Global climate action from cities, regions, and businesses

Impact of individual actors and cooperative initiatives on global and national emissions. 2019 edition.

Technical annex II: Methodology for quantifying the potential impact of international cooperative initiatives and assessing links between national climate initiatives and sustainable development goals (SDGs)

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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
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

This document provides a detailed overview of the methodology used to quantify the potential impact of international cooperative initiatives (ICIs) on national and global greenhouse gas (GHG) emissions, including:

- The process and criteria for selecting initiatives to include in this study;
- The methodology used in:
  - calculating the Function-Output-Fit (FOF) analysis;
  - quantifying the emission reduction potential of selected initiatives;
  - accounting for overlaps between different initiatives;
  - tools used to establish links, as well as potential synergies and trade-offs, between ICIs and Sustainable Development Goals (SDGs).

We first selected initiatives to quantify and analyse their potential impact on GHG 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 ten high-emitting economies: Brazil, Canada, China, the European Union (EU), India, Indonesia, Japan, Mexico, South Africa and the United States of America (US), as well as to "Rest-of-the-World" (RoW). We also identified initiatives with goals that could span many sectors and thus overlap with other initiatives targeting the same emissions source, for instance where a transport and air pollution initiative both target car emission standards or where initiatives that focus on promoting wind and solar energy both replace emissions from fossil fuel electricity generation. We accounted for overlaps between each initiative with the likely overlap they have with other initiative efforts. For more detail on our overlap calculations, please see Section 0.

Once all overlaps were accounted for, we aggregated the emission reductions that could be collectively achieved through the ICI activity in the ten high-emitting economies and RoW into a global total (Figure 1).

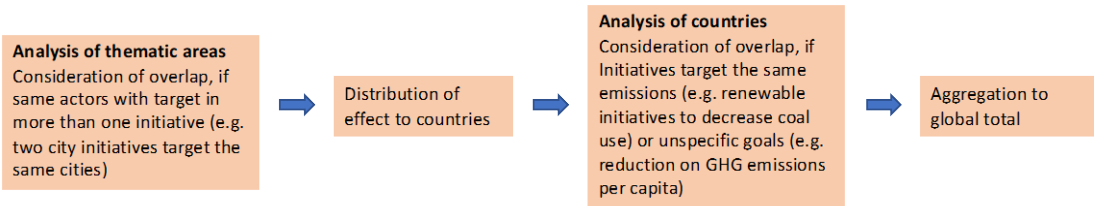

Figure 1. An illustration of the steps of the analysis

The ICIs quantified in this report were categorized into eight sectors: energy efficiency, buildings, transport, renewable energy (RE), industry and business, forestry, non-CO_2 GHGs, and cities and regions. Because the current national policies scenario projections based on Kuramochi et al. (2018) do not provide sub-sector level energy consumption projections, we used energy demand and supply projections from other sources including IEA World Energy Outlook (WEO) 2018 as well as IEA Energy Technology Perspectives (ETP) 2016 as proxies to calculate the ICIs' impact on energy demand and supply and CO_2 emissions. Table 1 lists all sources of proxy energy demand and supply projections used.

In the current analysis, the base year was determined by the most recent year for which data is available and the time horizon is 2030. Historical GHG emissions data is used up to 2016. The modelling base year for (sub)sector-level baseline scenarios ranged between 2013 and 2016, depending on the initiative and data availability. All GHG emission values are expressed using the global warming potential (GWP) values from the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007; Klein and al, 2007) to ensure consistency with our baseline scenarios.

Table 1: (Sub)sector-level baseline energy demand and supply projections against which the impact of international cooperative initiatives (ICIs) was calculated.

Action area/ sector	Current national policies scenario	Nationally determined contribution scenario
Energy Efficiency	IEA World Energy (WEO) 2018 (IEA, 2018) Current Policies Scenario (CPS); 2016 as base year.	IEA WEO 2018 New Policies Scenario (NPS); 2016 as base year.
Buildings	IEA WEO 2018 (CPS).	IEA WEO 2018 (NPS).
Transport	GFEI: current policies scenario projections from TIMER model provided to Kuramochi et al. (2018). CAATW: ICAO (2016).	GFEI: NDC scenario projections from TIMER model provided to Kuramochi et al. (2018). CAATW: Same as CPS (as emissions from international air travel are not included in NDCs).
Renewable Energy	IEA WEO 2018 (CPS) with exceptions described below: • AREI: Continental renewable capacity and generation projections for 2030 are taken from IEA WEO 2018 Sustainable Development Scenario (SDS) instead of the CPS. • GGA: For geothermal heating, base year (2014) values were taken from Lund and Boyd (2015), future business-as-usual projections of 2020 were taken from geothermal heat capacity projections from the IEA Geothermal Roadmap (IEA, 2011b), and 2030 projections were extrapolated from 2020 numbers using WEO 2018 CPS growth rates.	IEA WEO 2018 (NPS).
Industry & Business	RE100: IEA WEO 2018 (CPS). SBTi: IEA ETP 2016 (IEA, 2016a) (6 °C scenario: 6DS); 2013 as base year.	RE100: IEA WEO 2018 (NPS) SBTi: IEA ETP 2016 (4 °C scenario: 4DS); 2013 as base year.
Forestry	Forsell et al. (2016) reference scenario adjusted by current policies scenario projections by Kuramochi et al. (2018) for ten high-emitting economies; 2015 as base year.	Forsell et al. (NDC scenario); 2015 as base year.
Non-CO_2 GHGs	CCAC (CH_4 and HFC emissions): • CH_4 emissions: EPA database (US EPA, 2012) are used for historical numbers and future projections, while country-specific emissions use EDGAR (EU JRC and PBL, 2014); 2015 as base year. • HFC emissions: The historical emissions dataset up to 2013 was developed using the PRIMAP (Gütschow *et al.*, 2017) and EDGAR (EU JRC and PBL, 2014) databases, and future growth rates are based on	CCAC (CH_4 and HFC emissions): • CH_4 emissions: NDC scenario is proxied using the emissions projections under EPA database (U.S. EPA, 2012) and the % reduction in projected CO_2 emissions between CPS and NPS from IEA WEO 2018. • HFC emissions: The historical emissions dataset up to 2013 was developed using the PRIMAP (Gütschow *et al.*,

	the reference scenario reported in U.S. EPA (2012).	2017) and EDGAR (EU JRC and PBL, 2014) databases, and future growth rates are based on the reference scenario reported in U.S. EPA (2012).
Cities & Regions	Current national policies scenarios for all city and region actors follow national projections from Kuramochi et al. (2018).	Unconditional NDC scenarios for all city and region actors follow national projections from Kuramochi et al. (2018).

2 Selection of initiatives

As a first step, we identified an initial list of over 300 international cooperative initiatives (ICIs) that support national, subnational and non-state action, drawn from the Climate Initiatives Platform and supplemented by our own research. We narrowed the list to 54 based on whether initiatives:

- refer to transnational climate mitigation,
- have a potentially significant impact on GHG emissions,
- are transparent in their operations.

In consultation with experts in non-state and subnational action, we further refined the list based on whether the initiatives had a quantifiable target to calculate emissions reductions. Lastly, the list narrowed down to 17 ICIs based on whether the initiatives had realistic actionable and implementable mitigation plans and whether they passed a Function-Output-Fit (FOF) analysis, which assesses the initiatives' likelihood of implementation, indicated by recent progress, reporting, and other regular updates. The methodology for the FOF analysis can be found in (Chan *et al.*, 2018). Furthermore, if various initiatives cover the same topic area with high degrees of overlap, we choose the one with the most ambitious target and scope. Table 2 summarises the order and steps taken to select our final list of initiatives, while Table 3 displays the final selection of ICIs.

Table 2: Selection process of international cooperative initiatives (ICIs)

Selection steps	Number of ICIs in shortlist
1. **Full list of identified ICIs**	300+
2. **ICIs with links to mitigation**	263
3. **ICIs with potentially significant impact on transnational emissions reduction**	54
4. **ICIs with quantifiable targets**	30
5. **ICIs passing Function-Output-Fit analysis, with realistic actionable mitigation plans**	17

Table 3: Final list of selected ICIs for quantification

International cooperative initiative	Regions covered	Sector/theme
United for Efficiency (U4E)	Global (developing countries)	Energy efficiency
Super-efficient Equipment and Appliance Deployment (SEAD)	Global	Energy efficiency
Architecture 2030	Global	Buildings
Collaborative Climate Action Across the Air Transport World (CAATW)	Global	Transport
Lean and Green	Europe	Transport
Global Fuel Economy Initiative (GFEI)	Global	Transport
European Technology & Innovation Platform Phtovoltaic (ETIP-PV)	Europe	Renewable energy
Africa Renewable Energy Initiative	Africa	Renewable energy
Global Geothermal Alliance (GGA)	Global	Renewable energy
RE100 initiative	Global	Business and industry
Science Based Targets initiative (SBTi)	Global	Business and industry

[Deforestation] Bonn Challenge / New York Declaration on Forests	Global	Forestry
[Restoration] Governors' Climate and Forests Task Force (GCFTF) / New York Declaration on Forests	Global	Forestry
Climate and Clean Air Coalition (HFCs and methane)	Global	Non-CO_2 GHGs
Under2 Coalition	Global	Cities and regions
Global Covenant of Mayors for Climate and Energy	Global	Cities and regions
C40 Cities Climate Leadership Group (C40)	Global	Cities and regions

3 Quantification of potential GHG emissions reduction impact by international cooperative initiatives

3.1 Energy Efficiency

3.1.1 Super-Efficient Equipment & Appliance Deployment Initiative

3.1.1.1 *Description*

The Super-efficient Equipment and Appliance Deployment (SEAD) Initiative is a voluntary collaboration among governments working to promote the manufacture, purchase, and use of energy-efficient appliances, lighting, and equipment worldwide. SEAD is an initiative under the Clean Energy Ministerial (CEM) and a task of the International Partnership for Energy Efficiency Cooperation (IPEEC). SEAD consists of 18 participating governments (mostly in advanced economies) collaborating on the implementation of appliance energy efficiency policies. 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.[1] Letschert et al. (2012) estimated that realizing the SEAD Initiative's goal will save consumers more than US$1 trillion between 2010 and 2030.

3.1.1.2 *Quantification*

The energy savings potential of SEAD is quantified based on an assessment for the period between 2015 and 2025 conducted for OECD and non-OECD countries conducted by the Lawrence Berkeley National Laboratory (LBNL) and presented in IEA (2015). For "Current national policies plus initiatives' goals" scenario, we assumed that the energy consumption reduction rates below the current national policies scenario projections in 2030 in the SEAD member countries as of 2015 (Australia, Brazil, Canada, the European Union, India, Indonesia, Japan, Korea, Mexico, Russia, South Africa and the United States) equal the energy consumption reduction rates below the reference 6 °C scenario (6DS) for 2025 as calculated in IEA Energy Technology Perspectives 2016 (IEA, 2016a).

Since the Current national policies scenario projections based on Kuramochi et al. (2018) do not provide sector-specific energy consumption projections, we used the Current Policies Scenario (CPS) projections from IEA WEO 2018 as a proxy to calculate the energy consumption levels for the buildings and industry sectors in 2030 under the SEAD on a country level. For China, which became a SEAD member after 2015, we assumed that the energy savings potential relative to the SEAD member countries as of 2015 would be identical to the potential assessment results from Letschert et al. (V. E. Letschert *et al.*, 2012). We did not consider the potential impact in other new SEAD member countries (Argentina, Chile and Saudi Arabia) due to the relatively small size of energy consumption compared to other member countries. The calculated energy consumption levels under the SEAD as described above were then compared to the New Policies Scenario (NPS) projections of IEA WEO 2018 to estimate the energy savings potential under the "NDCs plus initiatives' goals" scenario compared to the NDC scenario.

CO_2 emissions reduction potential was calculated by multiplying the energy savings potential calculated above by electricity CO_2 emission factors from fossil fuel-fired power generation derived from the IEA WEO 2018 projections (CPS for "Current policies plus initiatives' goals" scenario and NPS for "NDCs plus initiatives' coals" scenario). The upper end estimate assumes replacement of coal-fired power generation and the lower end estimate assumes replacement of gas-fired power generation. For Canada, we used the IEA WEO 2018 US emission factors; for Indonesia we use the IEA WEO 2018

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

ASEAN-average emission factors; for Mexico we used values from the IEA Mexico Energy Outlook (IEA, 2016b).

3.1.2 United for Efficiency (U4E)

3.1.2.1 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 $GtCO_2e$ emissions reductions annually by 2030.[2] 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).

3.1.2.2 Quantification

Total global energy savings (TWh) from energy efficient appliances and equipment were quantified by the initiative, per appliance type and country. U4E quantified the potential energy savings from the initiative by product and country based on reductions relative to the "Policy scenario" which broadly corresponds to the IEA WEO 2018's Current Policies Scenario (CPS) and assumes minimum energy performance standards (MEPS) are implemented in the year 2020 at a level equivalent to the current day best MEPS.

To quantify the corresponding emissions reductions, we multiplied the country-specific electricity savings potential with the country-specific emissions intensity of coal-fired electricity (maximum emission reduction potential) and gas-fired electricity (minimum emission reduction potential). The emission intensity of power generation for coal-fired and gas-fired electricity is given by the CO_2 emissions from total power generation from the fuel divided by the total electricity generated through coal or gas-fired power generation. Power generation and emissions develop as projected by IEA WEO 2018’s CPS and NPS scenario, where country data is available. Emission intensity values for gas and coal generation of electricity in each key country are also calculated using IEA WEO 2018 (IEA, 2018), except for Mexico where emission factors are based on the Climate Action Tracker analysis (Climate Action Tracker, 2018), Indonesia, where we calculated the emissions intensity based on Indonesia’s share in total ASEAN energy use and assumed that this share remains constant, and RoW, which is proxied with the emission intensity values for non-OECD countries. Due to the defined scope of countries in our analysis, emission reductions are only calculated for Brazil, China, India, Indonesia, South Africa, Mexico, and the RoW.

The calculated energy consumption levels under the U4E as described above were then compared to the Current Policies Scenario and New Policies Scenario (NPS) projections of IEA WEO 2018 to estimate the energy savings potential under the “current national policies plus initiatives’ goals” and “NDCs plus initiatives’ goals” scenarios, respectively.

[2] https://united4efficiency.org/

3.1.3 Results

Table 4 - Global emission reduction potential from Energy Efficiency ICIs, without overlap, compared to current national policies scenario

Initiative	2030 impact
SEAD	520 – 1,200 $MtCO_2e$
U4E	560 – 1,200 $MtCO_2e$

3.2 Buildings

3.2.1 Architecture 2030

3.2.1.1 Description

The mission of Architecture 2030 (A2030) is to expedite the global low-carbon transition of the buildings sector, targeting energy efficiency improvements in the building envelope. A2030 pursues two main objectives: 1) to achieve substantial reductions in GHG emissions from the built environment and 2) to enhance the development of sustainable buildings and communities. In 2006, A2030 launched the 2030 Challenge, which sparked a net-zero emissions movement in the buildings sector[3]. Since then, it has been adopted by architectural design firms, the International Union of Architects, the American Institute of Architects, cities and the US Conference of Mayors. The 2030 Challenge entails the following targets, as stated on their website:[4]

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, and energy consumption performance standard of 70% below the regional average for that building type.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet the same target.
- The fossil fuel reduction standard shall be increased to 80% in 2020, 90% in 2025 and carbon neutral in 2030.

3.2.1.2 Quantification

We calculated the thermal energy efficiency improvements for new floor area, rebuilt floor area and renovated floor area, which result in the reduction of fossil fuel consumption in buildings. The energy consumption and emissions data per fuel type was obtained from IEA WEO 2018 CPS and NPS. Fuel CO_2 emission factors per fuel type were then calculated. We further calculated current and future energy intensity of buildings in mtoe/m^2, for both scenarios with the IEA WEO 2018 data and floorspace projections from IEA (2013) and IEA (2015) (for Canada and Indonesia).

We assumed a 1.5%/year demolition rate for OECD-countries and 2%/year for non-OECD-countries (ETP, 2016) to determine the number of rebuilt buildings per year and used a 1%/year renovation rate to determine the number of renovated buildings (Kriegler *et al.*, 2018). The sum of rebuilt, renovated and new building stock, in regions covered by the A2030 initiative, determined the amount of floor area potentially impacted by A2030. We applied different coverage rates per region on this sum to get an estimate of the amount of floor area under A2030 standards. Currently, A2030 is mainly active in the United States and Canada and has several projects in the EU and China. For the United States and Canada, the floor area coverage was set to 65% in 2017 and 100% in 2050, based on the assumption that A2030 will reach its target of full coverage in North America. The trajectory of current to target coverage is assumed to grow linearly in Canada and the US, as the initiative's sector penetration is already mature. For the EU and China, we assumed 1% floor area coverage in 2017 and 20% coverage

[3] https://architecture2030.org/about/
[4] https://architecture2030.org/2030_challenges/2030-challenge/

in 2050, following a logistic growth curve based on the current low number of projects in these regions. For the rest of the world, we assumed 1% floor area coverage in 2017 and 5% in 2050, with linear growth, based on the assumption that some additional projects will be executed in the rest of the world with a steady rate.

A2030 targets were quantified by using the relative targets as reducing the energy intensity per unit of floorspace (i.e., mtoe/m^2) due to the initiative's energy efficiency improvement, using 2016 as a base year. By applying floorspace and sector-specific energy mix projections, we determined the projected total fossil energy use by fuel type needed to satisfy future energy demand in buildings and their related emissions for a scenario with A2030, as well as emissions under a CPS and NPS scenario. Final emissions reductions from A2030 are then calculated for the "current national policies plus initiatives' goals" (by comparing to CPS results) and the "NDC plus initiatives' goals" (by comparing to the NPS results) scenarios. Uncertainty ranges were calculated depending on the order of fossil fuels which were reduced under the energy efficiency improvements. In the maximum emissions reductions' scenario, we assume that reductions come from coal first, then oil, then gas. In the minimum emissions reductions' scenario, we assume that reductions come from gas first, then oil, then coal.

3.2.2 Results

Table 5 – Global emission reduction potential of Buildings ICIs compared to CPS

Initiative	2030 impact
Architecture 2030	180 - 200 MtCO_2e

3.3 Transport

3.3.1 Collaborative Climate Action Across the Air Transport World

3.3.1.1 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 two main goals (ICAO, 2018):

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

3.3.1.2 Quantification

We refer to the results from our 2018 report (Data-Driven Yale, NewClimate Institute and PBL, 2018b). We assumed that international aviation emissions develop as projected by ICAO (2016), which served as our current national policies 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).

3.3.2 Global Fuel Economy Initiative

3.3.2.1 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 the University of California, Davis and the FIA Foundation, which hosts the secretariat.[5]

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)

3.3.2.2 Quantification

Quantification of the impact of the GFEI initiative used 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 and trucks is an input to the TIMER transport model (Girod, Van Vuuren and Deetman, 2012), and the default setting was changed to represent the GFEI targets. Manufacturing costs were changed accordingly. Two variants were calculated for cars, only scenario two was calculated for trucks:

1. For each IMAGE region, average fuel economy was set to 4.2 litres of gasoline equivalent (lge) per 100 kilometres by 2030 for new cars, representing a 50% improvement relative to 2005 according to GFEI (2016).
2. For each IMAGE region, average fuel economy by 2030 was set to 50% of 2005 level for cars, and average fuel economy by 2035 is set to 65% of 2005 levels for trucks.

The results for 26 IMAGE regions were scaled with the share of countries that participate in the Global Fuel Economy Initiative, based on the 2012 GHG emissions for road transport from the EDGAR database (Janssens-Maenhout *et al.*, 2017). Participants in the GFEI can be divided in 1) submitted baseline emissions, 2) submitted policy proposals, 3) implemented transport policies.[6] We have included all GFEI members in our analysis, assuming they will implement policies in line with the overall target of the initiative. Thus assuming, several countries will submit and implement additional transport policies.

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

[6] https://www.globalfueleconomy.org/in-country

GHG emission reductions were compared to the current policies scenario from Kuramochi et al. (2018), that includes implemented policies from large major emitting countries.

3.3.3 Lean and Green

3.3.3.1 Description

Lean and Green works with companies and government bodies with the intention to improve sustainability and reduce GHG emissions through sustainable transport, concentrating on freight modes. The initiative is implemented by Connekt: a Dutch non-profit network for sustainable mobility. Lean and Green is focused in Europe, with Netherlands, Italy, Belgium, Luxembourg and Germany all starting their own Lean and Green programmes. The initiative supports its participating entities to reduce its CO_2e emissions by 20% in five years' time. The Lean and Green network now comprises more than 400 frontrunners in five European countries, within the scope of two mobility themes: Logistics and Personal Mobility. The Lean and Green initiative provides a range of support to its frontrunners, among which including the exchange of best practices, developing tools and guidelines for emissions calculations, performance monitoring, and providing indicators and benchmarks.

3.3.3.2 Quantification

It is assumed that all EU countries will reduce 2015 freight emissions by 20% and follow vehicle emissions growth from the current policies or NDC scenario between 2020 and 2030. Emission projections are taken from the TIMER GHG projections, which are also used in other parts of the regions, cities and companies' assessment. There are two differences with other ICI calculations (except for GFEI):

- NDC scenario projections include all current implemented policies, and therefore GHG emissions are never lower than the current national policies scenario.
- GHG projections after target year are based on growth of car and trucks emissions, and not the emission growth of the whole economy.

3.3.4 Results

Initiative	**2030 impact**
CAATW	550 $MtCO_2e$
GFEI	540 $MtCO_2e$
Lean and Green	20 $MtCO_2e$

3.4 Renewable Energy (RE)

3.4.1 ETIP PV

3.4.1.1 Description

European Technology and Innovative Platform for Photovoltaics (ETIP PV) works with stakeholders (countries, industry, researchers) to accelerate the European market uptake of photovoltaic (PV) technologies. The initiative developed formerly from the Solar Europe Industry Initiative, gathering more than 200 experts along the PV value chain to make policy recommendations on how to improve competitiveness in the PV industry, including both the upstream segments (incl. feedstock supply, equipment manufacturing, cell and module production) and downstream segments (incl. technical solutions for grid integration, market solutions for grid integration, installation). The ETIP consists of an Executive Committee who oversees the strategy of the Steering Committee, the initiative's main decision-making body. The Steering Committee then directs activities of ad-hoc working groups consisting of sector experts. Working groups include Levelised Cost of Electricity (LCOE) & competitiveness, Integrated PV, Digital PV systems and grid, PV Industry forum, and PV Quality & reliability.

3.4.1.2 Quantification

ETIP-PV explicitly stated the aim to actively support the EU's green policy goals and additional actions to limit global temperature rise to 1.5 °C and increase its capacity from 115 GW at the end of 2018 (chart below) to more than 600 GW by 2025 and 4-9 TW by 2050 (ETIP PV, 2019).[7] Due to the unrealistic high level of this ambition, however, we instead quantified SEII's previous target of a 12% PV share of EU electricity generation in 2020 and 20% share in 2030.

Current national policies projections for solar PV and total electricity generation in the EU for 2030 were taken from the IEA WEO 2018's CPS, while projections under the NDC scenario were taken from IEA WEO 2018's NPS. Additional electricity generation from PV under the ETIP-PV objectives were compared to the baseline PV generation under the CPS and NPS. We then converted the additional electricity generation to emissions reductions by assuming the additional PV generation reduces electricity from coal and gas-fired generation, which define the maximum and minimum emissions reductions for the EU in 2030, respectively. The CO_2 emission factors for coal- and gas-fired electricity were also calculated from IEA WEO 2018.

Table 6: Parameter descriptions, values, units and sources used in the impact quantification for ETIP-PV

Description	Value	Unit	Source
Total electricity generation in the EU (2030) – CPS	3508	TWh	IEA WEO 2018 Current Policies Scenario
Total electricity generation from solar PV in the EU (2030) – CPS	196	TWh	
CO_2 emission factor coal-fired electricity in the EU (2030) - CPS	1.00	tCO_2 / MWh	
CO_2 emission factor gas-fired electricity in the EU (2030) - CPS	0.42	tCO_2 / MWh	
Total electricity generation in the EU (2030) – NPS	3354	TWh	IEA WEO 2018 New Policies Scenario
Total electricity generation from solar PV in the EU (2030) – NPS	253	TWh	

[7] https://etip-pv.eu/about/

CO_2 emission factor coal-fired electricity in the EU (2030) - NPS	1.04	tCO_2 / MWh	
CO_2 emission factor gas-fired electricity in the EU (2030) - NPS	0.44	tCO_2 / MWh	

3.4.2 African Renewable Energy Initiative

3.4.2.1 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 Initiative is mandated by the African Union and endorsed by African Heads of State and Government on Climate Change, and 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).[8] 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 RE systems that support their low-carbon development strategies while enhancing economic and energy security.
- Achieve at least 10 GW of new additional RE generation capacity by 2020, and at least 300 GW by 2030 on the African continent.[9]

3.4.2.2 Quantification

The current national policy projections for renewable and total electricity generation, as well as electricity generating capacity (solar, wind, hydro) were taken for the years 2016, 2020 and 2030 from the IEA WEO 2018 (CPS for current national policies scenario and NPS for NDC scenario). Electricity generation, capacity and emission values for 2020 under current national policies and NDC scenarios were approximated by linearly interpolating between the latest historical data provided and 2025 IEA projections, while 2016 and 2030 values were readily provided.

The new and additional renewable electricity generation capacity was then calculated by the difference between the targets set under the initiative for both 2020 and 2030 (as an absolute addition of electricity generation capacity under renewable sources) and the expected level of RE generation capacity assumed under IEA WEO 2018's CPS and NPS. We assumed that the distribution of AREI's capacity increase by energy source would follow the same projected trends as IEA WEO 2018. For 2030, we followed the same methodology, with the exception that continental renewable capacity and generation projections, as well as projections of renewable shares, were taken from the IEA WEO 2018's Sustainable Development Scenario (SDS) instead of the CPS (NPS was still used for the NDC scenario). This is because while we could agree with the CPS trend for hydro that implies a large proportion of African renewable capacity in 2020 (91%), we find the estimated share in 2030 (69%) 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 46%, 18%, and 37% of renewable electricity generation capacity respectively. Thus, we compared the renewable capacity by energy source from the scenarios (CPS/NPS for 2020, SDS/NPS for 2030) and the additional RE capacity installation by AREI targets to quantify the additionality. Renewable electricity generation is then calculated using respective capacities and load

[8] https://unfccc.int/news/africa-renewable-energy-initiative-increasing-renewable-energy-capacity-on-the-african-continent
[9] http://www.arei.org/#about

factors. The expected share of new African renewable generation is allocated to countries in 2020 and 2030, based on their projected share of continental renewable generation in the respective years.

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). The emissions savings from AREI resulting from displacing fossil fuel energy sources are then compared to both the current national policies (CPS) and NDC scenarios (NPS). For this we used emission factors derived from the IEA WEO 2018 data. In this quantification we assume that 100% of new renewable capacity will be developed through hydropower, wind, and solar PV sources given they are the most advanced and economically viable renewable technologies to date. Furthermore, projected growth in other renewable technologies are negligible aside from geothermal, which is captured within our GGA quantification below. AREI specific data can be found in Table 7.

Table 7: Parameter descriptions, values, units and sources used in the impact quantification of the AREI

Description	Value	Unit	Source
Total renewable electricity capacity of hydro, wind, and solar Africa (2030) - CPS	118	GW	IEA WEO 2018 Current Policies Scenario
CO_2 emission factor coal-fired electricity in Africa (2030) - CPS	0.97	tCO_2 / MWh	
CO_2 emission factor gas-fired electricity in Africa (2030) - CPS	0.40	tCO_2 / MWh	
Total Africa renewable electricity generation from hydro, wind, and solar (2030) – SDS	362	TWh	IEA WEO 2018 Sustainable Development Scenario
Total renewable electricity capacity of hydro, wind, and solar Africa (2030) - NPS	146	GW	IEA WEO 2018 New Policies Scenario
CO_2 emission factor coal-fired electricity in Africa (2030) - NPS	0.97	tCO_2 / MWh	
CO_2 emission factor gas-fired electricity in Africa (2030) - NPS	0.40	tCO_2 / MWh	
Total Africa renewable electricity generation from hydro, wind, and solar (2030) – NPS	439	TWh	

3.4.3

3.4.4 Global Geothermal Alliance

3.4.4.1 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 aspirational 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.[10] As of June 2019, GGA has 46-member countries and 37 partner organizations that range from development banks to academic organizations.

3.4.4.2 Quantification

The current national policies projections for geothermal capacity for electricity generation was taken for the years 2016, 2020 and 2030 from the IEA WEO 2018 CPS (and NPS 2018 for the NDC scenario). Base year global average capacity factors for geothermal electricity generation were calculated from (IEA, 2017) while global geothermal thermal heat capacity and average capacity factors are from (Lund and Boyd, 2015). These capacity factors are assumed to not significantly deviate by 2030. Electricity generation capacity and emission values for 2020 under CPS/NPS were approximated by linearly interpolating from present values to 2025 from IEA WEO 2018's CPS/NPS while 2030 values were provided directly. Global thermal heat capacity estimates for 2020 was provided by (IEA, 2011a) while 2030 values were estimated by applying the growth factor trends of the global final energy consumption of "other renewables" in WEO 2018. Additional geothermal capacity in GW was then calculated by the difference between the targets set under GGA for both 2020 and 2030 and the expected counterfactual scenario. Renewable electricity generation and heating values are then calculated using respective capacity and load factors. The expected share of GGA's additional geothermal capacity installations were allocated to countries based on their expected growth of geothermal capacity in 2020 and 2030 following IEA WEO 2018.

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 IEA WEO 2018 data. We define the upper and lower bound effects for additional geothermal generation as the replacement of coal and gas for both electricity and heating due to global trends in industry and buildings, although we recognize in some cases oil may be a more appropriate substitute for heating than coal. 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 is unlikely to have a significant impact on our aggregated results and is captured within the uncertainty range. The emissions savings from GGA resulting from displacing fossil fuel energy sources are then compared to both the current national policies (CPS) and NDC scenarios (NPS).

Table 8: Parameter descriptions, values, units and sources used in the quantification of GGA

Description	Value	Unit	Source
Global average capacity factor for direct-use geothermal heating (2014)	0.265	Dimensionless	Lund and Boyd (2015)
Global average capacity factor for geothermal electricity generation (2017)	0.72	Dimensionless	IEA Geothermal Power Statistics 2017
Total geothermal power capacity (2030) - CPS	26	GW	IEA WEO 2018 CPS
CO_2 emission factor coal-fired electricity (2030) - CPS	0.95	tCO_2 / MWh	
CO_2 emission factor gas-fired electricity (2030) - CPS	0.44	tCO_2 / MWh	
Total geothermal heat capacity (2030) - CPS	144	GW	Geothermal Roadmap
Total geothermal power capacity (2030) - CPS	29	GW	IEA WEO 2018 NPS

[10] http://www.globalgeothermalalliance.org/

CO_2 emission factor coal-fired electricity (2030) - CPS	0.95	tCO_2 / MWh	
CO_2 emission factor gas-fired electricity (2030) - CPS	0.45	tCO_2 / MWh	

3.4.5 Results

Table 9 – Global emission reduction potential of renewable energy ICIs

Initiative	2030 impact
AREI	320 – 800 $MtCO_2e$
Global Geothermal Alliance	220 – 470 $MtCO_2e$
ETIP PV	210 – 480 $MtCO_2e$

3.5 Industry and Business

3.5.1 RE100

3.5.1.1 Description

RE100 is an initiative of companies, with 189 members as of July 2019 that have committed to source 100% of their electricity from renewable sources by a certain individual target year and has overarching internal initiative goals of securing 1,000 member companies by 2020 and 3,000 by 2030. The work of RE100 is supported by a Steering Committee and a Technical Advisory Group.

3.5.1.2 Quantification

Our quantification of the impact of RE100 built upon general information provided in the Progress and Insights Report January 2018 (The Climate Group, 2018) and on company-specific data provided by CDP surveys from 2018. From this, we retrieved total electricity consumption and RE 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 previous internal interviews from the CDP/We Mean Business report (CDP and We Mean Business, 2016). We assumed that companies reach their RE targets linearly over time from their reporting year and target year, and that their total electricity and renewables consumption grows at the same rate as projected for global electricity generation in the IEA WEO 2018 CPS (or as in the corresponding NPS for the NDC scenario). All companies without defined RE targets were assumed to have a target of 100% renewable, since they are signatories of RE100. Companies without defined target years were conservatively assumed achieve the renewable target in 2050, while companies who have not achieved their target by the reporting year were conservatively assumed to reach their target by 2030.

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 in 2018 and scaled this up for all membership targets. We approximated the RE consumption for the 1,000 and 3,000 companies' by assuming them to be equal to the average RE consumption for the current membership group, projected for 2020 and 2030. Due to additional company sign-ups in between the data recording and time of assessment, we assumed that additional sign-ups have the same average total electricity and RE consumption as the members in the dataset.

By comparing the RE consumption of each company with targeted membership in 2020 and 2030 and the consumption recorded by the 2018 members, 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 assuming the additional RE consumption displaces fossil fuel sources. 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 calculated from the WEO 2018 CPS/NPS.

For 2020 and 2030, we 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. We have estimated approximately an additional 40 TWh consumed from renewable sources by RE100 countries in 2020 and 150 TWh consumed in 2030.

3.5.2 Science Based Targets Initiative

3.5.2.1 Description

The Science-Based Targets initiative (SBTi) is a collaboration between CDP, World Resources Institute (WRI), the Worldwide Fund for Nature (WWF), and the United Nations Global Compact (UNGC) and is 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 °C and pursue efforts to limit global warming to 1.5 °C, compared to pre-industrial temperatures. 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. SBTi aims to have 2,000 signatory companies committing science-based emissions targets by 2030.[11] [12]

3.5.2.2 Quantification

We determined the ‘science-based target’ benchmarks by calculating the target emissions intensity per production unit or activity indicator required per sector in 2050, under a 2°C scenario. These values were taken from the IEA’s ETP (2016), in line with the methodology presented by Krabbe et al. (2015) and the “The Business End of Climate Change” report (CDP and We Mean Business, 2016). Using this method, we calculated the emissions intensity for production in different industries for Scope 1 emissions. We assumed a coverage of 2,000 committed companies by 2030 and used the same current coverage and sign-up rate as CDP and We Mean Business (2016). The annual emission factor for production under SBTi conditions was based on a linear decrease towards the target intensity, starting in different sign-up years (until 2030) and achieved by 2050. For Scope 2 emissions reductions, we only assumed a reduction of electricity, in order to avoid double counting with decarbonization of the electricity generation. For emissions from purchased or acquired electricity, steam, heat, and cooling (scope 2 emissions), the decarbonisation targets were recalculated with baseline electricity CO_2 emission factors to avoid double counting of emissions reductions in the power sector.

All production activity not committed to SBTi followed a business as usual scenario (i.e. ETP 2016’s 6°C scenario), which we took as our current national policies scenario (ETP 2016’s 4°C scenario is used for our NDC scenario). The aggregate of the emissions under SBTi conditions and non-committed companies resulted in the total emissions under SBTi. To determine the emissions reduction potential compared to current national policies and NDC scenarios, we then compared the emissions of the SBTi scenario to the respective counterfactual scenarios.

[11] https://sciencebasedtargets.org/what-is-a-science-based-target/
[12] https://sciencebasedtargets.org/about-the-science-based-targets-initiative/

3.5.3 Results

Table 10 – Global emission reduction potential of Buildings ICIs compared to CPS

Initiative	2030 impact
RE100	1,880 – 4,030 $MtCO_2e$
SBTi	2,710 $MtCO_2e$

3.6 Forestry

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

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 (Goal 5 of ten Goals under NYDF). 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[13].

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 catalyse and reinforce a network of diverse examples of restoration of degraded and deforested lands that delivers benefits to local communities and to nature.[14]

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

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 (Goal 1), i.e. to halve the rate of forest loss by 2020 and completely end forest loss by 2030.

3.6.3 Quantification

In the 2019 analysis we quantified the NYDF's Goals 1 on deforestation and Goal 5 on restoration for 2030. For deforestation, the NYDF has a more ambitious deforestation target than the GCF Task Force.

The Goal 1 of the NYDF does not specify whether the aim is to reduce and then end gross or net loss of natural forests (New York Declaration on Forests, 2018); in other words it is not clear if Goal 1 takes natural forest regeneration and reforestation, which is part of Goal 5, into account. Therefore, we took the following approach that combines both Goals 1 and 5:

1) For the ten countries assessed, countries with positive net GHG emissions from land use, land-use change and forestry (LULUCF) would reach zero in 2030. For countries with negative GHG emissions already today and also projected for 2030 under current policies, we assume no additional reductions beyond current policies scenario projections.
2) For the rest of the world (ROW), total LULUCF GHG emissions would reach zero in 2030. This is based on an assumption that most ROW countries have positive LULUCF emissions in 2030

[13] https://nydfglobalplatform.org/endorsers/

[14] http://www.bonnchallenge.org/

(or in other words, most countries with negative LULUCF emissions are among the ten analysed in the project).

To ensure consistency between the global LULUCF emissions projections and the LULUCF projections from Kuramochi et al. (2018) used for country-specific scenario projections, we replaced global LULUCF emissions in the Climate Action Tracker and PBL IMAGE with business-as-usual (BAU) projections in Forsell et al. (2016), which uses a similar set of models as with the projections in Kuramochi et al. (Kuramochi *et al.*, 2018) with some adaptations described below:

1) emissions projections for the countries presented in Table 3 of Forsell et al. were replaced by current policies scenario projections from Kuramochi et al. (2018) whenever available. As a result, the 2010 emissions were estimated to be about 2.5 $GtCO_2e$/year, which is about 0.5 $GtCO_2e$/year in BAU scenario of Forsell et al. Part of the 0.5 $GtCO_2e$/year difference is attributable emissions from peat fires in Indonesia, which is excluded in Kuramochi et al. projections but included in Forsell et al. We did not account for the differences in global warming potential (GWP) values due to a rather large uncertainty of LULUCF emissions overall.
2) 2015 historical emissions were estimated to be about 2.8$GtCO_2e$/year by taking the average of upper and lower estimates based on the first step described above.
3) For NDC scenario, we use Forsell et al. projections without adaptation for years after 2015.

On historical GHG emissions from LULUCF, Kuramochi et al. (2018) primarily used data from national GHG inventories submitted to the UNFCCC whereas Forsell et al. (2016) used data from Food and Agriculture Organisation (FAO); Nicklas Forsell indicated that the LULUCF GHG data from national GHG inventories and FAO are in good agreement and thus comparable for most countries (Forsell, 2019).

3.6.4 Results

Table 11 – Global emission reduction potential of Forestry ICIs compared to CPS

Initiative	2030 impact
Bonn Challenge & GCF Task Force (NYDF)	5,380 – 5,620 $MtCO_2e$

3.7 Non-CO_2 GHGs

3.7.1 Climate and Clean Air Coalition

3.7.1.1 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).[15] 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 and WMO, 2011). There are currently 65 state partners involved in CCAC.

3.7.1.2 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.

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

3.7.1.3 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). This is equivalent to a reduction target of 26% in 2030, compared to the 2005 level, which we assume is reached linearly over time, starting from 2015. The impact of this initiative is calculated for the current 65 state partners only. Global historical and projected CH_4 emission data were retrieved from the EPA database (U.S. EPA, 2012), while the country-specific CH_4 emissions breakdown is taken from EDGAR (Janssens-Maenhout *et al.*, 2017). EPA non-CO_2 projections were used as the baseline (Current national policies scenario) for future CH4 emission development (Ibid). The baseline scenario for the NDC scenario (as sensitivity analysis) is proxied using the same EPA projections and the % difference between global CO_2 projections from IEA WEO 2018's CPS and NPS scenario, due to lack of data availability.

Country-specific CH_4 emissions are assumed to grow at the same rate as the global average. The CCAC target then translates to a CH_4 emission level of 8.2 $GtCO_2e$ in 2030, which includes a 1.2 $GtCO_2e$ reduction in CH_4 from the 65 state partners, compared to the current national policies scenario in 2030 (and a 0.4 $GtCO_2e$ reduction in CH_4 in 2030 compared to the NDC scenario). The emissions reduction impact is split across the 10 high-emitting regions of this analysis according to their share of total aggregated methane emissions covered under CCAC.

3.7.1.4 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 and PBL, 2014) databases, and future growth rates are based on the reference scenario reported in U.S. EPA (2012). The HFC emissions 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 overestimate of around 10%. We estimated a global reduction potential of 360 $MtCO_2e$/year by 2030 compared to the Current National Policies scenario. The emissions reduction from HFCs is calculated for all countries as we assume that all the parties adopting the amendment in 2016 will also eventually ratify them.

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.

3.7.2 Results

Table 12 – Global emission reduction potential of Non-CO_2 ICIs compared to CPS

Initiative	2030 impact
CCAC	1,410 $MtCO_2e$

3.8 Cities and Regions

3.8.1 C40 Cities Climate Leadership Group

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"[18]. 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"[16] and 2) to have cities achieve emissions neutrality by 2050[17].

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 $GtCO_2e$/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.[18]

3.8.2 Under2 Coalition

The Under2 Coalition, is an initiative that brings together subnational governments committed to ambitious climate action keeping global temperature rises to well below 2°C. The coalition is made up of 220 governments as of September 2019, representing 1.3 billion people and 43% of the global economy.[19] Each signatory of the initiative 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. The initiative supports governments to develop long term decarbonization pathways, scale and share best climate policy practices, and to track and maintain their emissions inventories. The Climate Group is the Secretariat to the Under2 Coalition.

3.8.3 Global Covenant of Mayors (GCoM)

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 7,600 local and regional authorities voluntarily committing to meet and exceed the EU 20% CO_2 reduction objective through energy efficiency and RE, 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 pledge to communicate these transparently to their citizens, and then develop inventories and climate action plans to achieve their goals.[20]

[16] https://resourcecentre.c40.org/join-deadline-2020
[17] https://resourcecentre.c40.org/climate-action-planning-framework-home
[18] https://www.c40.org/about
[19] https://www.under2coalition.org/about
[20] https://www.globalcovenantofmayors.org/participate/

3.8.4 Quantification

The quantification of all three cities and regions initiatives – C40, Under2 Coalition, and Global Covenant of Mayors (GCoM) consists of three general steps: 1) we formed an emissions baseline for each city and region by aggregating the emissions coverage from actors listed per initiative and calculating their emissions trajectory; 2) we constructed a policy scenario by scaling up actors' commitments to the initiative's goals, whether it be based on increasing ambition or increasing membership; and 3) we compared these aggregated emissions reduction impacts in the policy scenario with the counterfactual current national policies or NDC scenario, and distribute the impacts to each country.

Establishing emission trajectories

In the first step, we calculate the cities and regions' emission trajectories, choosing 2015 as the starting point of analysis, based on historical inventory data and quantifiable emissions reduction targets, depending on data reported by individual actors. This is the same methodology reported in Technical Annex I for subnational actors.

- Tier 1: if inventory year and inventory emissions are both available, we interpolate between the latest inventory emissions reported and the target year emissions, assuming a constant rate of decrease.
- Tier 2: if inventory emissions are known but not inventory year, we assume that inventory year is 2010, and apply the same interpolation as Tier 1 (the average year of last inventories was 2013; we assumed an earlier year of 2010 in order to not overestimate the emissions reductions for 2015 and consequently the emissions reductions between 2015 and 2030).
- Tier 3: for cases with no inventory emissions or inventory year, we base our interpolations on base year emissions and base year.

For cities that only report one target year, we assume a constant rate of reduction until the target year, after which we assume emissions have the same trend as the current policies scenario. For cities that have multiple targets, we interpolate from either the inventory or baseline emissions, whichever is available, up to the first target year (i.e., 2030). If a longer-term target (i.e., 2050) is available, we interpolate from the first target year (i.e., 2030) to the second target year (i.e., 2050) by assuming different rates of reduction between the target years.

Because of the nature of China's Alliance of Pioneer Peaking Cities' peak emissions year targets, we had to calculate the emissions reductions differently. We extrapolated emissions from 2012 until 2030, assuming the rate of change in emissions is identical to the rate of change in population. The population projection time series data is obtained from UN Populations Division, World Urbanization Prospects: The 2014 Revision (UN DESA, 2014). For two Chinese cities (Nanping and Jinchang) and two provinces (Sichuan and Hainan) that did not have population projections available, we used national level emissions growth rates based on the TIMER BAU model to extrapolate future emissions pathway.

For subnational actors that report inventory-year emissions that are lower than the estimated target-year emissions, we assume that these actors have achieved their target emissions reductions in the inventory year and then assume a constant emissions level after the inventory year (i.e., no additional reductions are assumed).

Subnational actors that report GHG emissions higher than 40 or lower than 0.2 tCO_2e/capita were removed from the dataset.

Estimating impact of ICIs

We then construct two types of scenarios: 1) a counterfactual current national policies scenario and NDC scenario, where actors follow the emissions growth rate of their country's scenarios from 2015 to 2030 using (Kuramochi *et al.*, 2018); 2) an "initiatives' goals" scenario where cities and regions reach the initiative's overarching goal, assuming that this is reached linearly from 2015.

For C40, the initiative's goal is to have all current members achieve carbon neutrality by 2050; for Under2Coalition, the initiative's goal is 80-95% under 1990 emission levels by 2050 for all members; for GCoM, it is to have quantifiable and concrete emissions reduction commitments for all current participating members. We present the "initiatives' goals" scenario as the quantified impact of the initiative and leave out calculations for the cities and regions' current climate commitments, as this is quantified in our individual commitments' analysis (see Technical Annex 1). All overarching targets are assumed to be reached linearly for convenience, since the report only presents 2030 results. Our dataset records emissions data for 51 C40 cities, 81 Under2 Coalition governments, and about 5,900 GCoM cities.

C40

For C40 cities with missing emissions data in our dataset (~25% of C40's emissions coverage, 67% of which lie outside our 10 high emitting regions of analysis), we calculate the amount of unrepresented emissions in the initiative's 2.4 $GtCO_2e$ coverage[21] and distribute the unrepresented emissions to the cities without emissions data, based on the cities' population shares. We assumed that the cities without emissions data have similar emissions per capita; while this is not entirely accurate, the bulk majority (67%) of the unrepresented emissions lie outside our 10 high emitting regions of analysis and are not country specific. Thus, the estimation of missing C40 cities emissions and distribution to countries have minimal effects on country emissions reduction impacts. We then aggregated the estimated emissions with the calculated 2015 emissions in our dataset to estimate base year emissions for the entire 94 C40 cities. The cities' emissions trajectories under the initiatives' goals scenario are then calculated by reducing base year emissions to zero by 2050 and the results are aggregated to the country level.

Under2 Coalition

For Under2 Coalition regions with missing emissions data in our dataset, we assume that the amount of missing Under2 Coalition emissions is equivalent to the amount of missing population, which equates to ~60% of the initiatives' emissions coverage, 49% of which lie outside our 10 high emitting regions of analysis. We estimate the emissions for the missing regions by converting the unrepresented population into emissions by assuming they have the same per capita emissions intensity as their country for the base year 2015. In Mexico's case, we assume that not more than 80% of Mexico's population will be covered by the initiatives' goals as there is already high coverage rate from the ICI in-country. Thus, we aggregate the estimated emissions with the calculated 2015 emissions in our dataset to estimate base year emissions for the entire 220 Under2 Coalition regions and governments.

Next, we construct the participating regions' 1990 historical emission levels based on their countries' per capita emissions intensities, with population data from the World Bank (World Bank, 2019) and emissions data from (Kuramochi *et al.*, 2018) and establish the minimum (80% decrease) and maximum (95% decrease) bounds for emissions reduction, based on the initiatives' goals. Regions in the initiative then linearly follow two paths to achieve the minimum and maximum of the initiatives' goals. Emissions reductions are then aggregated to the country level.

Global Covenant of Mayors

For GCoM, we take the initiatives' emission reduction impact calculations per region in 2030[22], which calculates the reductions expected per region. We estimate the impacts at the city level by breaking down the regional impacts based on the population share of GCoM cities within the GCoM region, before aggregating the GCoM cities back to country levels.

We take GCoM's regional impacts as our initiatives' goals scenario, which differs from C40 and Under2 Coalition's goals. While C40 and Under2 Coalition's initiatives' goals calculate the scenario where current membership achieves the overarching ambitious goal, the GCoM quantification method calculates a scenario where current members commit to concrete emission reduction goals that are as ambitious and achieve the same rate of emissions reductions as their neighbouring peers complying

[21] https://www.c40.org/about
[22] https://www.globalcovenantofmayors.org/impact2018/

with all GCoM requirements (Kona *et al.*, 2018). This is equally ambitious yet feasible due to GCoM consisting of over 9,000 city members.

In the last step, after establishing the emissions trajectories of city and region actors and aggregating the emissions reductions for each initiative to the country level, we compare the policy scenarios, or initiatives' goals scenarios, to each country's current national policies and NDC scenarios to calculate the additionality of the initiatives.

Note: throughout the quantification of the cities regions initiatives, we acknowledge that the assumption using a city's population 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 (World Bank, 2011). 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, we have used this simplified approach.

3.8.5 Results

Many cities and regions are represented in more than one of the C40, Under2 Coalition, and Global Covenant of Mayor initiatives. In this case, we quantify only one commitment in the order of higher overarching initiative ambition and more narrow scale of operation. Thus, if a city or region is part of multiple initiatives, it is first attributed to C40, then Under2 Coalition, then GCoM. This is due to our objective to quantify the most ambitious impact of these initiatives that are also realistically achievable. 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 reductions is discussed in Section 0. Table 14 presents all the data sources used in the quantification of cities and regions ICIs.

Table 13 – Global emission reduction potential from Cities/Regions ICIs

Initiative	2030 impact
C40	1490 MtCO_2e
Under2 Coalition	4,620–5,000 MtCO_2e
GCoM	1,440 MtCO_2e

Table 14: Data sources for cities and regions ICIs

Climate Action Platform	Data Source
Alliance of Pioneer Peaking Cities	Alliance of Pioneer Peaking Cities (2016). Accessed from: http://www.huanjing100.com/p-1307.html. Peak emissions years were used in the calculation of the cities' projected carbon emissions.
C40 Cities for Climate Leadership Group	C40 Cities for Climate Leadership. Accessed June 2019 from: https://www.c40.org/cities.
ICLEI Local Governments for Sustainability carbonn® Climate Registry	ICLEI Local Governments for Sustainability carbon*n*® Climate Registry (www.carbonn.org). (Data provided directly by ICLEI in June 2019). Individual targets and action plans for carbonn participants based on 2018 GPC Inventory responses. In cases where baseline information for participating actors was absent, it was supplemented with baseline information from data collected from carbon*n*'s reporting members (individual targets, action plans, and progress data) in March 2018.
CDP Cities	CDP. (2019). 2018 Cities Emissions Reduction Targets; 2018_Cities Community-wide Emissions Map; 2018 Cities Renewable Energy Targets Map.csv; 2018 City-wide Electricity_Mix. Accessed May 2019 from: www.data.cdp.net.
CDP 2018 Disclosure Survey	CDP. (Provided directly from CDP in July 2019). *GHG emissions and action data for companies based on the 2018 responses*.
Compact of States and Regions	Compact of States and Regions. (Data provided directly by the Compact of States and Regions in February 2019). 2018 States and Regions Open Portal Dataset collected via CDP States and Regions 2018 Information Request.
EU Covenant of Mayors for Climate & Energy	EU Covenant of Mayors for Climate & Energy. Individual targets and emissions data for reporting members. Accessed April 2019 from: www.globalcovenantofmayors.org.
Under2 Coalition	Under2 Coalition (Secretariat the Climate Group). Membership and action data collected from signatories' appendices. Accessed June 2019 from: https://www.under2coalition.org/members.
Global Covenant of Mayors for Climate & Energy	Global Covenant of Mayors for Climate & Energy. (Data provided directly by Global Covenant of Mayors in June 2019). Individual targets and emissions data for reporting members.
US Climate Alliance	U.S. Climate Alliance. Accessed July 2019 from: https://www.usclimatealliance.org/state-climate-energy-policies. Information from this source was supplemented through desk research of participants' climate action targets or plans.
US Climate Mayors	US Climate Mayors. Accessed July 2019 from: www.climatemayors.org and http://climatemayors.org/actions/climate-action-compendium/. Information from this source was supplemented through desk research of participants' climate action targets or plans.

4 Quantification of overlaps between ICIs

4.1 Approach

After calculating the emission reduction potential relative to a baseline scenario (i.e. current national policies scenario or NDC scenario) for each initiative, possible overlaps among initiatives were analysed within each country and on a global scale. Overlap occurs when the calculated emissions reduction potential of two or more initiatives are not (entirely) additional to one another (Hsu *et al.*, 2018).

For each of the ten major emitting economies as well as RoW, we first developed an overlap matrix (Figure 2) to identify potential overlaps between any two of the 17 initiatives assessed in this study. In the matrix, 'y' stands for 'yes' (there is overlap) and 'n' for 'no' (there is no overlap). We based this categorisation on whether one or more of the four types of overlap were evident and/or whether an ICI possibly reduces the potential impact of another ICI without it being accounted for in its initial quantification. The ICIs in the horizontal axis were compared to the ICIs in the vertical axis.

The impact of climate initiatives can overlap in various ways. We identified four different types of overlap: 1) geographic overlap (e.g. cities with commitments within regions with commitments), 2) targeted emissions overlap (e.g. two initiatives targeting emissions from freight transport), 3) membership overlap (e.g. a company committed to more than one initiative) and 4) non-sector overlap (in case an initiative does not target a specific sector it is potentially overlapping with sector-specific initiatives) (Hsu *et al.*, 2018; NewClimate Institute *et al.*, 2018).

Based on the overlap matrix, we quantified the overlap rates between initiatives. An overlap rate is defined as the percentage of GHG emissions reduction impact for an initiative that is overlapping with another initiative. To avoid double counting of overlaps, only overlaps between an initiative and all preceding initiatives in the list were considered (*e.g.* for initiative no.10 on the list, overlaps with initiatives no.1 through no.9 were quantified). The emission source overlap was the main indicator for overlap estimation; the overlap rates were quantified based on the energy balances data, GHG emissions data and/or sector-specific production data in the modelling base year (2013–2016, depending on the initiative). We also examined if there was a noticeable difference in ambition levels across initiatives to account for potential additional impact of an initiative even when the emissions coverage is fully overlapping with another initiative. Since all initiatives are unique one way or another in terms of their geographic, sector and emissions scope as well as their mid- to long-term target definitions, several initiative-specific assumptions were made; some examples are described in the technical annex II of the 2018 report (Data-Driven Yale, NewClimate Institute and PBL, 2018a).

Figure 2 Overlap matrix for identifying overlaps between ICIs (source: authors' elaboration)

			Energy efficiency		Buildings	Transport			Renewable energy			Businesses		Forestry		non-CO2 GHGs	Cities and regions		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			Super-efficient equipment and appliance deployment initiative	United for Efficiency	Architecture 2030	Collaborative Climate Action Across the Air Transport World	Global fuel economy initiative	Lean and Green	European Technology & Innovation Platform PhotoVoltaic	Africa Renewable Energy Initiative	Global Geothermal Alliance	RE100	Science Based Targets initiative	NYDF/Bonn Challenge	NYDF/Governors' Climate and Forest Task Force	Climate and Clean Air Coalition (Main)	Under 2 MOU = Under 2 Coalition	Global Covenant of Mayors for Climate & Energy	C40 Cities Climate Leadership Group
Energy efficiency	1	Super-efficient equipment and appliance deployment initiative		y	n	n	n	n	y	n	y	y	y	n	n	y	y	y	y
	2	United for Efficiency			n	n	n	n	n	y	y	y	n	n	n	y	y	y	y
Buildings	3	Architecture 2030				n	n	n	n	n	y	n	n	n	n	y	y	y	y
Transport	4	Collaborative Climate Action Across the Air Transport World					n	n	n	n	n	n	n	n	n	y	y	y	y
	5	Global fuel economy initiative						n	n	n	n	n	y	n	n	y	y	y	y
	6	Lean and Green							n	n	n	n	n	n	n	y	y	y	y
Renewable energy	7	European Technology & Innovation Platform PhotoVoltaic								n	y	y	n	n	n	y	y	y	y
	8	Africa Renewable Energy Initiative									n	n	n	n	n	y	y	y	y
	9	Global Geothermal Alliance										y	n	n	n	y	y	y	y
Businesses	10	RE100											n	n	n	y	y	y	y
	11	Science Based Targets initiative												n	n	y	y	y	y
Forestry	12	NYDF/Bonn Challenge													n	y	y	n	n
	13	NYDF/Governors' Climate and Forest Task Force														y	y	n	n
non-CO2 GHGs	14	Climate and Clean Air Coalition (Main)															y	y	y
Cities and regions	15	Under 2 MOU = Under 2 Coalition																y	y
	16	Global Covenant of Mayors for Climate & Energy																	y
	17	C40 Cities Climate Leadership Group																	

4.2 Results

In Table 15 and Table 16 the sectoral emission reduction potentials when accounted for overlaps are presented. To obtain these results, only intra-sectoral overlaps were considered.

Table 15 Sectoral emission reduction potentials after correction for overlap calculations, in 2030 ($MtCO_2e$/year)

Countries	Energy efficiency	Buildings	Transport	Renewable Energy
Brazil	31–94	0	8	0–1
Canada	5–12	12	5	1
China	136–309	10–19	30	18–40
EU	114–261	9–17	55	237–535
India	90–170	1–2	4	1–2
Indonesia	19–38	0	33	44–95
Japan	25–55	0	11	12–26
Mexico	19–44	0	46	9–20
South Africa	9–24	0	2	24–65
US	90–202	138–144	28	42–92
Rest of the world	343–680	7–10	334	358–872
World	686–1,321	177–204	1,110	748–1,752

Table 16 Sectoral emission reduction potentials after correction for overlap, in 2030 ($MtCO_2e$/year)

Countries	Business & Industry	Forestry	Non-CO_2 GHGs	Cities & Regions
Brazil	0	362–376	0	244–252
Canada	0	0	44	249–263
China	0	0	0	2,631–2,686
EU	0	0	152	455–524
India	0	0	152	294–294
Indonesia	0	1261–1312	80	370–370
Japan	0	0	11	65–66
Mexico	0	0	30	309–316
South Africa	0	0	0	215–215
US	0	0	304	874–1,038
Rest of the world	0	3,757–3,931	634	1,848–1,912
World	4,595–6,743	5,380–5,618	1407	7,554–7,937

Note: The potential impact of business and industry ICIs were not calculated at a country level.

5 Links between international climate initiatives and SDGs

While the Paris Agreement and Agenda 2030 on Sustainable Development were negotiated under two separate international processes, both these frameworks are interlinked and the failure in one process might undermine the other and vice versa (Iacobuta and Höhne, 2017). Well-designed climate measures that maximize synergies and avoid trade-offs are essential for jointly delivering on sustainability and climate goals.

5.1 SDG Climate Action Nexus Tool (SCAN-tool)

For the identification of potential synergies and trade-offs between the selection of high impact ICIs and the United Nations' SDGs we used Ambition to Action's SDG Climate Action Nexus Tool (SCAN-tool) (Gonzales-Zuñiga *et al.*, 2018b).

The SCAN-tool was developed with the aim of supporting policy makers achieve greater policy coherence and enable the achievability of multiple goals by providing an initial indication of which climate actions may potentially impact – in a positive or negative way – specific SDG targets (Gonzales-Zuñiga *et al.*, 2018a). This tool identifies a total of 982 links between sector-specific mitigation actions (covering seven sectors: electricity and heat, transport, buildings, industry, waste, agriculture, and forestry) and the 17 SDGs. Data in the tool was populated based on several studies on the nexus between climate action and specific development areas. All links are classified as either positive (where the mitigation action is likely to reinforce the SDG target) or negative (where there may be a potential trade-off for the SDG target). The tool does not assess the magnitude of the link. Potential links to SDG 13 (Climate action) and SDG 17 (Partnerships for the SDGs) are not assessed in the tool.

The use of the SCAN-tool for this analysis required some additional assessment steps, as the tool was developed to map specific mitigation actions against SDGs rather than international cooperative initiatives (ICIs). For this we took three main steps, which are described in detail in the next paragraphs.

First, we aligned SCAN-tool mitigation actions to the identified 17 high mitigation ICIs. We did this by creating a matrix of all mitigation actions from SCAN-tool and the ICIs, that was filled using expert knowledge of each individual initiative (see Figure 3; black circles indicate an alignment of the scope between an ICI and a SCAN-tool mitigation action, while white circles indicate no alignment of scope.)

Figure 3. Matrix aligning mitigation actions from SCAN-tool and selected 17 high mitigation potential ICIs. Black circles indicate an alignment of the scope between an ICI and a mitigation action, while white circles indicate no alignment of scope

	Renewable energy: Off-grid	Renewable energy: Bioenergy	Renewable energy: Ocean	Renewable energy: BECCS	Other technologies: CCS	Other technologies: Nuclear	Renewable energy: Large-hydro	Renewable energy: Small-hydro	Renewable energy: Geothermal	Renewable energy: Wind	Renewable energy: Solar PV	Renewable energy: Solar CSP	Power generation efficiency improvement (when using coal, oil, gas)	CHP	Reduction in transmission and distribution losses	Renewable energy: Solar heating	Other technologies: Gas	Fuel switch to low carbon vehicles	Modal share shift	Reducing transport demand	Energy efficiency	Fuel switch away from FF	Urban planning for EE	Improved cookstoves	Changing activity	Non-energy	Sustainable waste management systems	Reduce, Reuse, Recycle	Climate smart agriculture	Sustainable consumption practices	Sustainable forest management	Smart cities and green urban planning (positive land use change)	Carbon and energy pricing interventions	Dedicated financial products and credit	Training programmes	Awareness raising programmes	Innovation / R&D programmes	Institutional capacity building
United for Efficiency	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	○	○	●	○	○	○	○	○	●	●	●	●	●	●	○	●	○
Super-efficient equipment and appliance deployment initaitive (SEAD)	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	○	○	○	○	○	○	○	○	●	●	●	●	●	●	○	●	○
Architecture 2030	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	○	○	●	●	●	●	●	●	○	○	○
Collaborative Climate Action Across the Air Transport World (CAATW)	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	●	●	●	●	●	●	○	●	○
Lean and Green	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	○	○	●	○	○	○	○	○	○	○	●	●	●	●	●	●	○	●	○
Global fuel economy initiative	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	○	●	●	○	○	○	○	○	○	○	●	●	●	●	●	●	○	●	○
ETIP PV	●	○	○	○	○	○	○	○	○	○	●	●	○	○	○	●	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Africa Renewable Energy Initiative	●	○	○	○	○	○	●	●	●	●	●	●	○	○	○	●	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Global Geothermal Alliance	●	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
RE100	●	○	○	○	○	○	○	○	●	●	●	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○
Science Based Targets initiative	○	○	○	○	●	○	○	○	○	○	○	○	●	●	○	○	●	○	○	○	●	●	○	○	●	●	○	●	○	○	○	○	○	○	●	●	●	●
NYDF / Bonn Challenge	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	●	○	○	○	○	○	○	○
NYDF / Governors' Climate and Forest Task Force	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	●	○	○	○	○	○	○	○
CCAC: Climate and Clean Air Coalition (Main)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	●	○	●	●	○	●	○	○	○	○	○	○	○	○	○
Under 2 MOU = Under 2 Coalition	○	○	○	○	○	○	○	○	○	●	●	○	●	○	●	○	●	●	●	●	○	●	●	○	○	○	○	○	○	●	○	●	○	●	○	○	●	●
Global Covenant of Mayors for Climate & Energy (GCoM)	○	○	○	○	○	○	○	○	○	○	●	○	●	●	●	○	●	●	●	●	○	●	●	○	○	○	●	○	○	●	○	●	○	●	○	○	●	●
C40 Cities Climate Leadership Group (C40)	○	○	○	○	○	○	○	○	○	○	●	○	●	●	●	○	●	●	●	●	○	●	●	○	○	○	●	○	○	●	○	●	○	●	○	○	●	●

Second, we manually removed potential trade-offs to the following mitigation actions and sub-actions, as we considered these mitigation actions not to be in focus of the selected climate initiatives:

- "Renewable energy: bioenergy" when emissions increase due to use of non-sustainable feedstocks.
- "Fuel switch away from fossil fuels" where biomass is meant to replace fossil fuels in buildings and industry (SDGs 3,6,11,12, and15);
- "Other technologies: gas", were:
    - switching from coal to gas is considered as trade-off due to its contribution to GHG emissions (SDGs 3 and 11) or where
    - the switch is meant to pose a threat to the lock-in of conventional technologies (SDG 9);
- "Sustainable waste management", "Sustainable forest management", and "Reduce, reuse, recycle", where the formalisation of the respective sector poses a threat to informal jobs (SDG1); and
- "Fuel switch to low carbon vehicles" where:
    - biofuels were meant to replace fossil fuels (SDGs 2, 3, 6, 11 and 15), as switching to biofuels is not a strategy in focus of the selected climate initiatives,
    - the risk of death is increased form EVs because they are quieter than conventional vehicles (SDG 11), or
    - energy reliability is reduced due to switch to EVs (SDG 7).

Third, we manually assigned positive links to SDGs 13 and SDG17. While SCAN-tool does not provide links to SDG13 (climate action) and SDG17 (partnership for the SDGs), we recognize that these links are implicitly represented in all climate initiatives.

While the SCAN-tool provides a specific number of synergies and a specific number of trade-offs between SDGs and mitigation actions classified in different sectors, our analysis does not indicate the magnitude for the identified links. In our analysis, we show three possible categories: 1) "no links" (in grey); 2) "existence of only synergies" (in green, and 3) "existence of synergies and potential trade-offs" (both potential positive and negative links, in yellow) (see Figure 18 in the main report). The third category is assigned irrespective to the number of potential trade-offs identified; in other words, yellow is assigned when at least one potential trade-off is identified. Unlike the SCAN-tool, our analysis did not include the number of individual links (positive and/or negative) but only provided an indication of their existence based on the alignment of mitigation actions.

5.2 Explicit links between international climate initiatives and SDGs

Explicit links between international climate initiatives and SDGs, were based on methodology used for the ClimateSourth project can be found (see ClimateSouth, 2018).

The ClimateSouth Project is a collaboration between The German Development Institute/Deutsches Institut für Entwicklungspolitik (DIE), Blavatnik School of Government at the University of Oxford, The Energy and Resources Institute, and the African Center for Technology Studies.

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Glossary

Cities: Local governments that are administrative units of a specific geographical territory. For the purposes of this report, the term "cities" includes towns, urban communities, districts, and counties, as defined by the actors themselves and often also defined in the country's legal system.

Climate action by subnational and non-state actors: Any kind of activity that is directly or indirectly aimed at reducing GHG emissions or driving climate change 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): Multi-stakeholder arrangement through which subnational and non-state actors (e.g. cities, regions, businesses, NGOs, etc.) cooperate across border to mitigate or adapt to climate change, often in partnership with national governments or international organizations.

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

Quantifiable commitments to reduce greenhouse gas emissions**:** For the purposes of this report, quantifiable commitments typically include a specific emissions reduction goal, target year, and baseline year (e.g., a goal to reduce emissions by 20% compared to 2000 levels by 2020). In addition, calculating these targets' mitigation impact requires baseline year emissions. (See Technical Annex I for more details on how emissions reductions commitments are selected and quantified).

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.

Regions: Subnational 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" in this report includes US and Indian states, German Länder, and Chinese provinces. 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, sub-national states, provinces and regions.