IEA's World Energy Outlook (2017) (New Policies Scenario) SBTi: IEA ETP 2015, 4DS (IEA 2015)
Renewable	IEA's World Energy Outlook (2017)	IEA's World Energy Outlook (2017) (New

Energy	(Current Policies Scenario); AREI: Capacity values and continental renewable shares only are taken from WEO's Sustainable Development Scenario (SDS) instead of the CPS. GGA: For geothermal heating, base year (2014) values were ascertained from Lund and Boyd (2015), while future business-as-usual projections of 2020 and 2030 capacity were interpolated with the 2050 geothermal heat capacity projections from the Geothermal Roadmap (IEA 2011).	Policies Scenario)

13. Glossary

Cities: Administrative units that pledge commitments to a climate action platform, and which include municipalities, towns, urban communities, districts, and counties defined by the actors themselves.

Climate action by subnational and non-state actors: Any kind of activity that is directly or indirectly aimed at reducing GHG emissions or driving adaptation and resilience that is led by these actors. Actions can be pursued individually (by *one* sub-national or non-state actor) or cooperatively in the form of initiatives (by a *group* of actors, including non-state and/or sub-national actors).

Commitments by subnational and non-state actors: Planned climate action as well as action currently under implementation, which has been publicly announced. Commitments can be put forward and pursued individually (by *one* sub-national or non-state actor) or cooperatively in the form of initiatives (by a *group* of actors, including non-state and/or sub-national actors).

International Cooperative Initiative (ICI): Collaborative efforts to address climate change among countries, NGOs, academia, international organizations, states, regions, cities, businesses and investors.

Non-state actor: Any actor other than a national and sub-national government. This includes private actors, such as companies and investors, civil society and international organizations, among others.

Non-state and sub-national action: Any kind of activity that is directly or indirectly aimed at reducing GHG emissions and that is led by non-state and sub-national actors. Actions can be put forward and pursued individually (by *one* sub-national or non-state actor) or cooperatively in the form of initiatives (by a *group* of actors, including non-state and/or sub-national actors).

Non-state and sub-national commitments: Planned non-state and sub-national action which have been publicly announced. However, in contrast to the non-state and sub-national actions, implementation of the action is not yet underway. In practice though, the difference between commitments and action is often not clear. For example, planning how to implement a target could be considered an action. This report therefore considers both existing actions underway and planned commitments.

Scope 1 emissions: Direct emissions resulting from owned or controlled sources. See www.ghgprotocol.org for further details.

Scope 2 emissions: Indirect emissions resulting from purchased electricity, heat or steam. See www.ghgprotocol.org for further details.

Scope 3 emissions: Other indirect emissions not included in Scope 2 that are in the value chain of a reporting actor, including both upstream and downstream sources. See www.ghgprotocol.org for further details.

States and regions: Larger administrative units that are generally broader in population and in scope than cities. They usually have separate governing bodies from national and city governments but encompass lower administrative levels of government; often, they are the first administrative level below the national government. Regions can also include councils of subnational governments acting together.

Sub-national actor: Any form of government that is not a national government, such as cities, states, provinces and regions.

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