Addressing Overlaps in Non-State and Subnational Climate Action Aggregation Analyses

Bridging the gap, or counting chickens before they hatch?

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"Ideas are contagious, emotions are contagious, hope is contagious, courage is contagious. When we embody those qualities, or their opposites, we convey them to others." - Rebecca Solnit

Abstract

Non-state and subnational climate action (NSA) has great potential for bridging the emissions gap, but aggregating its potential impacts is challenging. This Master's thesis presents one of the aggregation challenges – addressing overlap between actions. Although overlaps lead to reinforcements in practice by, for example, technological learning and awareness raising, they lead to overestimates and double counting in ex-ante aggregation analyses when not properly accounted for. Therefore, an analytical framework for addressing overlaps between initiatives is presented in this thesis, based on seven good practices and a review of ten aggregation analyses (Figure I).

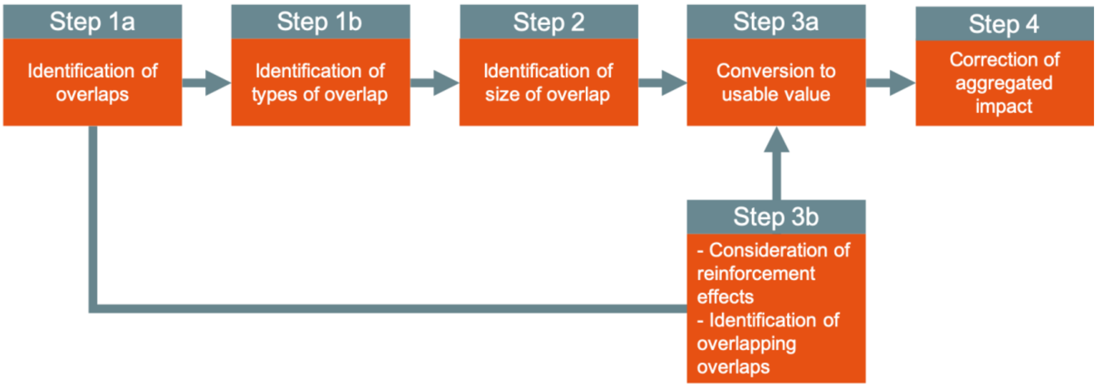

Figure I: Analytical framework for addressing overlaps between initiatives in NSA aggregation analyses.

First, overlaps need to be identified and categorised. Second, the size of overlaps needs to be determined. Third, the overlap needs to be quantified and finally, this value needs to be used to correct the sum of the potential impacts. This analytical framework was used to correct the summed greenhouse gas (GHG) emission reduction potentials (ERP) of seventeen key transnational emission reduction initiatives (TERIs) for overlaps between initiatives. Full realization of the ambitious targets was assumed which led to a global sum of ERPs of 20.4 – 27.2 $GtCO_2e$/year in 2030, compared to a current policies scenario. After factoring in overlaps between TERIs, the global aggregate of ERPs was estimated at 17.6 – 20.7 $GtCO_2e$/year in 2030. Hence, accounting for overlaps led to a reduction of roughly 13-23% of the summed potential impacts. Although the aggregate of ERPs is still substantial, this major difference illustrates the importance of addressing overlaps in ex-ante aggregation analyses. The thesis finds that the analytical framework is a useful and suitable method to refine overlap calculations, but several possible improvements are underlined. The presented analytical framework can therefore be seen as a first step towards more extensive overlap calculations. Moreover, the calculated aggregate of ERPs is substantial and showcases the possible level of ambition for national policies. In sum, the aggregation analysis demonstrates that exemplary NSA ambitions can bridge the emissions gap, but chickens should not be counted before they hatch.

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Acronyms and abbreviations

Acronym or abbreviation	Meaning
°C	Degrees Celsius
A2030	Architecture 2030
ADP	Durban Platform of Enhanced Action
AREI	Africa Renewable Energy Initiative
C40	C40 Cities Climate Leadership Group
CCAATW	Collaborative Climate Action across the Air Transport World
CCAC	Climate and Clean Air Coalition
CDP	Carbon Disclosure Project
CERP	Corrected Emission Reduction Potential
CH4	Methane
CIP	Climate Initiatives Platform
CO_2	Carbon dioxide
CO2e	CO2 equivalent
COP	Conference of the Parties
CPS	Current Policies Scenario
DDL	Data Driven Lab, Yale
EE	Energy efficiency
ERP	Emission reduction potential
ETIP PV	European Technology & Innovation Platform Photovoltaic
EU	European Union
FOF	Function output fit
FOR	Final overlap rate
GCFTF	Governors' Climate and Forest Task Force
GCOM	Global Covenant of Mayors for Climate & Energy
GFEI	Global Fuel Economy Initiative
GGA	Global Geothermal Alliance
GHG	Greenhouse gas
GP	Good practice
Gt	Gigatons
HFC	hydrofluorocarbons
IAM	Integrated assessment model
ICI	international cooperative initiative
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
L&G	Lean and Green
LPAA	Lima Paris Action Agenda
LULUCF	Land-use and land-use change and forestry
NAZCA	Non-State Actor Zone for Climate Action
NCI	NewClimate Institute

NDC	Nationally determined contributions
NPS	New Policies Scenario (World Energy Outlook)
NSA	Subnational and non-state action
NYDF	New York Declaration on Forests
NYDF	New York declaration on forests
OR	Overlap rate
PA	Paris Agreement
PBL	Netherlands Environmental Assessment Agency (*Planbureau voor de Leefomgeving*, in Dutch)
QO	Quantified overlap
R&D	Research and development
RE	Renewable energy
SBTi	Science based targets initiative
SBTI	Science Based Targets Initiative
SD	Sustainable Development
SEAD	Super-efficient Equipment and Appliance Deployment Initiative
SEII	Solar Europe Industry Initiative
SLCP	Short-lived climate pollutant
TERI	Transnational emission reduction initiative
TOR	Total overlap rate
TQO	Total quantified overlap
U4E	United for Efficiency
UN	United Nations
Under2	Under2MOU
UNFCCC	United Nations Framework Convention on Climate Change
US	United States (of America)
USD	US Dollars
WEO	World Energy Outlook
WWF	Worldwide fund for nature

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1 Introduction

1.1 Background

On December 12, 2015, a historic climate agreement was reached during the 21st Conference of Parties (COP) in Paris, commonly known as the Paris Agreement (PA). In the light of the global climate crisis and its related threats, the aim of the PA is to keep "a global temperature rise well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius" (United Nations, 2015). In addition, the PA is focused on increased adaptation to climate change and finance flows that are consistent with a low-carbon pathway (United Nations, 2015). To this date[1], 187 countries have ratified the PA (UNFCCC, 2019). During the same COP, the Intergovernmental Panel on Climate Change (IPCC) was asked to develop a special report on the impacts of global warming of 2 and 1.5 degrees Celsius (°C). The resulting IPCC special report lists numerous effects of climate change that are likely to get more severe with global warming of 2°C, compared to 1.5°C (IPCC et al., 2018). These include temperature extremes, droughts, heavy precipitation episodes, biodiversity loss, sea level rise, decreased food security and economic drawbacks (IPCC, 2018).

Despite global appraisal of the PA and the risks related to insufficient mitigation, the countries' pledges to fight climate change under the PA, as described in the nationally determined contributions (NDCs), are insufficient to meet the target of maximum of 2°C temperature increase, let alone a maximum of 1.5°C. The so-called *emissions gap* between the greenhouse gas (GHG) emissions under realization of unconditional NDCs and emissions in line with the 2°C target are estimated to be 12-18 Gigatons of CO_2 equivalents ($GtCO_2e$) in 2030. Moreover, the gap between GHG emissions under implementation of unconditional NDCs scenario and the 1.5°C pathway is estimated to be 29-35 $GtCO_2e$ in 2030 (United Nations Environment Programme, 2019), which equals roughly five times the GHG emissions of the United States (US) (Climate Action Tracker, 2019).

Nonetheless, climate initiatives from cities, regions, businesses and international organizations have emerged in the last couple of years. Initiatives from these *non-Party stakeholders* are referred to as *non-state and subnational action* (NSA), depicting their involvement in the United Nations Framework Convention on Climate Change (UNFCCC), while not being a sovereign state. Policies arising from sovereign states (i.e. Parties) are called *state action* (Chan, Falkner, et al., 2016; Roelfsema et al., 2018). NSA is referred to as *transnational climate governance* when at least two different countries are involved (Andonova et al., 2017; Hale, 2016). NSA can lead to innovation, raise ambition and generate good practices for climate policy (Chan et al., 2019; Widerberg & Pattberg, 2015). Moreover, several analyses demonstrate that the aggregated potential impact of NSA is large enough to close the 2°C emissions gap (Data Driven Yale et al., 2018; UNEP, 2018). Although action from each company, city or region will only be a "drop in the ocean […] being part of a larger coalition

[1] 29 October 2019

that has the potential to completely bridge the entire emissions gap will make it much more attractive to participate in and take action" (Blok et al., 2012, p. 472).

The number of NSA initiatives has significantly increased since the start of this century and NSA gained a prominent role in global climate governance in 2014 with the launch of the Lima-Paris Action Agenda (LPAA). Two years later, during COP 22 in Marrakech, the Marrakech Partnership for Global Climate Action was presented to "take the Lima-Paris Action Agenda to new heights" and "to look to spur new climate action in areas of untapped potential" (UNFCCC, n.d.). By 2018, the UN recognized 9,000 commitments from cities, representing 16 percent of the global population in 128 countries, and around 240 commitments from subnational states and regions – home to 17 percent of the global population. In addition, more than 6,000 initiatives from companies were identified – of which the combined revenue equals 36 trillion United States Dollars (USD), or, 40 percent of the global GDP (Hale et al., n.d.; United Nations Climate Change Secretariat, 2018).

1.2 Research gap and relevance

As NSA is gaining a more prominent role in the landscape of global climate governance, the number of studies examining it has been increasing (Hale, 2016; Hsu et al., 2019, 2017). Since 2012, an increase in the number of analyses on the emission reduction potential of NSA can be appointed in particular (Hsu et al., 2019). Such *aggregation analyses* are essential to global climate policy as they can showcase good practices, illustrate successful innovations (both technological and political) and present capacities of non-state and subnational actors. Moreover, aggregation analyses show whether the collective climate action and ambition is large enough to bridge the emissions gap and can contribute to enhancing ambition of other policymakers (Hsu et al., 2019).

Past aggregation analyses have shown that NSA can contribute significantly to closing the emissions gap and contribute to 1.5°C pathways (Chan, Falkner, et al., 2016; Data Driven Yale et al., 2018; Graichen et al., 2017; Roelfsema, 2017; Roelfsema et al., 2015; UNEP, 2018). However, the studies vary in applied methods and are often fragmented and incomplete (Hsu et al., 2019). Hence, Hsu et al. (2019) identified five major areas for research and development (R&D) in NSA aggregation studies (2019, p. 12): *"1) defining consistent taxonomies for defining the diverse landscape of non-state and subnational actions; 2) developing methodologies to quantify aggregate impact of their contributions, 3) factoring in overlaps with national efforts and initiatives; 4) assessing the likelihood that these actors achieve their goals and intended effects; and 5) addressing data gaps*". These five areas are essential for accurate quantification of NSA's potential impact and ultimately the actual size of the emissions gap. As the field of aggregation analyses develops, taxonomies and quantification methods become more validated and consistent. However, methods for addressing overlaps are often not made explicit or barely get attention in the analysis process (Hsu et al., 2019).

Overlap occurs when initiatives or policies target (partially) the same issue area. For example, initiatives and polices overlap when they aim to reduce the same GHG emissions in the same geographical area (Roelfsema et al., 2015; Schneider et al., 2015). Overlap enlarges the chance of initiatives' successes through reinforcing or amplifying mechanisms, by, for example, capacity building, awareness raising or technological learning (Chan et al., 2019).

According to some, overlaps between initiatives are crucial for impactful NSA, as it generates societal authority (see section 2.2.1) (Andonova et al., 2017). However, despite its crucial practical role, overlap leads to double counting or overestimates of the GHG reduction potential when not properly accounted for in ex-ante aggregation analyses (Roelfsema et al., 2018; Widerberg & Pattberg, 2015). Hence, accounting for overlap is essential for calculating the robust net potential impact of initiatives or policies and for comparing with ex-post analyses. Despite its importance for realistic aggregation results, overlaps were addressed in only eleven of the 24 aggregation analyses examined by Hsu et al. (2019), based on varying methods and assumptions. This led to divergent overlaps and aggregate results (Data Driven Yale et al., 2018; Hsu et al., 2019; Roelfsema et al., 2018; UNEP, 2018).

Accurately and consistently addressing overlaps is required for more refined ex-ante NSA aggregation results, which are necessary for five main reasons. First, more accurate aggregation results will alleviate the credibility for climate action because it will prove that ambition is real and potentially effective (Hale et al., n.d.). Second, more accurate results are required to track target realization of non-state and subnational actors and hold actors accountable (Bakhtiari, 2018; Widerberg & Pattberg, 2017). Third, more precise projections on NSA's potential impact are necessary for finding the most fruitful targets and actions, which will help both state and non-state actors in identifying potentially successful policies and initiatives (Bansard et al., 2017; Hale et al., n.d.). Fourth, a refined quantification leads to better projections on the progress of climate action, the PA, NDCs, and the size of the emissions gap (Graichen et al., 2017; Hale et al., n.d.; Hsu et al., 2019). Lastly, more accurate overlap methods and aggregation results are the first step towards assessing likelihood of target realization (Hsu et al., 2019).

Overall, improved methods for quantifying NSA's potential impact will lead to more fit targets and goals and ultimately more effective climate action. Addressing overlaps between initiatives and between initiatives and (national) policies is crucial for developing refined methods in aggregation analyses, but is currently often lacking consistency and accuracy (Hale et al., n.d.; Hsu et al., 2019).

1.3 Thesis objective, research question and internship

Based on the above-described need for more consistent overlap calculations and accurate aggregation results, this Master's thesis entails two main objectives. The first objective is to develop a more consistent and refined method for addressing overlaps. Secondly, this thesis aims to provide more accurate projections about the aggregated potential impact of seventeen key NSA initiatives, when accounted for overlaps between them. The two aims of this research are closely related to one another, as the development of a method for addressing overlaps will lead to refined aggregation results. This thesis focuses on the quantification of overlaps between initiatives, of which the process and results can be used as a starting point for the quantification of other overlaps, for example, between NSA and national policies. In order to meet the two main objectives, this thesis is based on the following research question:

How can methods to account for overlaps in non-state and subnational action aggregation analyses be refined and what is the aggregate potential impact of key initiatives, using the proposed overlap calculation method?

Here, the key NSA initiatives are seventeen transnational emission reduction initiatives (TERIs), which were selected and quantified by NewClimate Institute, without a correction for overlap. The GHG emission reduction potentials (ERPs) were based on a current policies scenario (CPS), to avoid major overlaps with national emission reduction pledges. Section 3.1 provides in a further description of the selection and quantification process. The seventeen TERIs under analysis and their corresponding sectors are shown in Table 1.

Table 1 The seventeen TERIs under assessment

TERIs	Sector
United for Efficiency	Energy efficiency
Super-efficient Equipment and Appliance Deployment Initiative	Energy efficiency
Architecture 2030	Buildings
Collaborative Climate Action across the Air Transport World	Transport
Global Fuel Economy Initiative	Transport
Lean and Green	Transport
Africa Renewable Energy Initiative	Renewable Energy
Global Geothermal Alliance	Renewable Energy
European Technology & Innovation Platform Photovoltaic	Renewable Energy
Science Based Targets Initiative	Business
RE100	Business
Bonn Challenge (New York Declaration on Forests, goal 5)	Forestry
Governors' Climate and Forest Task Force (New York Declaration on Forests, goal 1)	Forestry
Climate and Clean Air Coalition	Non-CO_2
Under2MOU	Cities &Regions
C40 Cities Climate Leadership Group	Cities & Regions
Global Covenant of Mayors for Climate & Energy	Cities & Regions

1.4 Context of this research

This research builds on previous work from NewClimate Institute, DataDriven Lab and PBL Netherlands Environmental Assessment Agency from 2018. This collaboration worked on a first global assessment of climate commitments from non-state and subnational actors (Data Driven Yale et al., 2018). An elaborate description of this analysis and the main results are provided in section 2.3.9. In 2019, the collaborating organizations updated their aggregation analysis, to which this thesis contributed as part of an internship with NewClimate Institute (in Cologne, Germany). The internship consisted of two parts. During the the first part, I assisted in the selection and quantification phase of the seventeen TERIs. In the second part, I worked on my thesis, focusing on addressing overlaps between initiatives in the aggregation analysis. Building upon knowledge acquired during the quantification processes of the seventeen TERIs, the core task of the internship in relation to the thesis was to develop a method for addressing overlaps between initiatives in aggregation analyses and apply it on the seventeen TERIs.

1.5 Thesis structure

This thesis consists of 6 main chapters. Chapter 2 elaborates on the definition, characteristics and emergence of NSA. Furthermore, it provides a description of the different types of academic research into NSA, among which the main type of study under assessment in this thesis, aggregation analyses. The second section of chapter 2 gives a more in-depth definition and description of overlap, followed by good practices for addressing overlaps in aggregation analyses. In the third section of chapter 2, ten aggregation analyses are reviewed, focusing on methods for addressing overlaps. Using the good practices as a guidance, elements from the ten reviews were used to develop an analytical framework for addressing overlaps, which is described in section 2.4. Chapter 3 illustrates the application of this framework on the aggregation of the seventeen key TERIs, as well as the methods for the sensitivity analyses. In chapter 4, the intermediate and final results of the calculation of overlap, aggregation and sensitivity analyses are presented. Chapter 5 provides in a discussion of the limitations of the research, the contribution to literature and recommendations for future research. Chapter 6 demonstrates a short overview of the research, main results and answer to the research question.

2 Theory, Concepts and Literature Review

This chapter has four sections. The first section provides a more elaborate definition of NSA and a description of its main characteristics and categories. In addition, NSA's emergence in global climate governance, its role in academic literature and types of studies are elaborated on. In the second section, overlap is defined, different types of overlap are described and good practices for addressing overlaps are demonstrated. Subsequently, a review of ten aggregation analyses is provided, with a particular focus on the assessment of overlaps in relation to the good practices. A table at the end of the third section shows how each aggregation analysis incorporated the good practices. Based on the good practices and the results in the table, an analytical framework for addressing overlaps is presented in the final section of this chapter.

2.1 Non-state and subnational climate action

2.1.1 Definition, characteristics and categories

Non-state and subnational actors can be defined as "*any group participating in global (climate) governance that is not a sovereign state*" (Roelfsema et al., 2018, p. 67). There are various possible organisational structures of such actors. For example, non-state actors can include civil society, businesses and non-governmental organizations and therefore differentiate from traditional governance structures of a sovereign country (Chan & Pauw, 2014). Subnational actors include cities, regions, sub-sovereign states, provinces or other regulatory bodies which are beneath the national legislations (Roelfsema et al., 2018). NSA is defined as "*a diverse set of governance activities taking place beyond strictly governmental and intergovernmental (or multilateral) settings* (Chan & Pauw, 2014, p. 4). Although NSA initiatives vary greatly in internal organization and structures, they are generally similar in their emphasis on collaboration, consensus and their limited issue areas, corresponding solutions and often specific goals, and their aim on the public good, rather than private interests (Chan & Pauw, 2014).

Although NSA can involve more than climate-related issues, in this thesis the focus specifically lies on NSA that aims for climate change mitigation (Chan, Brandi, et al., 2016). There are several types of mitigation-related NSA (see Table 2), although the names are often used interchangeably in literature (Hsu et al., 2019). First, a single subnational or non-state actor can pursue goals under an *individual commitment* (Data Driven Yale et al., 2018). Individual commitments can cooperate nationally, with or without the sovereign state, under a *cooperative initiative*.

Initiatives which emerge from transnational climate governance are called transnational emission reduction initiatives (TERIs). TERIs are defined as "*international activities outside the UNFCCC driven by non-state actors or coalitions of national governments that have committed to reduce greenhouse gas emissions"* and are the main topic of this thesis (Roelfsema et al., 2018, p. 68). There are roughly two types of TERIs: first, cooperative initiatives which cross national borders are called international cooperative initiative (ICIs), and secondly, the collaboration of sovereign states outside the UNFCCC, through e.g. protocols or agreements. Well-known TERIs include the Global Covenant of Mayors (GCoM), the Science Based Targets Initiative (SBTi) and Under2Coalition (Data Driven Yale et al., 2018).

Table 2 Main characteristics of the four types of NSA

NSA category	Actors	Geographical coverage	Part of thesis?
Individual commitments	Single non-state or subnational actors	n/a	No
Cooperative initiatives	Non-state and/or subnational actors and often the national government	Within a country's boundaries	No
International cooperative initiatives	Non-state and/or subnational actors and often national governments	In at least two different countries	Yes, TERI
International agreements & protocols	National governments	In at least two different countries	Yes, TERI

2.1.2 NSA as a response to lacking national policies

NSA has frequently emerged as a response to lacking climate governance from official regulatory bodies, such as the Parties of the UNFCCC. This was evident when former US president Bush stated the US would not ratify the Kyoto Protocol in March 2001 (Bäckstrand & Kuyper, 2017) and when an attempt to negotiate a successor to the Kyoto Protocol failed during COP 15, 2009 (Hale, 2016). The emergence of NSA initiatives at that moment is referred to as a *Cambrian explosion* of transnational climate governance (Bäckstrand et al., 2017; Hale, 2016). Although the impact and spread of NSA was still small after several years of existence, substantial foundations were built for large, future influence (Hale, 2016). Two years later, during COP 17 in Durban (South Africa), the Durban Platform of Enhanced Action (ADP) was formed. The ADP had two workstreams, one was to write the legal text to be adopted during COP 21 (the Paris Agreement) and the other was to investigate ways to enhance ambition. In this second workstream, NSA was discussed as a possible means to raise national climate ambitions (Widerberg & Pattberg, 2015). During COP 20 in 2014 (Lima, Peru), an "Action Day" was part of the programme. In addition, the Lima-Paris Action Agenda (LPAA) and Non-State Actor Zone for Climate Action (NAZCA) were founded. LPAA and NAZCA were introduced to galvanize the groundswell of actions on climate change mitigation and adaptation from cities, regions, businesses and civil society organizations. In addition, the NAZCA platform was used to showcase existing actions, implicitly motivating other (state) actors (Chan et al., 2015). A year after the PA was adopted, the Marrakech Partnership for Global Climate Action was founded. This partnership is seen as the continuity of the LPAA, but also represents an increasing criticism towards accountability, transparency and legitimacy of non-state and subnational climate action (Bäckstrand & Kuyper, 2017). Perhaps the most notable spark of more transnational climate governance, however, was the response of non-state and subnational actors to US President Trump's announcement to withdraw from the long-negotiated Paris Agreement in June 2017. Hundreds of US actors such as states, universities, businesses and cities announced that they would continue striving to reach the goals of the PA with the message "We Are Still In" (Light & Hale, 2018; Pickering et al., 2018; Urpelainen & Van de Graaf, 2018).

2.1.3 NSA in academic literature

NSA has evolved from a tiny niche with barely any impact, to a serious player in the field of global climate governance since the late 1990s. Hence, the number of studies analyzing NSA has grown with it (Hale, 2016). The landscape of NSA literature is rather diverse but can be split into roughly five categories. First, there are studies aiming to expand the existing databases of NSA initiatives, or strive to build extra databases with new variables (Andonova et al., 2017) (see e.g. (Chan, Falkner, et al., 2016; Widerberg & Stripple, 2016)). Secondly, a much larger field of study is the effect of NSA on national climate governance or the success of the UNFCCC processes. Such studies examine whether NSA delegitimizes the UNFCCC or provides it with more tools for climate governance. The findings differ from underlining the catalyzing effect of NSA to emphasizing the so-called chaos in climate governance and governments lacking responsibility (see e.g. (Andonova et al., 2017; Bäckstrand & Kuyper, 2017; Bakhtiari, 2018; Chan, Brandi, et al., 2016; Chan & Pauw, 2014; Michaelowa & Michaelowa, 2017; Van der Ven et al., 2017; Widerberg & Pattberg, 2015)).

Third, there is research about NSA's power structures, which focuses on the legitimacy of NSA's existence, its role and its accountability towards outputs and impact. This category is more concentrated on internal governance structures rather than effects on external structures. In such studies, statements as 'the more the better' when considering NSA are examined (see e.g. (Chan et al., 2019; Gordon, 2018; Kuyper et al., 2018; Widerberg & Pattberg, 2017).

The fourth category entails studies which emphasize the need for research and development in NSA analysis. The authors of such papers provide frameworks for assessment, new insights in impact analyses and methodological "tips and tricks". In addition, fields in NSA research which have not been studied yet are highlighted. The studies in this category are generally quite new, which is in line with the current stage of NSA research as it is entering an era of refinements (see e.g. (Bertoldi et al., 2018; Hale, 2016; Hale et al., n.d.; Hsu et al., 2019; Van Asselt, 2016; Van der Ven et al., 2017).

Finally, the category *aggregation analyses*, as touched upon before in chapter 1, are studies that analyze the potential impact of non-state and subnational actors with varying scope and coverage, mostly in terms of potential GHG emission reductions. As methodological frameworks for assessing potential impacts are still under development, aggregation analyses vary in scope and are based on various assumptions (Hsu et al., 2019). The number of existing aggregation analyses is still rather low, compared to the other categories of studies (see e.g. (America's Pledge Initiative on Climate, 2018a; Data Driven Yale et al., 2018; Global Covenant of Mayors, 2018; Graichen et al., 2017; Roelfsema, 2017; Roelfsema et al., 2015, 2018; UNEP, 2015).

2.2 Overlap

2.2.1 Definition and description

As described in section 1.2, Hsu et al. (2019) presented five major areas of research and development for NSA studies, specifically focusing on aggregation analyses of GHG mitigation initiatives. One of these areas is factoring in overlaps between NSA initiatives and national policies and overlap between initiatives – of which the latter is the core focus of this thesis.

As touched upon in chapter 1, overlap between initiatives occurs when two or more initiatives operate in the same geographical region and target the same GHG emissions, directly or indirectly (Hsu et al., 2019; Roelfsema et al., 2015). It is not "bad" or "wrong" that overlap exists. Actors who strive to reach the same goal share knowledge and contribute to awareness raising and technological learning (Chan, Falkner, et al., 2016; Roelfsema et al., 2018; Widerberg & Pattberg, 2017). Overlap may reinforce or amplify actions from different initiatives and avoids that the actions land in ignorance (Hale, 2016). Therefore, overlap is seen as a prerequisite for successful climate governance by some[2] (Andonova et al., 2017), or inevitable due to the interdisciplinary nature of climate policy (Hale, 2016). From an ex-post view, it is nearly impossible to dedicate GHG reductions to a certain initiative – scientists agree that the web of actions and reactions builds towards a change in society and that an individual initiative cannot be successful on its own. Overall, overlap between initiatives (and national policies) creates NSA's societal authority – the resulting reinforcing interrelations are required for a common voice and significant impact (Hale, 2016).

However, overlap becomes an important issue in ex-ante aggregation analyses, as it can cause overestimations or double counting of potential impacts when it is not properly acknowledged and accounted for (Hsu et al., 2019). Summing the potential impacts of two or more overlapping initiatives would lead to an unrealistically high outcome in the aggregate result. This is especially crucial in bottom-up quantification of the potential impact of initiatives when each initiative is quantified separately, while assuming full target realization and highest ambitions of the NSA initiatives (Bakhtiari, 2018; Hsu et al., 2019; Widerberg & Pattberg, 2017). This is closely related to the assumed level of additionality – reflecting which share of an initiative's impact is additional to ambitions of other initiatives (Hsu et al., 2019). TERIs in particular are prone to overlap due to their international nature, broad scope of targeted emissions and high level of ambition. Hence, they can overlap within sectors (intra-sectoral overlaps), but also between sectors (inter-sectoral overlaps) (Widerberg & Pattberg, 2015; Widerberg & Stripple, 2016).

2.2.2 Categories of overlap

Here, three main categories of overlap between initiatives are defined, elaborating on the categories of overlap demonstrated by Hsu et al. (2019), NewClimate Institute et al. (2018), Roelfsema et al. (2018), Widerberg and Pattberg (2017) and Graichen et al. (2017). The categories are illustrated in Figure 1.

[2] Here, success means the achievement of targets or pledges, e.g. in terms of GHG emissions reduction.

a) **Duplicate targets overlap** occurs when the TERIs entail similar goals and actions and therefore can be seen as duplicates of one another. Duplicate targets overlap can occur in three ways:
   i. **Duplicate members overlap** occurs when a subnational or non-state actor is involved in two or more similar TERIs and is therefore also referred to as *membership overlap*. For example, membership overlap would occur when a company is committed to two similar renewable energy (RE) initiatives, or a city is member of more than one city initiative. On a larger scale, duplicate members could occur when sovereign states are signatories of two or more similar TERIs. When aggregation TERIs with duplicate members overlap, double counting of potential impacts would occur.
   ii. **Encompassing members overlap** occurs when a larger legislative actor that is committed to an initiative encompasses the commitments of another, smaller actor. For example, encompassing members overlap occurs when a province is committed to a regional initiative, while cities in that province are committed to cities' initiatives. This type of duplicate targets overlap would lead to double counting of potential impacts.
   iii. In case targets and related actions are similar, but the actors of the TERIs are different and not encompassing, **same goal, different actors overlap** would occur. Hence, a wide scope of emissions is targeted by similar initiatives, but unrelated actors. For instance, this type of overlap occurs when two TERIs aim to reduce the broad pool of transport-related emissions, through rather similar actions, but one TERI targets cities and the other companies. The actors technically target different emissions, but due to the sectoral and geographical overlap and similarities in TERIs, one TERI might piggyback on the success of the other TERI. This can cause overestimates in the ex-ante aggregation analysis and difficulties in the ex-post emission reduction allocation[3].

b) **Targeted emissions overlap** occurs when TERIs entail different goals (and actions), but the quantified potentials overlap or interact. It differentiates from duplicate targets overlap because the main topic or subject is different in targeted emissions overlap and therefore the overlap is more indirect. Targeted emissions overlap can occur in two ways:
   i. **Competing targets overlap** occurs when initiatives are competing for the same emissions reductions and the estimated reductions are not (fully) additional to each other. Competing targets overlap could occur between RE initiatives as they both aim to reduce the amount of fossil fuels in the power generation mix and therefore potentially compete in reducing emissions from fossil-based power. Additionally, initiatives could compete for the same

[3] *Same goal, different actors overlap* is a good example of overlap which causes reinforcing effects in practice (e.g. through knowledge sharing between different actors or technological developments), but overestimates in the ex-ante analysis. Because of its reinforcing effects, the allocation of impacts ex-post is complicated – appointing the 'game changer' is nearly impossible in such a case.

resources – e.g. land capacity for wind turbines or geothermal sites. This type of overlap would lead to overestimation in the aggregate potential impact.

ii. **Indirect interaction overlap** occurs when TERIs do not compete for the same emission reductions, but it is highly plausible that their potential impacts indirectly interact when they target the same source of emissions. For example, energy efficiency (EE) initiatives indirectly interact with RE initiatives even when their quantified targets are additional to each other, as they both target the emissions from electricity generation. The negative effect from overlap on the aggregate result occurs through, for example, a slightly lower emission factor for the second TERI, as low-hanging fruit would be targeted by the first TERI. For example, electricity generation with a high emission factor would be displaced before relatively clean electricity generation would be displaced[4]. The extent and impact of overestimation on the aggregate result of this overlap differs per type of target. For example, an RE initiative with a relative target (i.e. a certain percentage of electricity generation from a renewable source) will reach its target faster after the total amount of required electricity generation was reduced by efficiency measures and this reduction is only assumed to happen in fossil-based power. The quantification of absolute RE targets (i.e. a certain amount of installed capacity in the target year) will be influenced far less by indirect interaction.

c) **Unspecific target setting overlap** occurs when initiatives are broadly defined in terms of targeted sectors and emissions, so they potentially overlap with sector-specific initiatives. For example, this type of overlap occurs with cities and regions which have broadly defined emissions reduction commitments, but without specifying targeted means or sectors. Hence, sector-specific targets and achievements could be double-counted.

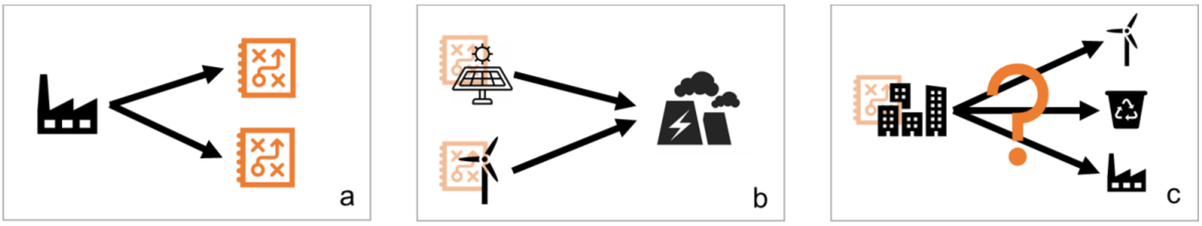


Figure 1 Three overlap categories (own illustration). a) Duplicate members overlap, b) Targeted emissions overlap, c) Unspecific target setting overlap

2.2.3 Good practices for addressing overlaps

As described in chapter 1, Hsu et al. (2019) defined five major areas of research and development, of which one is factoring in overlaps as the current methods lack consistency and accuracy. They describe two good practices (GPs) for factoring in overlaps: 1) identify the

[4] Although this is perhaps not the case in practice, this is often assumed in the quantification of a TERI. Hence, when addressing overlaps in an aggregation analysis, the type of quantification process should always be considered.

presence of overlap, compare the level of ambition when there is overlap and determine reinforcement effects, and 2) when comparing the ambition, describe the applied method in using either no additional effect, partial conservative effect, partial effect or full effect. Elaborating on these GPs for factoring in overlaps, seven GPs for addressing overlaps are defined here, which ensure that the two GPs from Hsu et al. (2019) are properly addressed. The seven GPs are given in Box 1, with the related GP from Hsu et al. (2019) in parentheses.

I. Consideration of intra-sectoral overlaps *(GP 1)*
II. Consideration of inter-sectoral overlaps *(GP 1)*
III. Explicit identification of types of overlap *(GP 1)*
IV. Presentation of the applied overlap rates (reflecting the share of the initiatives that overlaps) *(GP 2)*
V. Explicit and elaborate argumentation or calculations for overlap rates *(GP 2)*
VI. Consideration of reinforcement effects and/or overlapping overlaps *(GP 1)*
VII. Explicit use of an order in the overlap analysis when required for determining additionality *(GP 2)*

Box 1 Good practices for addressing overlaps in NSA aggregation analyses (Hsu et al., 2019)

GPs I and II ensure that the potential impacts of NSA initiatives are put into a broad perspective of possible overlaps – within its sector (GP I), but also beyond (GP II). When implementing GP III, researchers ensure that less obvious types of overlap are considered, too. For transparency and replicability, overlap rates need to be presented (GP IV), ideally with calculations or argumentations (GP V). GP VI ensures that overlaps are not merely viewed in the sense of additionality to previous initiatives, but that its possible reinforcements or amplifications are considered too. In addition, GP VI underlines the importance of assessing whether overlaps are fully independent, or whether they in fact overlap in the same section. In many cases, an order in the overlap analysis is required for accurate assessment additionality and amplification (GP VII).

2.3 Review of aggregation analyses

In order to determine how the seven GPs can be implemented in an aggregation analysis, ten aggregation analyses were studied, with a focus on the way how overlaps were addressed. Below, a review of these ten major aggregation analyses published between 2012 and the time of writing (October 2019) is presented. In 2012, the first major aggregation analysis of climate action outside the UNFCCC was published (Blok et al., 2012), while the context of transnational climate governance was rather similar to today's. To comply with the research objectives, only aggregation analyses in which overlaps were considered are part of the literature review. In addition, the aggregation analyses needed to have an international focus or an in-depth analysis of a high-emitting country and cover a variety of initiatives. The ten aggregation analyses were collected from the supplementary information in Hsu et al. (2019), an overview of major aggregation analysis presented in the NSA guide published under the Initiative for Climate Action Transparency (NewClimate Institute et al., 2018) and snowball sampling based on the references. As aggregation analyses are scarce in academic publishing, the majority of the studies described here is grey literature. The reviews include a short summary of the main results and an assessment of the overlap calculations, focusing on the seven GPs. At the end of section 2.3.11, a summarizing table of this overlap assessment is presented (Table 8).

2.3.1 Blok et al. (2012)

Blok et al. (2012) quantified the GHG emission reduction potential of 21 initiatives in six sectors, aiming to ascertain if these are sufficient to "wedge the gap", i.e. closing the emissions gap between countries' emission reduction pledges and maximum 2°C global warming. The initiatives were selected based on a few criteria, of which a minimum reduction potential of 0.5 $GtCO_2e$ by 2020. The resulting 21 initiatives were not official TERIs at the time, but exemplified possible actions, already initiated by several front-runners. The quantification of the potential impact was done rather simply, as acknowledged by the authors, but the results provide an order of magnitude estimate. In addition, given the time of publication (2012, hence several years before the Paris Agreement), the results were of great relevance for future research[5].

Blok et al. (2012) executed the analysis in three steps: 1) Quantification of the impact on GHG emissions of each initiative separately, 2) Calculation of the additional effect to national pledges, accounting for overlaps between the initiatives and pledges and 3) Calculation of the aggregated potential impact of the initiatives, when accounted for overlaps between the initiatives. Blok et al. (2012) analyzed the potential impact of sectors in a specific order: companies, other actors, energy supply, special sectors and finally air pollutants. They found an aggregate potential of 10 $GtCO_2e$ reduction in 2020 compared to a business as usual emissions trajectory, considering overlaps. Blok et al. (2012) accounted for overlaps by applying overlap factors, which reflected the share of the calculated potential impact that is additional to the initiatives quantified before (GP VII). Since all initiatives were considered separately, both intra-sectoral and inter-sectoral overlaps are factored in (GPs I and II). The rates of additionality are shown in Table 3, but the authors did not explicitly argue the percentages (GPs IV and V). The values in the table imply that different types were considered (GP III) and that amplification effects and/or overlapping overlaps were accounted for, but the authors did not specify how (GP VI). The aggregate of the potential impacts without considering overlaps equals roughly 16 $GtCO_2e$ in 2020.

Table 3 Emission reduction potential of 21 initiatives and shares of additionality (Blok et al., 2012).

	Initiatives	**Emissions reductions ($GtCO_2e$)**	**Additional to all initiatives above**
Actors	Top-1000 companies emission reduction	0.7	n/a
	Supply chain emission reductions	0.2	50%
	Green financial institutions	0.4	30%
	Voluntary offset companies	2.0	70%
	Voluntary offset consumers	1.6	70%
	Major cities initiative	0.7	70%

[5] Based on the amount of citations in later aggregation analyses.

	Sub-national governments	0.6	70%
Sectors	Building heating and cooling	0.6	50%
	Ban of incandescent lamps	0.2	30%
	Electric appliances	0.6	30%
	Cars & trucks emission reduction	0.7	70%
	Boost solar photovoltaic energy	1.4	50%
	Boost wind energy	1.2	50%
	Access to energy through low-emission options	0.4	100%
	Phasing out subsidies for fossil fuels	0.9	50%
	International aviation and maritime transport	0.2	70%
	Fluorinated gases initiative	0.3	50%
	Reduce deforestation	1.8	70%
	Agriculture	0.8	70%
	Enhanced reductions methane and air-pollutants	1	100%
	Efficient cookstoves	0.6	100%

2.3.2 Wouters (2013)

A year after the publication of Blok et al. (2012), Wouters (2013) continued with the theory proposed by Blok et al. (2012) and refined the methodology in their Master's thesis *Wedging the Gap*. They researched the potential impact of ten relevant initiatives, active at the time of writing, from six sectors, aiming to lift the research of Blok et al. (2012) to a more realistic scenario. Without considering overlaps, they found a GHG reduction potential of 3.6-4.7 $GtCO_2e$ in 2020. Intra-sectoral overlaps were mainly avoided by quantifying only one of similar initiatives, or by subtracting emission reductions from an initiative's impact if the impact was also assumed in another initiative, to avoid double-counting (GP I).

As the total calculated potential impact (not accounted for overlaps) equals to roughly a quarter of the calculated impact by Blok et al. (2012), Wouters (2013) estimated that the inter-sectoral overlap would be a quarter of the overlap (the opposite of additionality) determined by Blok et al. (2012) (GP II). Besides this assumption no other calculations are provided (GP V). Wouters (2013) used the same order in the overlap analysis as Blok et al. (2012) (GP VII). After accounting for the overlaps, they found a reduction potential of 3.2-4.5 $GtCO_2e$ in 2020. The overlap factors used by Wouters (2013) are shown in Table 4 (GP IV). These values imply that different types of overlap and amplification effects were considered, although not identified explicitly (GPs III and GP VI).

Table 4 Six sectors and the applied overlap factors (Wouters, 2013).

Wedge	Overlap with initiatives above	Lower value	Upper value
Top 1000 companies	0%	0%	0%
Major cities initiative	7.5%	0%	15%
Cars & trucks	7.5%	0%	15%
Boost solar PV energy	12.5%	0%	25%
Boost wind energy	12.5%	0%	25%
Agriculture	7.5%	0%	15%

2.3.3 Roelfsema et al. (2015)

Roelfsema et al. (2015) analysed the potential impact of seventeen international cooperative initiatives, of which some were merged into one for analysis purposes. The initiatives were selected from databases managed by the UNFCCC, NAZCA platform and the Climate Initiatives Platform (CIP). They found that the 17 initiatives could reduce global GHG emissions with 2.5 $GtCO_2e$ by 2020 and with 5.5 $GtCO_2e$ by 2030, compared to "IMAGE 3.0 baseline scenario". The largest GHG emission reductions were expected from companies, cities and forestry initiatives.

Overlap between initiatives was found to be relatively small: 0.3 $GtCO_2e$ in 2030, based on percentages of additionality determined by the authors (see Table 5) (GP IV). However, the authors only scarcely argue the applied overlap rates and often assumed full additionality of initiatives (GP V). Inter-sectoral and intra-sectoral overlaps were both considered (GPs I and II), but Roelfsema et al. (2015) did not specify how they used the concept of "additionality" and therefore the order of analysis remains unclear. However, it is not certain if a specific order was required in the analysis (GP VII). Although not made explicit, based on Table 5 it may be concluded that different types of overlap were considered (GP III). No explicit evidence is provided concerning overlapping overlaps or amplification effects, but the shares of additionality are rather high, implying that they might have been considered (GP VI). Contrary to the low overlap between initiatives, the authors expected much overlap between the initiatives and country policies and pledges: 70%, based on the assumption that national governments will not exclude initiatives' efforts from national progress. Except for these assumptions, they did not elaborate extensively on the applied methods for overlap calculations.

The authors critically note that TERIs lack monitoring, reporting and verification of progress. They conclude that, considering the high overlap between initiatives and pledges, the calculated initiatives' potentials are not sufficient to close the emissions gap.

Table 5 Initiatives and the applied overlap percentages (Roelfsema et al., 2015)

Initiative	Additional to other ICIs
Top 500 companies in the Carbon Disclosure Project	100%
WBCSD: Cement sector with the Cement Sustainability Initiative	90%
Major cities initiatives: C40 & Covenant of Mayors	75%
Global Fuel Initiative	96%
Including HFCs in the Montreal Protocol	100%
Methane in Air Pollution policy: Global Methane Initiative	100%
REDD+: Reducing Emissions from Deforestation and Forest Degradation	100%
International shipping sector (IMO)	100%
International aviation sector (ICAO)	100%
Zero Routine Flaring by 2030	29%

2.3.4 UNEP (2015)

The authors of UNEP (2015) quantified the potential impact of initiatives that could substantially contribute to closing the emissions gap for 2020. They selected TERIs based on several criteria, of which a minimum reduction potential of 50 $MtCO_2e$/year. After correction for overlaps between initiatives, UNEP (2015) found a potential impact of 2.5-3.3 $GtCO_2e$

reduction in 2020. Contrary to the aggregation analyses described before, UNEP (2015) dedicated an entire chapter to describing the overlap analysis, though the exact applied quantification remains unclear in several cases.

First, they developed a matrix for sectoral overlaps to identify potential overlaps. Although one might find overlaps between EE and energy supply initiatives and between land-use initiatives, they limited the overlaps to companies, cities, regions and energy efficiency (see Figure 2). The matrix ensured the usage of an order in the overlap analysis (GP VII) and consideration of (most of) the types of overlap (GPs I, II, and III).

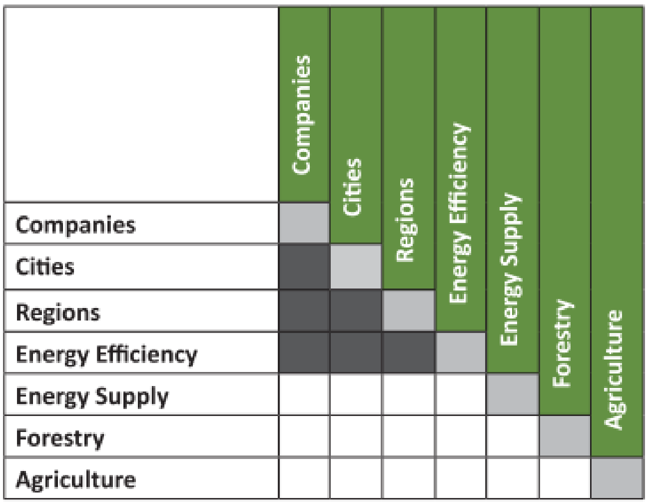


Figure 2 Overlap matrix: the dark grey fields indicate the considered overlaps (UNEP, 2015)

UNEP (2015) determined overlap rates for each identified overlap. For overlaps from cities with companies, they stated that the assessed cities constituted to 15% of the global energy-related emissions, of which one third can be addressed to industry in cities. Hence, the authors assumed a maximum overlap of 33%. In addition, the companies under analysis constitute to 32% of the emissions from the top 1000 largest companies. Therefore, the overlap between companies and cities was calculated as: 15%*33%*32% = 2%. This 2% is used to correct the cities' potential impact for overlaps with companies' impact. However, this calculation entails one factor too many: the 32% of the companies' coverage is already accounted for in the companies' impact and therefore should not be used again in the overlap rate. Subsequently, an overlap of 10% was determined for overlap between companies and regions. However, the way the authors calculated this percentage is not made entirely clear.

Duplicate members overlap was found between cities committed to multiple initiatives. The authors avoided this overlap by applying a certain prioritization of initiatives in the quantification, which meant that the GHG emission reduction potential of only one initiative would be included in the aggregate result. To account for city-region overlap (encompassing members overlap), cities' potential impacts were deducted from regional potential impact. However, some additional steps of this calculation were not explained clearly.

For overlaps of a lighting initiative – *en.lighten* – with cities initiatives, the authors determined the share of a country's population targeted by en.lighten in cities. This share was used as the maximum overlap factor for en.lighten with city initiatives: 4%. For overlap between company initiatives and en.lighten, the authors found that 18% of all lighting is used in industry (in 2002, but assumed to be unchanged). Again, the authors mistakenly applied 32% as an additional factor for the overlap rate calculation, leading to 6% as an overlap factor.

Other overlaps between initiatives were not accounted for, based on the assumption that those were relatively small, or they were avoided by careful selection of initiatives. Overall, overlaps were considered to a high degree and the calculations were explained elaborately (GPs IV and V), but the calculations contained with several inaccuracies and unclarities. There is no evidence of consideration of amplification effects (GP VII). In contrast with Roelfsema et al. (2015), the authors of UNEP (2015) assumed that overlap with national pledges would not be more than one third.

2.3.5 Graichen et al. (2017)

Graichen et al. (2017)[6] aimed to further contribute to existing aggregation analyses on NSA by quantifying the emission reduction potential of nineteen key international climate initiatives and comparing them to the intended NDCs (INDCs) at the time of writing. They performed their analysis in three steps. First, the global potential impact of the selected initiatives was calculated, using current policies including INDCs as a baseline. In the second step, the global potential impact was broken down into eight countries: Brazil, China, the EU, India, Indonesia, Japan, Russia and the USA. In this step, overlaps were accounted for: intra-sectoral overlaps, inter-sectoral overlaps and overlap between initiatives and specific policies in the INDCs which were not considered in the global projection. In the final steps, they aggregated the potential impact to a global result, including overlaps. They found a GHG emission reduction potential of 5-11 $GtCO_2e$ in 2030, compared to the INDCs pathway.

Graichen et al. (2016)[7] accounted for five types of overlap in their quantification (GP I, II and III). First, they defined *duplicate targets* overlap, which is similar to the category described in section 2.2.2. The second type of overlap, *similar target setting*, occurs when different initiatives have targets that directly overlap because they are expressed in the same metric, when initiatives aim for the same goal, or when targets potentially compete. In case of same metrics or competing targets, Graichen et al. (2016) assumed either full additionality (0% overlap) or no additionality at all (100% overlap) to obtain a range in the results. The third category of overlap defined by Graichen et al. (2016) is *unspecific target setting*, similar to the category defined in section 2.2.2. Graichen et al. (2016) found this type of overlap occurring in cities and regions initiatives with RE initiatives, with building sector initiatives and with transport sector initiatives. To account for the overlap, they estimated the share of a population living in cities and regions with commitments and used this as a maximum overlap rate. Fourth, to account for overlaps with INDCs, Graichen et al. (2016) only considered initiatives which were found to be additional to the INDCs. Finally, Graichen et al (2016) accounted for overlaps between business initiatives and non-business initiatives by applying 100% and 0% overlap. They chose this wide range because of a lack of case-specific data.

The description of types of overlap by Graichen et al. (2016) was rather elaborate and may be seen as an extensive theoretical framework, but how they addressed each overlap is not made entirely clear (GP IV). In addition, not all overlap rates are presented (GP V), but the

[6] NewClimate Institute granted access to the original calculations in Excel files
[7] The report from 2017 was an update to the 2016 edition, therefore the technical annex is from 2016.

order of analysis is provided in a comprehensive table (GP VII). There was no mention of consideration of amplification effects or overlapping overlaps (GP VI).

2.3.6 Blok et al. (2017)

Chapter 4 in the Emissions Gap Report (Blok et al., 2017) examines two main questions: Can the emissions gap of 2030 be bridged, and, what are the most promising options to do so? The Emissions Gap Report of 2017 showed that the 2030 emissions gap was 11-13.5 $GtCO_2e$ for a 2˚C pathway and 16-19 $GtCO_2e$ for the 1.5˚C target. Blok et al. (2017) assess the emission reduction potentials in 2030 for key economic sectors, hence not limited to NSA. The emission reduction potentials were found in a broad array of (academic) literature. They aggregated these bottom-up potentials and compared the sum to the size of the emissions gap. The analysis had a socio-economic focus, which meant that the assessed actions had an emission reduction cost equal to or lower than US$100/$tCO_2e$ and it was assumed that the potentials were feasible under beneficial political circumstances.

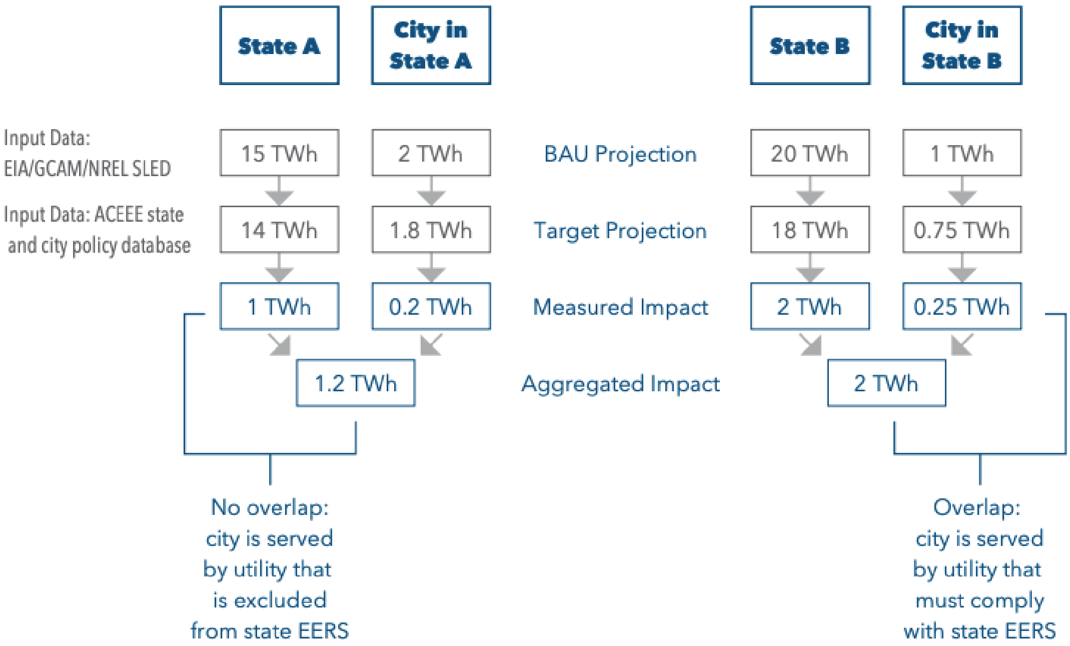
The potentials were analysed compared to a current policies scenario, and the assessed sectors included agriculture, buildings, energy, industry, transport and the broad category “other”. The emission reduction potentials added up to a total of 30 – 36 $GtCO_2e$ in 2030 (accounted for overlaps) and therefore would be more than sufficient to bridge the 1.5˚C emissions gap of the time. To ensure consistency, GHG emission reduction potentials in single point estimates were converted to a range by applying ±25% in general, or ±50% in case of higher uncertainty.

Overlap was considered in four sectors: agriculture, buildings, energy and industry (GP I). For agriculture, the authors found overlap between shifting dietary patterns and decreasing food loss and waste. In the buildings sector, overlap was assumed to occur between the measures: construction of new buildings, retrofit of existing buildings, the implementation of energy efficient lighting and energy efficient appliances. In the energy sector, Blok et al. (2017) identified overlaps between the implementation of RE and carbon capture and storage (CCS). In the industry sector, they accounted for overlaps between energy efficiency measures and energy supply adjustments. These identified overlaps imply that different types were considered (GP III) and due to the broad definition of the sectors it may be assumed that Blok et al. (2017) considered inter-sectoral overlaps (GP II). Although they clearly present which overlaps were accounted for, they did not specify their applied methods of overlap calculations, nor were any overlap rates presented (GPs IV, V, VI and VII).

2.3.7 America’s Pledge Initiative on Climate (America’s Pledge) (2018a)

In July 2007, former New York City Mayor Michael R. Bloomberg and California Governor Edmunch G. Brown, Jr., founded America's Pledge with the aim to “*analyze, catalyze, and showcase climate action leadership by US governors, mayors, business leaders, and others”* (America’s Pledge Initiative on Climate, 2018a, p. 5). America’s Pledge covers NSA from the United States (US) as it was a response to President Trump's announcement in 2017 about his lack of intention to ratify the Paris Agreement. By the end of 2017, Bloomberg and Brown's first report demonstrated great ambition from actors which represented more than half of the US economy – showing a swift and impactful potential to drive decarbonization in the US. In America's Pledge (2018), an up-to-date analysis of the potential impact of US states, cities, businesses and other actors was presented. The authors found that current NSA commitments could decrease US emissions by 17% in 2025, compared to 2005 emission levels. In addition, they calculated that further engagement of non-state and subnational actors, within reasonable political and legal limits, could reduce US emissions by 24% in 2025 below 2005 levels.

America's Pledge (2018b) quantified GHG emission reduction potentials using the tool ATHENA[8], with extensive consideration of overlaps and policy interactions. Most of these were automatically addressed in their model. The usage of the model ensured that several types of overlaps were considered, but these were not explicitly mentioned (GPs I, II and III). When ATHENA did not properly account for overlaps, the authors elaborately explained how they considered these overlaps, but without much quantitative detail (GPs IV and V). Furthermore, they executed an extensive analysis of additionality, illustrated in Figure 3.



In this example, two states (State A and State B), have energy efficiency targets that would result in 1 TWh and 2 TWh of energy savings, respectively. In addition, at least two cities in these states also have their own energy savings goals. For the city in state A, the city's utility is excluded from compliance toward the state's policy, and thus no overlap is assumed. The resulting aggregate figure adds together both the city and state level impacts. In state B, however, the city resides within a utility region that must comply with the state goal and thus overlap is assumed to occur. In this case, we view the city's impact as contributing to the state's, and the aggregate total is equal to the state total. This example represents a simplified version of the approach and does not apply to all sectors included in the ATHENA analysis. More details on the aggregation methodologies employed, by sector, can be found in the sections that follow.

Figure 3 Schematic and description showing how additionality was considered in America's Pledge (2019b, p. 14).

[8] Aggregation Tool for modelling Historic and Enhanced Non-federal Actions. The tool is a combination of sector-specific models, of which each is based on common underlying assumptions regarding overlaps and policy interactions.

America's Pledge (2018b) did not sum business initiatives with cities and regions commitments, to avoid possible overlaps. However, the authors note that if initiatives overlap in a sector with the potential effect of overachievement of one or more initiatives, this should only be addressed in the aggregation process. They explicitly argue that showing results of individual initiatives, without overlaps accounted for, is not problematic. Presumably, ATHENA did not require a specific order in the overlap analysis and automatically accounted for reinforcements (GPs VI and VII).

The authors of America's Pledge (2018b) explained the approaches towards overlap rather elaborately, but theoretically: straightforward numbers and calculations concerning overlaps are barely provided and hard to find in the long technical appendix.

2.3.8 Roelfsema et al. (2018)

Roelfsema et al. (2018) did an integrated assessment of large, sector-specific TERIs, pragmatically avoiding overlaps before the aggregation. Roelfsema et al. (2018) used the integrated assessment model (IAM) IMAGE to obtain an order of magnitude estimate of emission levels after TERIs are implemented, and to find the overlaps with NDCs. The authors underlined the cruciality of existing data gaps, as non-state and subnational actors are not obliged to emissions reporting. Hence, they presented their study as a starting point for further analysis of new or expanded initiatives, and as an example on how an NSA aggregation analysis with an IAM can be done. The assessed TERIs were collected from the CIP and complemented with other potentially high-impact initiatives, resulting in a selection of ten of the largest initiatives that cover most economic sectors.

TERIs were assumed to overlap if they operated in the same country and sector. For Scope 2 (indirect, electricity emissions), full overlap was assumed between cities and companies. For Scope 1 (direct emissions), 50% overlap between cities and companies was assumed, due to a lack of literature for more precise estimates. The level of overlap was calculated based on the fraction of total emissions from the overlapping sectors and regions in 2010 and applied to 2020 and 2030 calculation potential impacts. Overlap between the two assessed cities initiatives (C40 and Covenant of Mayors) was assumed to be 25%, based on Wouters (2013), reflecting the fraction of emissions that is emitted in the same location. However, this overlap rate in Wouters (2013) was based on several case-specific assumptions (e.g. the membership numbers at the time of writing) and therefore needed to be adjusted based on new factors, which Roelfsema et al. (2018) did not do. Although not explicitly stated, it is assumed here that Roelfsema et al. (2018) used the same overlap rate to account for overlaps between the cities initiatives and Carbon Disclosure Project (CDP). All applied overlap rates in Roelfsema et al. (2018) are presented in Table 6 and reflect the share of sectoral and regional emissions that overlap (GPs I, II and IV), along with the order of analysis (GP VII), but detailed calculations or data sources were not provided (GP V). The table implies that different types of overlap were considered, though not explicitly stated (GP III). It is not specified whether the authors considered reinforcements or overlapping overlaps, but the overlap rates seem to be sufficiently moderate (GP VI).

The total projected reductions of all TERIs added up to 2.5 $GtCO_2e$ by 2020 and 5.0 $GtCO_2e$ by 2030, with relatively small overlap: 0.2 $GtCO_2e$ in 2020 and 0.3 $GtCO_2e$ in 2030. 70-80% overlap is assumed with NDCs. Roelfsema et al. (2018) concluded that TERIs can only slightly contribute to closing the emissions gap.

Table 6 Overlap rates used by Roelfsema et al. (2018)

Initiative	Overlap with above initiatives
Carbon Disclosure Project	n/a
C40 Cities and Covenant of Mayors	25%
Cement Sustainability Initiative	10%
Global Fuel Economy Initiative	4%
Kigali Amendment	0%
Global Methane Initiative	0%
New York Declaration of forests	0%
International Maritime Organization	0%
International Civil Aviation Organization	0%
Zero Routine Flaring by 2030	70%

2.3.9 Data Driven Yale, NewClimate Institute & PBL (2018)

Data Driven Yale (DDY), NewClimate Institute (NCI) and PBL Netherlands Environmental Assessment Agency (PBL) analysed climate action from over 6,000 cities, states and regions and more than 2,000 companies, focussing on Brazil, China, India, Indonesia, Japan, Mexico, Russia, South Africa, the US and the European Union (EU). These numbers and scope make the study the largest aggregation analysis assessed in this literature review. DDY, NCI and PBL (2018) found that individual subnational and non-state actors can reduce global emissions with 1.5-2.2 $GtCO_2e$ and TERIs with 15-23 $GtCO_2e$ by 2030 (accounted for overlaps). The potential impacts were calculated using a bottom-up analysis of each initiative.

The TERIs under assessment vary greatly in origin, targeted technologies and emissions, which made the results of the quantification prone to overlaps and double counting. DDY et al. (2018) identified three types of overlap occurring between the TERIs (GP III). Similar to the categories described in section 2.2.2, they found, duplicate members overlap, for which they only considered the TERI with the highest ambition. Secondly, targeted emissions overlap was found to occur in three ways: 1) direct overlap – when the two initiatives target the same emissions and in the same metric, 2) when the same goal is expressed, but the means are undefined and 3) when the targets are potentially competing, for e.g. reducing the same emissions. The authors gave renewable energy targets in the same region as an example calculation, similar to Graichen et al. (2017). How the first two types in this overlap category were considered is not made explicit but it is stated that these require in-depth analysis of the origin and targeted sectors of the initiatives. When unspecific target setting overlap occurred to a large extent (i.e. for the US, EU, Russia and Japan), an overlap range of 100% and 50% was applied. For the other countries where no significant overlaps were assumed to occur between sector-specific and sector-unspecific initiatives, the calculated potential impacts from the sector-specific initiatives was subtracted from the potential impacts from unspecific initiatives (i.e. assuming 100% overlap).

No other types of overlap besides the three main categories were assumed, but calculations were often shaped in such a manner that double counting was avoided[9]. The three types of overlap imply that both intra-sectoral and inter-sectoral overlaps were considered

[9] NewClimate Institute granted access to the original calculations in Excel files.

(GPs I and II). Although the overlap calculations were not documented to a great extent, the Excel file provided in insights about the determination and height overlap rates and order of analysis (GPs IV, V and VII). No reinforcements or overlapping overlaps were considered (GP VI). Overall, the identified overlaps led to a substantial reduction of the sum potential impact.

2.3.10 De Villafranca Casas et al. (2019)

De Villafranca Casas et al. (2019) analysed the potential impact of 24 practical and realistic (policy) actions which could decrease global GHG emissions. Although the study did not assess NSA in particular, it is an example of an aggregation analysis with extensive consideration of overlaps. In addition, the themes and sectors under assessment are somewhat similar to the ones frequently considered in NSA aggregation analyses. Major sectors under assessment include RE, coal-fired power, forestry, transport, EE and buildings.

De Villafranca Casas et al. (2019) divided the 24 actions into three categories: "On Track", "Scale Up" and "Need Focus", depicting their current level of commitment, progress and projections. De Villafranca Casas et al. (2019) show that implementing all 24 actions could reduce global GHG emissions by 19 $GtCO_2e$ in 2030, when accounted for overlap.

Many analysed actions were closely related to each other, which make them prone to overlaps. De Villafranca Casas et al. (2019) state they use a similar overlap approach as Blok et al. (2012), Roelfsema et al. (2015) and UNEP (2015). To avoid double counting, they accounted for overlap in three steps: 1) Overlap matrix, 2) Estimation of minimum and maximum overlap rate and 3) Assessment of final, average overlap rate. In the overlap matrix, possible overlaps between the action under assessment and all preceding actions in the list were determined (GP I and II). As a result, a matrix with binary values was developed, with the values y (yes, there is overlap) and n (no, there is no overlap). A part of this matrix is shown in Figure 4.

Scope		Action	A_1 Faster uptake of renewables following most recent market trends	A_2 China peaking its coal consumption in 2025	A_3 HFC cuts under the Kigali Amendment and more ambitious reductions	A_4 India renewable energy, energy efficiency penetration, and coal shifts	A_5 Faster uptake of renewables following leaders	A_6 International aviation: enhanced energy efficiency	A_7 Zero deforestation and restoration of degraded forests	A_8 Reduced methane emissions from oil and gas production
Global	A_1	Faster uptake of renewables following most recent market trends		y	n	y	n	n	n	n
China	A_2	China peaking its coal consumption in 2025			n	n	y	n	n	n
Global	A_3	HFC cuts under the Kigali Amendment and more ambitious reductions				n	n	n	n	n
India	A_4	India renewable energy, energy efficiency penetration, and coal shifts					y	n	n	n
Global	A_5	Faster uptake of renewables following leaders						n	n	n
Global	A_6	International aviation: enhanced energy efficiency							n	y
Global	A_7	Zero deforestation and restoration of degraded forests								n
Global	A_8	Reduced methane emissions from oil and gas production								

Figure 4 Screenshot of part of overlap matrix. (De Villafranca Casas et al., 2019, p.5)

De Villafranca Casas et al. (2019) did not specify different types of overlap, but the results in the matrix imply that they considered overlap in broad terms (GP III). For each instance of overlap, De Villafranca Casas et al. (2019) determined overlap rates, given in a percentage that reflects what share of the preceding action overlaps with the action under assessment. In the third step, the total overlap was determined and assessed. De Villafranca et al. (2019) used a minimum and maximum overlap rate to maintain a range in the results. In some cases, the total overlap rates were found to be too large and not reflecting the additionality of the initiative in question. In such cases, the authors decreased the overlap rates (GP VI).

The authors used IEA WEO statistics or other sector-specific data for the determination of overlap. For example, the maximum overlap between reducing GHG emissions from the apparel industry and faster development of RE in India was based on India's share in the global fashion industry value chain. If no data was available, the authors used the overlap categories of 0%, 25%, 50%, 75% or 100%, based on expert judgement. They found a total average overlap of 13.0 $GtCO_2e$ in 2030 – a rather high value compared to the aggregate result of 19.0 $GtCO_2e$ reductions. The applied overlap rates are shown in Table 7 (GP IV). Not all calculations for the overlap rates were provided in the report but were elaborately argued in the Excel calculations (GP V)[10].

The authors found that order in the matrix was of great influence for the extent of overlap per action: actions lower in the list are more prone to overlaps as there are more preceding actions to be overlapping with (GP VII). Although this does not change the aggregate result, it led to biased results per action. In order to show individual actions' results, the total quantified overlap was distributed over all actions, proportional to the calculated potential impacts (GP VI).

Table 7 Overlap rates applied in De Villafranca Casas et al. (2019)

Action	Category	GHG emissions reduction potential ($GtCO_2e/yr$)	Total overlap with preceding actions in the list (%-potential of action)
Faster uptake of renewables following most recent market trends	1 - On Track	2.2	0%
China peaking its coal in 2025	1 - On Track	1.0	13%
HFC cuts under the Kigali Amendment and more ambitious reductions (global)	1 - On Track	1.0	0%
India renewable energy, energy efficiency penetration, and coal shifts	1 - On Track	0.6	5%
Faster uptake of renewables following leaders (global)	2 - Scale Up	6.0	8%
International aviation: enhanced energy efficiency	2 - Scale Up	0.37	0%
Zero deforestation and restoration of degraded forests (global)	2 - Scale Up	2.5	0%
Reduced methane emissions from oil and gas production (global	2 - Scale Up	1.45	10%
Fashion industry: value chain GHG emissions reductions (global)	2 - Scale Up	1.17	95%

10 NewClimate Institute granted access the original calculations in Excel files.

International shipping: full implementation of the new target	2 - Scale Up	0.39	7%
China peaking its coal earlier than 2020	2 - Scale Up	1.5	70%
Southeast Asian countries slow down coal plant expansion (*i.e.* Indonesia and Vietnam)	2 - Scale Up	0.56	25%
Fossil fuel subsidies removal (global)	2 - Scale Up	2.3	60%
Fast uptake of electric vehicles (EVs) (global)	2 - Scale Up	0.6	100%
China peaking its oil consumption early	2 - Scale Up	0.35	100%
Reduction of Canadian tar sands production	2 - Scale Up	0.08	100%
United States on track for deep 2050 targets	2 - Scale Up	1.15	75%
European Union's 40% to 60% GHG emissions reductions by 2030	2 - Scale Up	0.55	75%
Implementation of conditional NDCs	2 - Scale Up	2.5	75%
Strengthened energy and material efficiency in the industry (global)	3 - Need Focus	1.6	75%
Deployment of near zero emissions buildings and efficient appliances and lighting (global)	3 - Need Focus	1.55	90%
Agriculture: reduced meat consumption (global)	3 - Need Focus	1.0	12%
Efficient cooling in buildings (global)	3 - Need Focus	0.84	100%
Reduction of China's non-CO_2 GHGs	3 - Need Focus	0.82	100%
Gross sum of GHG emissions reduction potential ($GtCO_2e$/yr) from all 24 actions (central estimate)	N/A	32.1	N/A

2.3.11 Overview of the consideration of good practices in the ten aggregation analyses

Table 8 gives an overview of the ten aggregation analyses and the good practices for addressing overlaps in aggregation analyses. Good practice VI, *consideration of reinforcement effects and/or overlapping overlaps*, is not included in the table, as none of the studies accounted for possible amplification effects from overlaps and only De Villafranca Casas et al. (2019) adjusted total overlap rates for overlapping overlaps. Table 8 shows that none of the aggregation analyses applied all seven good practices, but when combining elements of the different studies a complete framework for addressing overlaps can be formed, which will be introduced in the next section (2.4).

Table 8 Consideration of good practices for addressing overlap in the ten studied aggregation analyses.

	Considers intra-sectoral overlaps? (GP I)	Considers inter-sectoral overlaps (GP II)	Identifies overlap types? (GP III)	Presents overlap rates? (GP IV)	Argues overlap rates or gives calculation? (GP V)	Provides order in overlap analysis when used? (GP VII)
Blok et al. (2012)	Yes, using rates of additionality.	Yes, using rates of additionality.	Not explicitly, but methods and values reflect that different types are considered.	Yes, in terms of additionality.	No, merely based on assumptions.	Yes: Companies Other actors Energy supply Special sectors Air pollutants
Wouters (2013)	Yes, but mainly by considering only one of two or more similar initiatives.	Yes, using overlap rates.	Not explicitly, but methods and values reflect that different types are considered.	Yes, but only for inter-sectoral overlaps.	Yes, rather clearly (but mainly based on Blok et al. (2012)).	~ Yes: same as Blok et al. (2012)
Roelfsema et al. (2015)	Yes	Yes	Not explicitly, but methods and values reflect that different types are considered.	Yes, in terms of additionality to other ICIs. <u>**However**</u>, it remains unclear how additionality was defined.	No	Yes: Companies Other actors Air pollution Forestry Small impact ICIs
UNEP (2015)	Yes	Yes	Not explicitly, but methods and values reflect that different types are considered.	Yes, for many cases.	Yes, for many cases, but sometimes not documented in a clear way and several mistakes in calculations.	Yes: Companies Cities Regions Energy efficiency Energy supply Forestry Agriculture Shown in the overlap matrix, but sometimes text is unclear about order.
Graichen et al. (2017)	Yes	Yes	Yes, explicitly and defined	Yes, but it is not made clear whether the presented %s reflect all overlaps.	Yes, but mainly as theoretical examples. However, it is assumed here that these	Yes: Forestry Cities & regions Buildings Transport RE Industry & business

	Considers intra-sectoral overlaps? (GP I)	Considers inter-sectoral overlaps (GP II)	Identifies overlap types? (GP III)	Presents overlap rates? (GP IV)	Argues overlap rates or gives calculation? (GP V)	Provides order in overlap analysis when used? (GP VII)
					examples reflect the calculations and applied methods.	Non-CO_2
Blok et al. (2017)	Yes	Yes, as the defined sectors are broad.	Not explicitly, but the overlaps vary greatly which reflects that different types were considered	No	No, barely	Not explicitly.
America's Pledge (2018)	Yes	Yes	Not explicitly, but methods and values reflect that different types are considered.	In some cases, but most overlap calculations were done in ATHENA.	Yes, where necessary.	Yes, where necessary.
Roelfsema et al. (2018)	Yes	Yes	Not explicitly, but methods and values reflect that different types are considered.	Yes	Yes, but sometimes documentation is missing and some possible mistakes were found.	Yes
DDY, NCI & PBL (2018)	Yes	Yes	Yes, different types are defined and applied in calculations.	No (but they were found in the Excel calculations)	Yes, theoretical explanation is elaborate, but calculation steps remain somewhat unclear.	Yes, mostly
De Villafranca Casas et al. (2019)	Yes	Yes	Not explicitly, but methods and values reflect that different types are considered.	Yes	Yes	Yes, in matrix

2.4 Analytical framework for addressing overlaps

In section 2.3.11, an overview of the execution of the seven good practices (Box 1) in the ten aggregation analyses was presented. When combining the seven good practices and the execution of these in the ten aggregation analyses, a coherent and complete analytical framework for addressing overlaps can be developed. This resulting framework is illustrated in Figure 5 and its steps are described below. The corresponding methods, which are based on this framework, are presented in chapter 3.

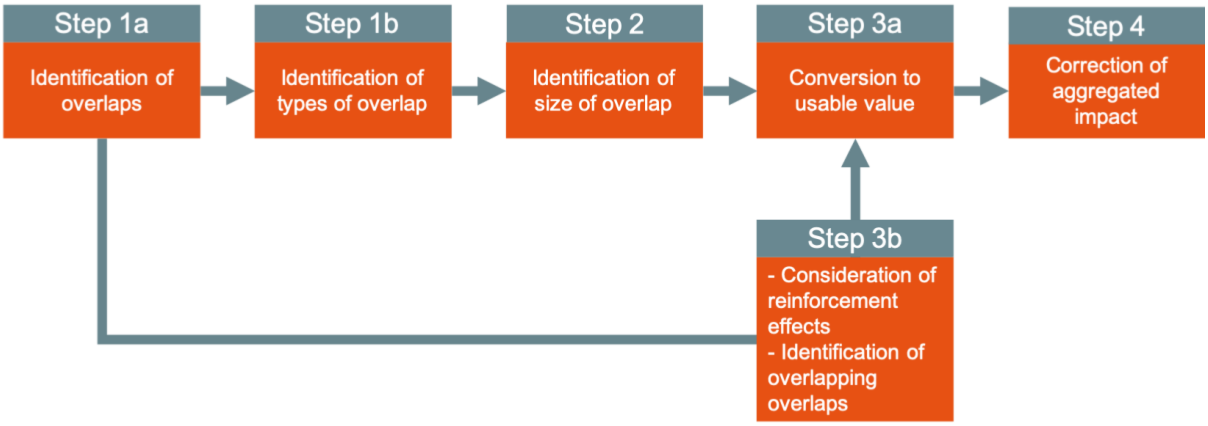


Figure 5 Analytical framework for addressing overlaps in NSA aggregation analyses

2.4.1 Step 1: Identification of overlap

First, the occurrences of overlap (step 1a, Figure 5) and the types of overlap (step1b, Figure 5) need to be identified to meet GPs I, II and III (Box 1). Developing a matrix ensures that all possible overlaps are assessed, both intra-sectoral and inter-sectoral overlaps. In addition, it ensures visualization of the identified overlaps and therefore decreases the chance of overseeing overlaps later in the process. Although some authors used binary values in the matrix for simplicity (e.g. De Villafranca Casas et al. (2019) and UNEP (2015)), such a matrix does not leave room for any interpretation and are not useful for quantifications later in the analysis. Instead, a matrix depicting types of overlap is favourable, which will benefit the transparency and of the intermediate results and the analysis later. Prior to filling in the matrix, a permanent and correct order of analysis needs to be determined (GP VII), as the order is the basic structure of the matrix. Moreover, the analysis from Step 2 onwards greatly depends on the order, as shown in several of the ten studied aggregation analyses (e.g. Blok et al. (2012), Roelfsema et al. (2015) and De Villafranca Casas et al. (2019)). During the process of identifying the occurrences of overlap, the three main types of overlap as described in section 2.2.2 need to be considered, to ensure that indirect or less obvious overlaps are not overlooked, as exemplified by Graichen et al. (2017) and Data Driven Yale et al. (2018). In Figure 6, an example of a binary overlap matrix for three initiatives is shown.

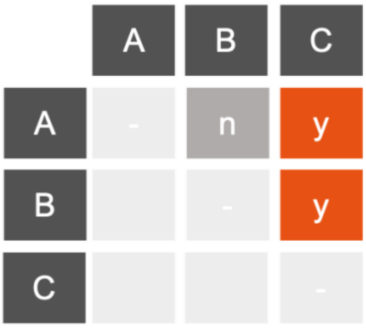


Figure 6 An example of a binary overlap matrix to identify overlaps between NSA initiatives (own illustration).

2.4.2 Step 2: Determination of overlap rates

Several of the ten aggregation analyses demonstrate that overlap can be avoided by selecting rather unique initiatives, or consciously quantifying specific elements. However, in many cases, it is required to calculate or determine an overlap rate in order to quantitively account for overlap, as described in GPs IV and V (Step 2, Figure 5). If an initiative overlaps with a preceding initiative, the overlap rate should reflect the overlapping share of the preceding initiative, see Figure 7. In Figure 7, C and A reflect initiatives of which the targeted emissions in regions, sectors, countries or any other kind of collective partially overlap. Here, the targeted emissions of C overlap with a quarter of A's targeted emissions, which means that the maximum amount of overlap rate would be 25% of A's potential impact. Preferably, overlap rates are based on the amount of overlap in the *quantified target year* in order to reflect the overlapping potential impact as accurately as possible. This way of determining overlap rates was explained by several authors, of which most prominently Wouters (2013), UNEP (2015), Roelfsema et al. (2018), Data Driven Yale et al. (2018) and De Villafranca Casas et al. (2019). When the overlap rate is applied on the potential impact of an initiative, the coverage rate of the preceding initiative is automatically accounted for, as it is reflected in a lower potential impact and therefore should not be used as an additional factor in the determination of overlap. As noted by Wouters (2013), the height and strength of an overlap rate depends on the quantified TERI's level of potential or ambition. Such strength is related to how much of the overlap would actually lead to double counting or overestimates in the aggregate result.

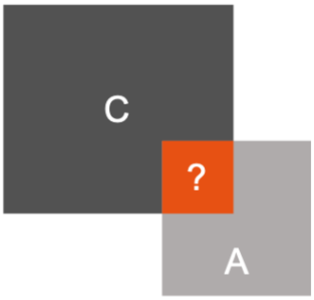


Figure 7 Schematic illustration of a TERI C that partially overlaps with TERI A (own illustration).

In order to determine overlap rates or avoid overlaps in the aggregation process, the level of knowledge about the initiatives' quantification and available (time) capacities are crucial. As illustrated by the ten studied aggregation analyses, some authors were able to include a high level of detail in the overlap calculations, matching the in-depth analysis of the quantifications (e.g. UNEP (2015), Graichen et al. (2017), America's Pledge (2018), Data Driven Yale et al., (2018) and De Villafranca Casas et al. (2019)). Others were (seemingly) forced to use crude estimates as overlap rates, due to too little information about the quantification processes, time constraints or perhaps limited knowledge about the significance of overlap (e.g. Wouters (2013), Roelfsema et al. (2018) and Blok (2017)). Below, a framework for finding overlap rates per category of overlap is provided. In principal, as shown in this framework and argued by the ten aggregation studies, the overlap should either be quantified in the aggregation analysis or overlap before the aggregation analysis. In exceptional cases, for example because of great time constraints or lack of information, for example, a crude estimate of the overlap would suffice.

2.4.2.1 Duplicate targets overlap

As explained in section 2.2.2, there are three types of duplicate targets overlap: *duplicate members overlap*, *encompassing members overlap*, and *same goal, different actors overlap*. In case of duplicate members overlap that occurs on a large scale and the desired results are based on the same scale (i.e. sovereign states with commitments to more than two similar TERIs), the amount of overlap within the initiatives needs to be determined. This could entail the share of overlapping targeted technologies, actions or policy instruments. Hence, a (quick) analysis of the TERIs in question would be required. When duplicate members overlap occurs on a smaller scale, overlap could be avoided in the quantification process of the TERIs by prioritizing the initiative with the highest ambition level and removing the impact of the less ambitious initiative. However, the ten aggregation analyses have shown that quantification processes cannot always be adjusted, so an estimated share of the overlapping members could function as an overlap rate, based on a sample of both initiatives, for example. If such information is not available either, one of the TERIs could be excluded from the aggregation, or a very broad overlap range could be applied. However, the latter option might lead to large uncertainties in the results.

When encompassing members overlap was identified in Step 1, the ideal option to avoid overlap in the aggregation by removing the smaller (legislative) entities from the quantification process. One could decide to add the share of the smaller entities' impact which is additional to its encompassing TERI, as done by America's Pledge (2018). Sometimes, encompassing members overlap occurs between initiatives with (slightly) different targets. This needs to be accounted for in Step 3. When the quantification process cannot be adjusted, or when there is not enough information available, two options remain to overcome encompassing members overlap. One, only add the potential impact of the TERI with the highest ambition to the aggregation. Two, only add the TERI with the largest (legislative) entities to the aggregation. In practice, these two options would often lead to the same resulting TERI, but the argumentation needs to be provided to meet GP V.

For same goal, different actors overlap, ideally the overlap rates are based on a number of factors, reflecting the overlapping *action area*, i.e. the overlap of sectors and actions. As shown by UNEP (2015), different shares can be used in order to obtain an overlap rate that reflects the overlapping action areas and the strength of this overlap. The overlap rate should mainly be based on the preceding initiative – adding too many factors risks underestimating the amount of overlap.

2.4.2.2 Targeted emissions overlap

As described in section 2.2.2, two types of targeted emissions overlap are defined: *competing targets* and *indirect interaction*. In practice, competing targets overlap only occurs with substantially ambitious initiatives. To tackle this type of overlap, the quantification process can be adjusted, for example by using different emission factors, which would be a good and accurate solution to avoid overlaps in the aggregation. If this is not possible, the potential impact can be reduced with a certain percentage that reflects the difference in emission factors, or an overlap rate should be determined that reflects the share of competition. In case there is very little known about the origin of the competing targets overlap, one could decide to use a rather broad range of overlap range. However, it seems to be unlikely that this would occur in an aggregation analysis, since competing targets overlap would often be identified in the overlap matrix with sufficient information at hand.

Determining a range for indirect interaction overlap is more difficult, as predicting any synergies between the initiatives depends on numerous assumptions. An in-depth analysis on policy interactions might be helpful to find an overlap rate, but in case of time constraints 5-10% overlap would be appropriate. If any evidence is found that overlap rates for indirect interaction should be higher, the higher values need to be used.

2.4.2.3 Unspecific target setting overlap

In case of *unspecific target setting* overlap, the most accurate overlap rate is based on the emissions coverage of the TERI in question, multiplied with the sectoral coverage of the preceding initiative (see e.g. UNEP (2015)). This latter factor needs to be applied in case the sectoral emissions are not evenly divided over the regional coverage of the TERI in question, which results in either a higher or lower share of emissions coverage. If no information is available about sectoral coverage, an overlap rate based on emissions coverage should suffice. In case no emissions data is available, population coverage can be used as proxy for overlap (as done by Graichen et al. (2017) and DataDriven Yale et al. (2018)). If no population data are available either, some creative solutions need to be found, e.g. overlap rates based on land coverage, with a broad range to reflect its uncertainty, or a very broad range of overlap rates.

2.4.3 Step 3: Quantification of overlap & final overlap rate

2.4.3.1 Determining the total overlap rate

After determining overlap rates, it is required that the rates are converted to a quantified, usable overlap, which entails Step 3 (Step 3a, Figure 5). As aggregation analyses are mainly about GHG emission reduction potentials, the overlap rates can be converted to an amount of GHG emissions overlap. In the example of Figure 7 above, this means that the maximum quantified overlap would be 0.25A, A being the potential impact of initiative A. If the initiative in question overlaps with more than one initiative (initiative C overlaps with initiatives A and B, see Figure 6), the different quantified overlaps need to be summed. Subsequently, this sum needs to be converted to a percentage of the initiative in question (initiative C) to show what share of the potential impact would – in theory – overlap with the potential impact of preceding initiatives (initiatives A and B). This results in the total overlap rate.

2.4.3.2 Considering overlapping overlaps

After the total overlap rate is determined, it needs to be adjusted for *overlapping overlaps*. The above described method assumes that all overlaps are independent and that the overlaps build up – in other words, the *overlaps do not overlap* (see the example in Figure 8). This could mean that the total overlap rate becomes higher than it should. As a consequence, initiatives lower in the matrix are almost not additional to preceding initiatives. This issue was often not explicitly acknowledged in the aggregation analyses. Only De Villafranca Casas et al. (2019) adjusted the total overlap rates of actions lower in the matrix, based on an assumed higher degree of additionality. The overlap rates presented in Blok et al. (2012), Wouters (2013) and Roelfsema et al. (2015) imply that this was accounted for.

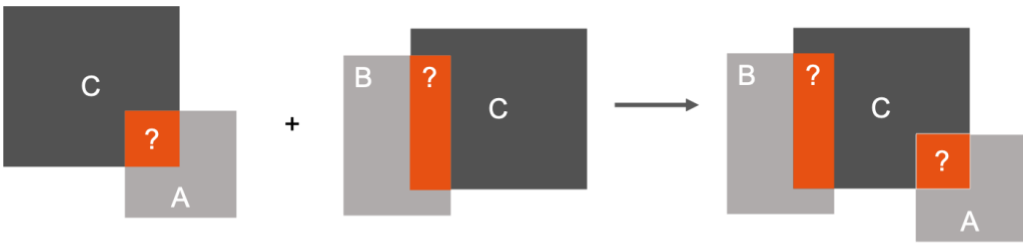


Figure 8 Illustration of overlaps which do not overlap (own illustration).

To what extent initiative C's is additional to initiatives A and B in Figure 8, depends on interactions and overlaps between initiatives A and B. It is important to address *overlapping overlaps* as they partially determine the additionality of initiative C. To some extent, the extent of overlapping overlaps can be estimated based on available information (e.g. the developed matrix from Step 1), but often this assessment will depend on several assumptions, especially when the number of analysed initiatives is high. See Figure 9 for the same overlaps, but a case of *overlapping overlaps*.

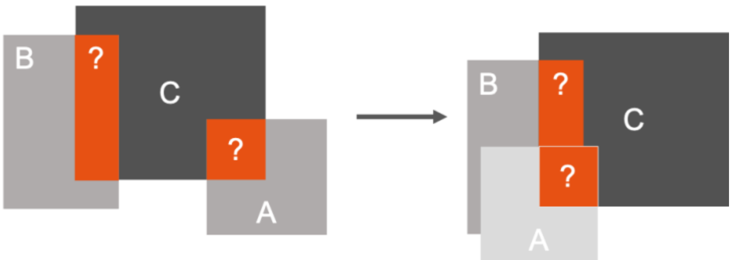


Figure 9 Illustration of a shift from overlaps which do not overlap, to overlapping overlaps (own illustration).

2.4.3.3 Considering reinforcement effects and determining the final overlap rate

While overlapping overlaps are being considered, reinforcement effects too. As described in section 2.2.1, initiatives could reinforce or amplify one another, by, for example, awareness raising and technological learning. However, in this framework, overlaps are assumed to lead to double counting or overestimates, and hence reduce the sum potential impact. When reinforcement effects are identified, the total overlap should be decreased. After addressing overlapping overlaps and reinforcements, the total overlap rate might require several other adjustments. For example, completely removing smaller actors from the quantification in Step 2 because of duplicate members overlap (section 2.4.2.1) might lead to too low impacts. The total overlap rate can be decreased to balance this. It is possible that the total overlap rate exceeds 100%, which should be adjusted to a maximum of 100% overlap. At last, the final overlap rate is determined.

2.4.4 Step 4: Correction for overlaps

After the final overlap rate has been determined, it needs to be used to correct the potential impact for overlap. The final overlap is deducted from the calculated potential impact, which is Step 4 (Figure 5). The four steps of the overlap calculations of Figure 5 are illustrated in Figure 10 using the initiatives A, B and C as examples. Note that the matrix only contains binary values and Step 3b is missing, both for simplicity purposes.

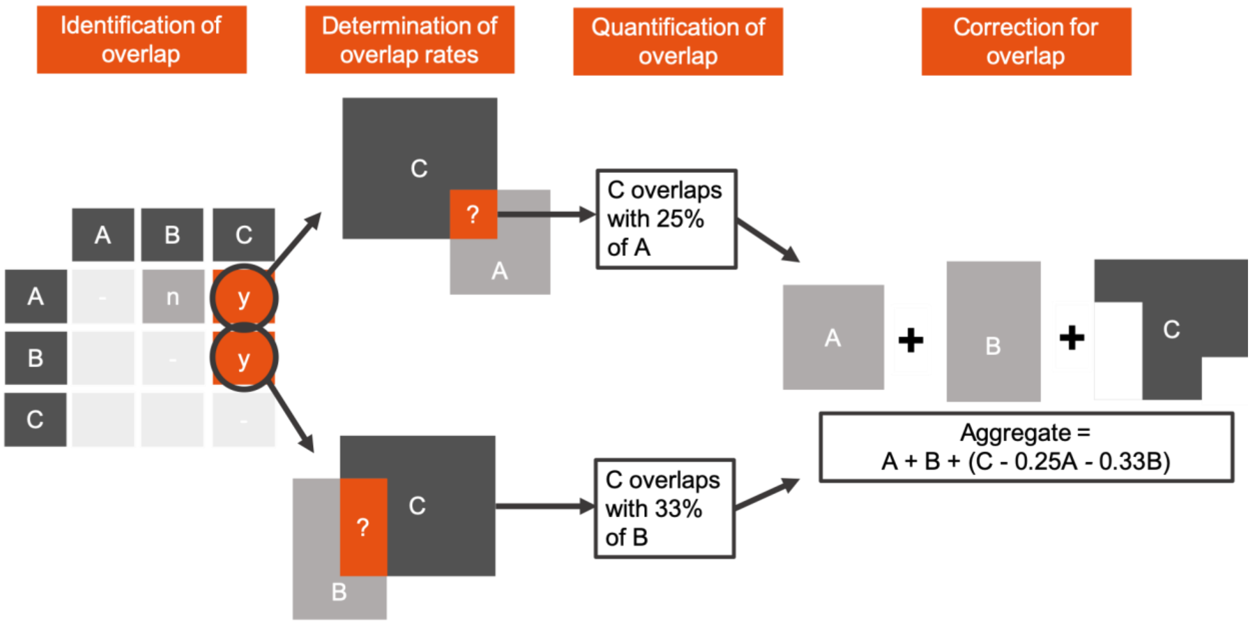


Figure 10 Illustration of the analytical framework for addressing overlaps in NSA aggregation analyses (own illustration).

3 Methods

In this chapter, the application of the analytical framework in the aggregation analysis of seventeen TERIs is described, which means that the methods for the overlap calculations are presented. In the first section of this chapter, the seventeen TERIs and their quantification processes are described. Subsequently, the execution of the four steps of the analytical framework is described. In the final section of this chapter the methods for the sensitivity analyses are given.

3.1 Data description

The seventeen TERIs under assessment in this research were selected by NewClimate Institute et al. (2019) from a list of over 300 initiatives (obtained from Climate Initiatives Platform, supplemented by NewClimate Institute's research). This list was narrowed down to 24 TERIs, according to the following criteria: 1) the TERIs had defined a quantifiable goal, 2) the TERIs had a potentially significant impact on emissions, and 3) the TERIs conducted an actionable mitigation plan focused on implementation. Subsequently, the 24 TERIs were checked for a high likelihood of implementation, the fourth criterion, based on a function-output-fit analysis (FOF analysis). A FOF-analysis measures whether initiatives generate outputs that are consistent with their main functions (Chan et al., 2018). A selection of seventeen TERIs met the four criteria. Their potential impact was calculated in terms of GHG emission reductions, assuming that all TERIs would achieve their targets. This assumption meant that initiatives would not displace their emissions, nor decelerate the implementation rate of other initiatives (NewClimate Institute et al., 2019). If possible, targets and membership of the TERIs were scaled-up to realistically ambitious levels. The emission reduction potential was compared to a current national policies scenario (CPS) and NDC scenario. However, to avoid any major overlaps with national pledges, this thesis focuses on the CPS, although possible overlaps with the current policies are not accounted for (see chapter 5). The potential impacts of the seventeen TERIs were calculated for ten high-emitting countries and regions: Canada, China, Brazil, the EU, India, Indonesia, Japan, Mexico, South Africa and the US. In addition, the potential impact was aggregated to a global level, which also included the world's remaining countries.

Below, brief descriptions of the seventeen TERIs and their quantification is provided, grouped per sector. The resulting potential impacts were not yet accounted for overlaps and hence are the input data for overlap analysis. In most cases, a minimum and maximum potential impact was calculated in the quantification process. However, if the quantification of the potential impact led to a single point estimate, a range was applied manually to ensure consistency, following Blok et al. (2017). Assuming that the calculated values are a maximum, the minimum values were obtained by reducing 20%. At the end of this section, a table with the quantified targets and the calculated global potential impacts per TERI is provided (Table 9).

3.1.1 Electric efficiency

Two TERIs targeting EE were quantified: Super-efficient Equipment and Appliance Deployment initiative (SEAD) and United for Efficiency (U4E).

SEAD is a voluntary collaboration between governments, in order to promote the production, purchase, and use of energy-efficient appliances, lighting and equipment worldwide. SEAD entails eighteen member governments, mainly from the Americas, Asia and Europe (SEAD, n.d.). The quantification of its emission reduction potential is based on electricity savings from increased efficiency in the member states, multiplied with the CO_2 emission factors from fossil fuel-fired power generation of the country in question. The upper estimate is based on replacing coal-fired power generation first, the lower estimate is based on replacing gas-fired power generation first (NewClimate Institute et al., 2019).

U4E is an EE TERI focused on developing countries, with the aim to move markets towards more energy-efficient equipment and appliances. U4E informs policymakers about the environmental and economic benefits of EE, assists with implementation of strategies and identifies good practices for increasing efficiency (United for Efficiency, n.d.). The quantification of U4E's potential is done in a similar way as for SEAD (NewClimate Institute et al., 2019). In the quantification of the EE initiatives, several countries were covered in both (ibid.).

3.1.2 Buildings

Architecture2030 (A2030) is the only buildings' TERI in this research. Its mission is to transform the built environment from a major contributor of GHG emissions to a main solution to the climate crisis. A2030 strives to provide leadership for and design of the high-impact actions. A2030 pursues two objectives: 1) to achieve a significant reduction in the energy consumption and GHG emissions of the built environment and 2) to advance sustainable, equitable buildings and societies (Architecture2030, n.d.-a). For the quantification of its potential impact, A2030's '2030 Challenge' targets were used (Architecture2030, n.d.-b):

- "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 to carbon neutral in 2030."

Based on these targets, thermal energy efficiency improvements were calculated, resulting in decreased consumption of fossil fuels in the built environment. Only fossil fuel reductions were quantified – a shift to or reduction of electric heating was not accounted for. The fossil energy savings were then converted to GHG emissions reductions using the country-specific emission factors of fossil fuels. Similar to the EE initiatives, a range of emission reductions was calculated by either reducing coal-based or gas-based thermal energy first.

3.1.3 Transport

Three TERI from the transport sector are examined: Collaborative Climate Action across the Air Transport World (CCAATW), Global Fuel Economy Initiative (GFEI) and Lean and Green (L&G).

CCAATW strives for sustainable growth in aviation worldwide by improving air transport fuel efficiency and stabilizing the sector's net CO_2 emissions from 2020 onwards (ICAO, 2014). The quantification of the potential impact was based on the target of carbon neutral growth and the results were obtained from an IAM (NewClimate Institute et al., 2019).

GFEI aims for a more efficient global car fleet through research, global advocacy and support of countries when they seek policy solutions. Around 70 countries have developed fuel economy policies with GFEI's support. These policies aim for cleaner and more efficient vehicles, in both the light and heavy-duty vehicles' sector. The two main goals of the initiative are: 1) improve fuel efficiency of light duty vehicles with 50% by 2030 for new vehicles, and by 2050 for all vehicles and 2) improve fuel efficiency of heavy-duty vehicles with 35% by 2035 for new vehicles (Global Fuel Economy Initiative, 2017). These two goals were used for the quantification, which was done using the IAM IMAGE 3.0. One of the inputs for the models is efficiency of cars and trucks, which was adjusted for the GFEI targets (NewClimate Institute et al., 2019). To avoid overlaps with L&G, freight transport was not addressed in the calculations for the EU.

L&G aims for reducing emissions from freight transport. The initiative is founded by Connekt – a Dutch non-profit network for sustainable mobility. Currently, L&G only has members in Europe, and its majority of members are Dutch companies. The initiative awards its members with a certain amount of 'stars', reflecting their level of commitments. In the quantification, the goal of 20% reduction in freight emissions within five years is used. The calculations were executed in an IAM (Lean & Green, n.d.; NewClimate Institute et al., 2019).

3.1.4 Renewable energy

Three RE TERIs are part of the analysis: European Technology and Innovative Platform for Photovoltaics (ETIP PV), Africa Renewable Energy Initiative (AREI) and Global Geothermal Alliance (GGA).

ETIP PV works with national governments, industry and academics in Europe to accelerate the European market uptake of photovoltaic (PV) technologies. The initiative originates from the Solar Europe Industry Initiative (SEII). ETIP PV targets different parts of the PV value chain, ultimately aiming for 600 GW PV capacity by 2025 and 4-9 TW by 2050 in the EU. However, as this goal is unrealistically ambitious considering the current state of the market, it was decided to quantify the ambition of the former SEII: 12% PV share of the EU's electricity generation by 2020 and 20% share by 2030. The additional share of PV compared to the baseline of electricity generation leads to GHG emissions reduction: it replaces either coal-fired power (high reductions range) or gas-fired power (low reductions range) (NewClimate Institute et al., 2019).

The AREI aims for accelerating renewable electricity generation in Africa. It aims to achieve an additional 10 GW or RE capacity by 2020 and pursues the effort of generating 300 GW RE by 2030 (AREI, n.d.). These values were used to determine the amount of fossil-fired power to be replaced and therefore reducing GHG emissions, accounting for reasonable load factors. Again, this was done in a high and low reductions range (coal vs. gas) (NewClimate Institute et al., 2019).

The GGA was launched at COP 21 to serve a platform for dialogue, cooperation and coordinated action between the global geothermal industry, policymakers and stakeholders. It aims for increased use of geothermal energy, both for power generation and direct use of heat.

The GGA's goal is to increase the installed capacity for geothermal power generation by five-fold, and more than double geothermal heating by 2030 (Global Geothermal Alliance, n.d.). The quantification of GGA's potential impact was based on the assumption that additional capacity from GGA, considering reasonable load factors, will lead to a lower demand of fossil-based electricity and heat and therefore decrease GHG emissions. Again, an uncertainty range was applied in the calculations, i.e. geothermal energy either replaces coal or gas first.

3.1.5 Industry and business

Two TERIs in the aggregation analysis target industry and business: *RE100* and *Science-Based Targets Initiative* (SBTI). Both initiatives are within the We Mean Business Coalition.

RE100 is a global corporate leadership, aiming for 100% renewable electricity in major businesses. It is led by The Climate Group and CDP and strives to increase the demand for renewable electricity by triggering business through compelling business cases, identifying barriers in policies and celebrating achievements of its 204[11] members. RE100 was launched in the Climate Week NYC 2014 and has members in Europe, North-America, China, Japan and Australia (RE100, n.d.). RE100 holds a target of 3,000 members in 2030, which is assumed to be reached linearly in the quantification of its potential impact. The average electricity consumption of the current membership was used for this scale-up of membership. The additional renewable electricity demand was calculated and it was assumed to displace the demand for fossil fuels. Using local emission factors of electricity generation, the GHG emissions reductions were calculated. For a low GHG reduction potential, RE100 would replace gas-fired electricity first, for a high reduction it would replace coal-fired electricity (NewClimate Institute et al., 2019).

The SBTI arose from a collaboration between CDP, the WRI, the Worldwide Fund for Nature (WWF) and the United Nations Global Compact (UNCG). GHG emissions targets are considered 'science-based' if they are in line with the PA: limit global warming to well-below 2°C above pre-industrial levels and pursue efforts to limit global warming to 1.5°C. SBTI's overall aim is that all industries and companies act in line with the PA and that corporations play a significant role in reducing global GHG emissions. Currently, 676 companies are taking action, of which 276 companies have approved science-based targets[12] (Science Based Targets Initiative, n.d.). SBTI aims to have 2,000 signatory companies by 2030, which was used as a scale-up of membership in the quantification, assuming a linear trajectory. A 2°C pathway was assumed for the quantification of SBTI's potential impact, by using industry-specific target emission intensities, based on the 2016 IEA's Energy Technology Perspective (ETP). A linear trajectory towards the target emission intensity was assumed. Electricity demand levels in line with a 2°C pathway were also obtained from ETP data, while not decreasing the emission intensity of electricity generation to avoid double-counting with renewable electricity initiatives. The GHG emission reductions were calculated by comparing the SBTI scenario to the ETP data without SBTI's impact (NewClimate Institute et al., 2019).

11 Number of members on October 23, 2019
12 Data obtained on October 23, 2019

3.1.6 Forestry

The *Bonn Challenge* and the *New York Declaration on Forests* (NYDF) are the two examined forestry initiatives. However, to ensure data consistencies and avoid overlapping targets, only NYDF's Goal 1 on deforestation and Goal 5 on restoration were quantified, assuming that these covered the Bonn Challenge too. NYDF is a worldwide partnership of governments, companies, civil society and indigenous people who strive to end loss of natural forest (Goal 1) and restore 350 million hectares of forestlands by 2030 (Goal 5). These are two of the ten NYDF's targets, which are all aiming for more sustainable forest governance (New York Declaration on Forests, 2014). There are large uncertainties about the carbon stock in natural forests and the potential of reforestation or afforestation in reducing global GHG emissions. Hence, for the quantification of the potential impact of NYDF, zero emissions from *land-use and land-use change and forestry* (LULUCF) were assumed and compared to LULUCF projections without implementation of NYDF's Goal 1 and 5 (NewClimate Institute et al., 2019).

3.1.7 Non-CO_2 Greenhouse gasses

The Climate and Clean Air Coalition (CCAC) aims for the implementation of policies which lead to substantial reductions of short-lived climate pollutants (SLCPs) by 2030. It is a voluntary partnership of governments, intergovernmental organizations, businesses, scientific institutions and civil society organizations. The 120 state and non-state actors are committed to improve the air quality and reduce global warming. CCAC's actions include training and institutional strengthening, support for developing new legal frameworks, campaigning, and development of knowledge resources and tools (CCAC, n.d.; NewClimate Institute et al., 2019). The quantification of CCAC's potential impact is focused on the SLCPs methane (CH_4) and hydrofluorocarbons (HFCs). For CH_4, a reduction target of 26% in 2030, compared to the 2005 level, is assumed. For HFCs, it was assumed that CCAC targets a phase-down as pledged in the Kigali Amendment (NewClimate Institute et al., 2019).

3.1.8 Cities and regions

Three initiatives targeting cities and regions were part of the aggregation analysis: *C40 Cities Climate Leadership Group (C40)*, *Under2 Memorandum of Understanding (Under2),* and *Global Covenant of Mayors for Climate and Energy (GCoM)*.

C40 is a worldwide network of megacities, which are committed to fighting climate change. C40 supports these cities in organizing collaboration, sharing knowledge and driving impactful sustainable action. The network consists of 94 cities, representing over 700 million citizens and a quarter of the economy. C40 defined two goals: 1) every C40 city needs to develop a climate action plan that is in line with the Paris Agreement, before 2020 and 2) cities need to achieve carbon neutrality before 2050 (C40, n.d.; NewClimate Institute et al., 2019).

Under2 is part of the Under2Coalition, which is a global community of regions and subnational states committed to ambitious climate action, in line with the PA. More than 220 governments, representing 1.3 billion people and almost half of the global economy, are part of the Coalition. The signatory subnational governments of Under2 commit to reduce their GHG emissions with 80-95% compared to 1990 levels, or to below 2 annual metric tons per capita, by 2050. This is in line with the reductions required for maximum 2°C global warming. Signatory governments of Under2 become part of the Under2Coalition (NewClimate Institute et al., 2019; Under2Coalition, n.d.).

Active in 139 countries, GCoM is the largest global alliance for city climate leadership. GCoM entails 10,000 signatory cities and local governments, representing over 800 million people. It was launched in June 2016, when the EU Covenant of Mayors and global Compact of Mayors were merged. GCoM underlines a long-term vision of promoting and supporting voluntary climate action, working towards a low-carbon, sustainable society (GCoM, n.d.). For the calculation of GCoM's potential impact the expected impacts per region were used, as determined by GCoM.

For the quantification of potential impact of the cities and regions initiatives, first emissions baselines for the signatory cities or regions without commitments were developed. Then, the initiatives were scaled-up in terms of membership or ambition, based on the overarching goals of the initiatives. The TERIs' or actor-specific targets were applied on this scale-up to calculate the TERIs' trajectories. Comparing the GHG emissions from these scenarios to the baseline resulted in the emissions reductions (NewClimate Institute et al., 2019).

3.1.9 Overview of analysed TERIs

Table 9 below summarizes the quantified targets of the seventeen TERIs and presents the calculated potential impact. The values here are not accounted for overlaps, except for GCOM and C40 for which encompassing members overlap and duplicate members overlap was accounted in the quantification process. The single point estimates are not given with their added minimum input value.

Table 9 The selected TERIs, their quantified targets and calculated GHG reduction potential for 2030, not accounted for overlaps (obtained from NewClimate Institute et al., 2019).

Sector	TERI	Quantified target	Emission reduction potential for 2030 ($GtCO_2e$/year)
Energy efficiency	**U4E**	Members to adopt policies for energy-efficient appliances and equipment	0.6 – 1.2
	SEAD	Members to adopt current policy best practices for energy efficiency product standards	0.5 – 1.2
Buildings	**A2030**	New buildings and major renovations shall be designed to meet an energy consumption performance standard of 70% below the regional (or country) average/median for that building type and to go carbon-neutral in 2030	0.2
Transport	**CCAATW**	Two key objectives: 1) 2% annual fuel efficiency improvement through 2050 2) Stabilise net carbon emissions from 2020	0.6
	L&G	Member companies to reduce CO2 emissions from logistics and freight activity by at least 25% over a five-year period	0.02
	GFEI	Halve the fuel consumption of the LDV fleet in 2050 compared to 2005	0.5

Renewable energy	**ETIP PV**	Supply 20% of electricity from solar PV technologies by 2030	0.2 – 0.5
	AREI	Produce 300 GW of electricity for Africa by 2030 from clean, affordable and appropriate forms of energy	0.3 – 0.8
	GGA	Achieve a five-fold growth in the installed capacity for geothermal power generation and a more than two-fold growth in geothermal heating by 2030	0.2 – 0.5
Business & industry	**RE100**	2,000 companies commit to source 100% of their electricity from renewable sources by 2030	1.9 – 4.0
	SBTI	By 2030, 2,000 companies have adopted a science-based target in line with a 2°C temperature goal	2.7
Forestry	**NYDF (Bonn Challenge & GCFTF)**	Two main quantifiable long-term targets: end forest loss by 2030 in member countries (NYDF/ GCFTF); Restore 150 million hectares of deforested and degraded lands by 2020 and an additional 200 million hectares by 2030 (NYDF/Bonn)	5.4 – 5.6
Non-CO_2 GHGs	**CCAC**	Members to implement policies that will deliver substantial short-lived climate pollutant (SLCP) reductions in the near- to medium-term (i.e. by 2030)	1.4
Cities & regions	**UNDER2**	Local governments aim to limit their GHG emissions by 80 to 95% below 1990 levels by 2050 (220 members)	4.6 – 5.0
	GCOM	Member cities have a variety of targets (+9,000 members)	1.4
	C40	94 signatory cities have a variety of targets, aiming for 1.5°C compatibility by 2050.	1.5

3.2 Application of analytical framework

3.2.1 Step 1: Identification of overlap: overlap matrix

First, an overlap matrix was developed to analyse all potential overlaps and make the overlaps visible. The axes of the matrix consisted of the seventeen TERIs, in the order as shown in Table 10. This order was based on the typology of the initiatives in question: TERIs which target energy-end use emissions were placed first, followed by TERIs which target direct energy-use emissions or emissions from electricity generation. TERIs related to GHG sequestration and non-CO_2 gasses were third and non-sector specific TERIs were placed last. This order roughly follows the theory of *trias energetica*, while keeping initiatives of the same sector together (Blom et al., 2011). The building initiative Architecture2030 was quantified as an efficiency improvement initiative, hence its placement in the first category. Cities and regions TERIs were placed last assuming that all preceding sectors reflect the means of cities and regions to reach their target. Within sectors, the initiative with the highest potential impact was placed first. The matrix was developed using a decision tree, shown in Figure 11. The decision tree was used to find to occurrences of overlap and the type of overlap. Using the categories of overlap defined in section 2.2.2 as end points, the decision tree is based on numerous questions to find the category of overlap. The resulting matrix can be found in section 4.1.1.

Table 10 The assessed TERIs and corresponding sectors, in order of analysis

No.	Sector	Acronym
1	Energy efficiency	U4E
2	Energy efficiency	SEAD
3	Buildings	A2030
4	Transport	CAATW
5	Transport	GFEI
6	Transport	LG
7	Renewable Energy	AREI
8	Renewable Energy	GGA
9	Renewable Energy	ETIP PV
10	Business	SBTI
11	Business	RE100
12	Forestry	BC
13	Forestry	NYDF
14	Non-CO_2	CCAC
15	Cities &Regions	Under2MOU
16	Cities & Regions	C40
17	Cities & Regions	GCoM

As illustrated in the decision tree (Figure 11), first, geographical overlap needed to be determined, which is a prerequisite for any overlap at all (1). By using the second box (2), it was determined whether the TERIs specify their targeted emissions and action. If TERIs do not specify targeted emissions or actions, it was examined whether they indirectly overlap with other (sector-specific) TERIs (3), leading to *unspecific target setting*. When TERIs are active in the same geographical region but do not aim to reduce the same emissions, their potential impacts do not overlap.

In case TERIs were found to target the same sector and emissions (2), it was examined whether their goals and, where possible, targeted actions are similar (4). Goals entail the principal goal of the initiative – e.g. implementation of more solar PV, efficiency improvements in industry or reduction of transport emissions. Hence, this differs from the ultimately intended effect, which would be reducing fossil-based power in the case of solar PV. In some cases, TERIs aim for specific actions (e.g. advice for policy interventions or information campaigns), which could overlap with actions from other TERIs. If the initial goals (and actions) were found to be different (4), additionality of the calculated potential impacts was determined (5). In case the TERI in question did not appear to be fully additional to the preceding initiative, *competing targets overlap* was identified. When the potential impacts of the TERIs were found to be additional to each other, their potential *indirect interactions overlap* was determined (6).

If the goals (and actions) of the TERIs were found to be similar (4), duplicate targets overlap was examined, leading to *duplicate members overlap.* In case no identical signatories were found, it was determined whether *encompassing targets overlap* was evident (8). If this was not the case, *same goal, different actors overlap* was found.

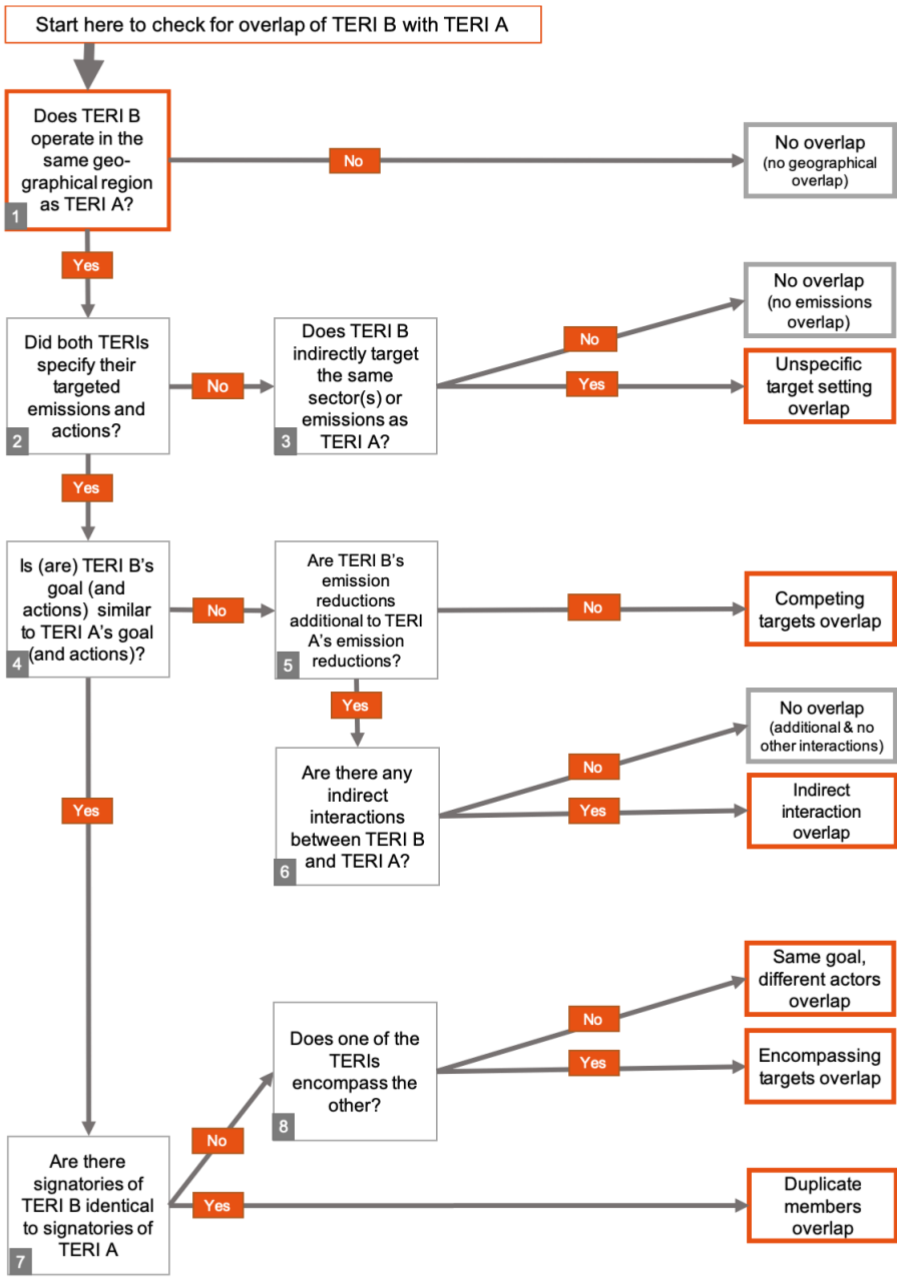


Figure 11 Decision tree for determining overlap between TERIs (own illustration).

3.2.2 Step 2: Determination of overlap rates

After overlaps and categories of overlap were defined in Step 1, the identified category of overlap was used as a starting point for determining or calculating the overlap rates. An overlap rate (OR) is given in a percentage of a preceding initiative, see eq. 1 and eq. 2.

$$OR_{C,A} = x\% \rightarrow C\ overlaps\ with\ x\%\ of\ A \qquad \text{eq. 1}$$

$$OR_{C,B} = y\% \rightarrow C\ overlaps\ with\ y\%\ of\ B \qquad \text{eq. 2}$$

If the data availability allowed it, all overlaps were based on the expected overlap of 2030, to find the most accurate representation of overlap as possible. When it was not possible to base overlap rates on the 2030 values, it is stated below. Detailed calculations and argumentation are provided in the Excel appendix. In the Excel file, it is also specified more elaborately where country-specific overlaps differed and how the global overlap rates were determined. The methods described below are about the most frequently used overlap rates in countries.

3.2.2.1 Duplicate targets overlap

Duplicate members overlap was identified in roughly two manners. First, it was found to occur on a large, national scale when the duplicate signatories came from sovereign states. In such a case, the TERI was assumed to fully overlap with the preceding, (almost) identical TERI, Hence, an overlap rate of 100% was applied, and when necessary adjusted for the (slight) discrepancies in actions or targeted technologies. Second, duplicate members were between cities' initiatives. In such a case, the least ambitious initiatives were not considered for actors committed to two or more initiatives. This meant that the TERI GCoM was prioritized over the TERI C40 when a city was involved with both.

Encompassing membership overlap was accounted for by adjusting the quantification processes: the potential impacts from legislative entities (here, cities) that were embraced by larger committed legislative entities (here, regions) were removed from the aggregated results. In practice, this meant that ERPs from cities' initiatives were neglected when the encompassing region was committed to Under2MOU. Because the ambition levels of cities' initiatives were rather similar to the regional initiatives, no extra correction for different levels of ambition was found to be necessary. The ERPs of cities presented in Table 9 were already accounted for encompassing targets overlap.

For *same goal, different actors overlap* estimates of overlaps in the goals and targeted actions were made, based on a quick analysis on the initiatives in question.

3.2.2.2 Targeted emissions overlap

As explained in section 2.2.2, there are two types of targeted emissions overlap: competing targets overlap and indirect interactions overlap. The GHG emission reduction potentials of the analysed TERIs were not large enough to be competing for emission reductions. Although indirect interactions overlap was identified in various cases (see Figure 12, section 4.1.1), not much was known about the extent and impact of it and because of time constraints further research was not possible. Therefore, conservative overlap rates were applied in case of indirect interaction: 5-10%.

3.2.2.3 Unspecific target setting overlap

In case of *unspecific target setting overlap*, emissions coverage was used as an overlap rate. Sufficient data was available to calculate the emissions coverage per country for each instance of unspecific target setting overlap, so it was not necessary to use population coverage or any other shares as a proxy for overlap. As no information was available about the global coverage of TERIs with unspecific targets, for the unspecific target setting overlap in rest of the world and world values an average emissions coverage of the TERI in question was used.

Because of the scale-up calculations of initiatives, it was not possible to calculate emissions coverage for the 2030 potential impact. Hence, the emissions coverage was based on data from 2015, not accounting for the scale-up. In addition, the emissions coverage was not adjusted for uneven distribution of sectors over a country. However, considering that preceding initiatives generally target rural areas more[13], due to a great portion of industry-related TERIs, it was assumed that the lack of scaled-up emissions coverage would balance with the rather high emissions coverage.

3.2.3 Step 3: Quantification of overlap & total overlap rate

After determining the overlap rates, the percentages were converted to an absolute value of overlap. The overlap rates were multiplied with the emission reduction potential (ERP) of the initiative that the overlap refers to, to obtain an overlap in terms of $MtCO_2$ – the quantified overlap (QO), see eq. 3 and eq. 4.

$$QO_{C,A} = ERP_A * OR_{C,A} \quad \text{eq. 3}$$
$$QO_{C,B} = ERP_B * OR_{C,B} \quad \text{eq. 4}$$

Minimum overlap rates were applied on the minimum potential impact, maximum rates on the maximum potential impact. Subsequently, these absolute overlaps were summed, giving the total quantified overlap (TQO) which reflected the total amount of $MtCO_2$ reductions that is supposedly already achieved by preceding initiatives, see eq. 5.

$$TQO_C = \sum_{k=A}^{B} QO_k \quad \text{eq. 5}$$

Based on these minimum and maximum total overlaps, the total overlap rate (TOR) was calculated, which is the total overlap as a share of the calculated minimum or maximum potential impact of the initiative in question. It reflects the percentage of an initiative's ERP that overlaps with preceding initiatives, see eq. 6.

$$TOR_C = \frac{TQO_C}{ERP_C} \quad \text{eq. 6}$$

Subsequently, the final overlap rate (FOR) was determined, see eq. 7.

$$FOR_C = TOR_C - overlapping\ overlaps - reinforcements \quad \text{eq. 7}$$

The total overlap rate was adjusted for overlapping overlaps, as described in section 2.4.3. Overlapping overlaps were accounted for when the TERI in question was found to significantly overlap with two or more TERIs from the same sector. Hence, overlapping overlaps were not considered in case of indirect interaction overlap. In this research, major overlapping overlaps only occurred between EE TERIs. On a global scale, the overlap rate of SEAD was reduced with 50% (i.e. multiplied with 0.5) when U4E and SEAD both overlapped with a TERI, to represent overlapping targets of the EE TERIs. In each country, overlapping overlaps were

[13] This assumption is based on the quantification of UNEP (2015), see section 2.3.4.

only assumed to happen between the EE TERIs with cities and regions initiatives, as the in-country results of EE initiatives were substantially divergent. There, overlap rates for SEAD was reduced with 80%[14].

Reinforcing overlaps were not found to occur in this analysis, for two reasons. One, the calculated potential impact was based on full implementation of the ambition and therefore already entailed rather challenging assumptions. For example, in the case of EE TERIs, implementing reinforcement effects would lead to exceeding theoretical maximums of efficiency improvements. Secondly, in case of obvious technological overlaps, these were avoided in the quantification process and therefore could not lead to reinforcements in the aggregation of potential impacts. In sum, the most conservative approach for reinforcement effects was chosen, in order to stay close to reality when considering the highly ambitious input values. By definition, the share of overlap cannot exceed 100%. Hence, 100% was the maximum FOR.

3.2.4 Step 4: Correction for overlap

In the final step of the overlap calculation, the ERP was corrected for the final overlap as determined in Step 3, resulting in the corrected ERP (CERP). This was done by subtracting the final overlap rate from the calculated potential impact of the TERI in question, see eq. 8.

$$CERP_C = ERP_C - (ERP_C * FOR_C) \qquad \text{eq. 8}$$

3.3 Sensitivity analyses

In order to test the above described methods for robustness, three sensitivity analyses were executed. First, the order in the overlap matrix was tested. Following several of the studied aggregation analyses (e.g. UNEP (2015), Graichen et al. (2017)) and the NSA aggregation guidance NewClimate Institute et al. (2018), TERIs with the largest legislative entities as actors were placed first and the overlap rates were adjusted accordingly. The order in this sensitivity analysis is shown in Table 11. This sensitivity analysis was done for two reasons. First, the analysis provided in the possibility to examine the influence of the order on the feasibility of the analytical framework (e.g. whether or not elements become more complicated with a different order). Secondly, if the analytical framework works properly, the order of analysis should not substantially influence the aggregate result since the amount of overlaps between the TERIs are not affected by the order. Hence, the methods can be tested for accuracy by using another order and no difference in aggregation results was expected.

[14] Please refer to the Excel appendix to see how the calculations were executed.

Table 11 Order of overlap analysis for the first sensitivity analysis

No.	*TERI*	*Sector*
1	UNDER2	Cities & regions
2	GCoM	Cities & regions
3	C40	Cities & regions
4	AREI	Renewable energy
5	GGA	Renewable energy
6	CCAC	Non-CO_2 GHGs
7	RE100	Business & industry
8	SBTI	Business & industry
9	ETIP PV	Renewable energy
10	NYDF	Forestry
11	SEAD	Energy efficiency
12	U4E	Energy efficiency
13	A2030	Buildings
14	CAATW	Transport
15	GFEI	Transport
16	L&G	Transport

In the second sensitivity analysis, the impact of indirect interaction overlaps was tested. The overlap rates of indirect interaction (5-10% in the initial calculations) were increased and decreased with 50%. The height of overlap rates for indirect interaction is the most prone to misconception, while indirect interaction was found frequently in the analysis of this research. Hence, the influence of higher and lower overlap rates for indirect interaction might be grounds for further research. A slight difference of maximum ±5% with the initial aggregate result was expected, based on the relatively low overlap rates.

The third sensitivity analysis was used to test the influence of the final overlap rate. It included a moderate change of ±10% of the total overlap rate (eq. 9 and eq. 10), which was expected to cause similar changes as the second sensitivity analysis (i.e. ±5% difference with the initial aggregate result). Secondly, the final overlap rates were increased and decreased with 50% (eq. 11 and eq. 12), which were expected to give higher differences with the initial aggregation results, up to 25%. The sensitivity analysis of the overlap rate was tested to examine the influence of minor to substantial deviations in the determination of overlap rates.

$$CERP_C = ERP_C - (ERP_C * 0.9FOR_C) \quad \text{eq. 9}$$

$$CERP_C = ERP_C - (ERP_C * 1.1FOR_C) \quad \text{eq. 10}$$

$$CERP_C = ERP_C - (ERP_C * 0.5FOR_C) \quad \text{eq. 11}$$

$$CERP_C = ERP_C - (ERP_C * 1.5FOR_C) \quad \text{eq. 12}$$

4 Results

4.1 Step 1, 2 and 3: intermediate results from methodological framework

4.1.1 Step 1: Identified overlaps

For Step 1 of the analytical framework, the occurrences and categories of overlap need to be determined. As described in section 3.2.1, an overlap matrix was used for this, meeting GPs I, II and III (Box 1). The resulting matrix is shown in Figure 12, a larger version of the figure is provided in the Excel appendix. Figure 12 shows all identified overlaps between initiatives, and specifies the category of overlap. In some cases, half indirect interaction was found, generally when only half of either initiatives overlaps. If no overlap was found, the cells show an 'n'.

			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
			U4E	SEAD	A2030	CCAATW	GFEI	L&G	AREI	GGA	ETIP PV	SBTI	RE100	NYDF / Bonn	NYDF / GCFTF	CCAC	Under2	C40	GCoM
Energy efficiency	1	U4E		Y: duplicate members	n	n	n	n	Y: indirect interaction	Y: 1/2 indirect interaction	n	n	Y: 1/2 indirect interaction	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
	2	SEAD			n	n	n	n	Y: 1/2 indirect interaction	Y: 1/2 indirect interaction	Y: indirect interaction	Y: same goal, different actors	Y: indirect interaction	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
Buildings	3	A2030				n	n	n	n	Y: 1/2 indirect interaction	n	n	n	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
Transport	4	CCAATW					n	n	n	n	n	n	n	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
	5	GFEI						n	n	n	n	Y: same goal, different actors	n	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
	6	L&G							n	n	n	n	n	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
Renewable energy	7	AREI								Y: 1/2 indirect interaction	n	n	n	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
	8	GGA									Y: 1/2 indirect interaction	n	Y: indirect interaction	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
	9	ETIP PV										n	Y: indirect interaction	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
Businesses	10	SBTI											n	n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
	11	RE100												n	n	n	Y: unspecific target setting	Y: unspecific target setting	Y: unspecific target setting
Forestry	12	NYDF / Bonn														Y: indirect interaction	Y: unspecific target setting	n	n
	13	NYDF / GCFTF														Y: indirect interaction	Y: unspecific target setting	n	n
non-CO2 GHGs	14	CCAC															Y: unspecific target setting	n	n
Cities and regions	15	Under2																Y: encom-passing targets	Y: encom-passing targets
	16	C40																	Y: duplicate members
	17	GCoM																	
Overlap rates with preceding initiatives			n/a	44%	0%	0%	0%	0%	0%	10%	31%	5%	15%	6%	0%	0%	33%	45%	34%

Figure 12 Overlap matrix, demonstrating the identified overlaps and global final overlap rates

Because the GHG emission reduction potentials of the seventeen TERIs were always additional to each other, no competing targets overlap was identified in Figure 12. However, this led to many cases of indirect interaction as TERIs were regularly found to target the same source of emissions. In addition, unspecific target setting is a common category of overlap due to the three major cities and regions TERIs and their place as final sector in the matrix analysis. In many cases, TERIs do overlap due to a different geographical scale (e.g. AREI and ETIP PV). In addition, overlap was often avoided during the quantification process of potential impact which would result in no overlap in Figure 12, or only indirect interaction overlap. Hence, the number of overlaps demonstrated in the matrix is lower than initially identified, or which are theoretically there.

4.1.2 Step 2 & Step 3: (final) overlap rates

As described in section 3.2.2, overlap rates depend on the overlap categories as identified in the matrix (Figure 12) and, in general, the share of overlapping ERPs. Most evidently, this resulted in the systematic approach for unspecific target setting, using the emissions coverage of committed cities and regions. The emissions coverage rates were found to be rather low in Global South countries (e.g. Indonesia and India), sometimes even close to 0%. However, this was assumed not to be problematic, as the overall GHG emission reduction potential in Global South countries was relatively low as well. Likewise, the emissions coverage rates of cities and regions initiatives for Global North countries were high, which balances with the higher ERPs of TERIs. In addition, this is in line with increased "strength" of overlap when potential impacts are higher, as touched upon before in section 2.4.2. Another frequently used overlap rate was related to the high number of indirect interaction overlaps. Many rather low overlap rates were applied in the calculations. Overall, overlap rates were often in the same order of magnitude, except for some outliers (e.g. high emissions coverage in some countries, and high overlap rates between the two EE initiatives). The overlap rates were feasible and led to quite constant total overlap rates in each country. However, it should be noted that due to the avoidance of overlap in the quantification, not many overlap rates needed to be calculated and a lot of complexity and inaccuracy was prevented.

In the bottom row of Figure 12, the final overlap rates with preceding initiatives for the world's results are demonstrated. In the column for U4E "n/a" is given, as it is the first TERI and therefore has no preceding initiatives. It should be noted that these overlap rates do not reflect the theoretical overlap, as a lot of overlap was avoided by tweaking the quantification processes. Especially between cities' initiatives a lot of overlap was avoided, as explained before in section 3.2.2.

4.2 Step 4: Aggregate potential impact, corrected for overlaps

In Table 12, the global emission reduction potentials per initiative are presented. In the third column, the potential impact without a correction for overlap is given, including the applied range when the calculated potential impact was given as a single-point estimate (as opposed to Table 9, where single point ERPs were given). In the last column, the global emission reduction potentials when accounted for overlaps are shown. The global final overlap rates, presented in Figure 12, were applied on the calculated ERPs to correct them for overlaps.

Table 12 Emission reduction potentials of the analysed ICIs, without and with correction for overlap.

Sector	TERI	Emission reduction potential for 2030 ($GtCO_2e$/year), not accounted overlaps (minimum – maximum)	Emission reduction potential for 2030 ($GtCO_2e$/year), accounted for overlaps (minimum – maximum)
Energy efficiency	**U4E**	0.56 – 1.20	0.56 – 1.20
	SEAD	0.53 – 1.22	0.36 – 0.62
Buildings	**A2030**	0.18 – 0.20	0.18 – 0.20
Transport	**CCAATW**	0.44 – 0.55	0.44 – 0.55
	GFEI	0.43 – 0.54	0.43 – 0.54
	L&G	0.02 - 0.02	0.02 – 0.02
Renewable energy	**AREI**	0.32 – 0.80	0.30 – 0.71
	GGA	0.22 – 0.47	0.18 – 0.30
	ETIP PV	0.21 – 0.48	0.21 – 0.46
Business & industry	**SBTI**	2.03 – 3.39	2.04 – 2.10
	RE100	1.88 – 4.03	1.82 – 3.75
Forestry	**NYDF (Bonn Challenge & GCFTF)**	5.38 – 5.62	5.38 – 5.62
Non-CO_2 GHGs	**CCAC**	1.13 – 1.41	0.86 – 0.85
Cities & regions	**UNDER2**	4.55 – 5.00	3.06 – 2.18
	C40	1.19 – 1.49	0.91 – 0.85
	GCOM	1.15 – 1.44	0.94 – 0.94

In Table 13 below, the sum of potential impact without a correction for overlap is provided, compared to the aggregate of the ERPs when accounted for overlaps. The correction for overlap has led to a 13% reduction of the minimum potential impact, the maximum potential impact was reduced with 23% due to overlaps, when comparing the aggregate to the sum of all ERPs. A major part of this reduction is due to overlaps of Under2 with preceding initiative (unspecific target setting), as explained above. The maximum overlaps reduction of almost a quarter is substantial, especially when considering that many significant overlaps were already avoided in the quantification process (see section 3.2.2) and the targeted sectors are rather divergent (see section 3.1). As may be predicted from the overall moderate overlap rates, the differences with the ERPs after corrections for overlap are not extremely high. Only the results of Under2, C40 and GCOM are quite notable. Due to the high maximum overlap rate and the TERIs' activity in high-impact countries, the maximum emission reduction potentials were found to lower than the minimum after the correction for overlap.

Table 13 The global sum of the emission reduction potential of all TERIs without a correction for overlaps, the TERIs' global aggregate reduction potential with a correction for overlap, and the percental difference between the sum and aggregate.

	Minimum emission reduction potential for 2030	Maximum emission reduction potential for 2030
Sum all of all TERIs (not accounted for overlap)	20.4 $GtCO_2e$/year	27.2 $GtCO_2e$/year
Aggregate of all TERIs (accounted for overlap)	17.7 $GtCO_2e$/year	20.9 $GtCO_2e$/year
Percentage reduction after overlap correction	13%	23%

4.3 Sensitivity analyses results

As described in section 3.3, three elements of the analytical framework were tested for sensitivity and robustness. In Table 14, the global aggregate of the potential impacts is shown, for each applied sensitivity analysis and accounted for overlaps.

Table 14 Sensitivity analyses, expected results, absolute and relative results

Sensitivity analysis	Expected effect	Minimum potential impact in 2030 ($GtCO_2e$/year)	Percentage difference with initial minimum results	Maximum potential impact ($GtCO_2e$/year)	Percentage difference with initial maximum results
1: Different order in overlap analysis	No to little difference	17.4	-1.7%	20.7	-0.6%
2: Indirect interaction overlap rates, reduced with 50%	Slight difference (higher)	17.8	0.7%	21.2	1.3%
2: Indirect interaction overlap rates, increased with 50%	Slight difference (lower)	17.2	-2.9%	19.2	-7.8%
3: Total overlap rates, increased with 10%	Slight difference (lower)	17.3	-2.1%	19.8	-4.7%
3: Total overlap rates, increased with 50%	Big difference (lower)	16.2	-8.3%	17.2	-17.4%
3: Total overlap rates, decreased with 10%	Slight difference (higher)	17.9	1.1%	21.2	1.6%
3: Total overlap rates, decreased with 50%	Big difference (higher)	19.0	7.4%	23.9	14.5%

4.3.1 Sensitivity analysis 1: different order of analysis

For the different order of analysis, no to little difference with the initial results was expected. Concerning the maximum results, this expectation was indeed met. However, for the lower-end estimate, a rather large difference of 1.7% (0.3 $GtCO_2e$/year) was found. A possible explanation for this is that in the initial calculations the maximum impact of a TERI was often found to be negligible due to overlaps, while some minimum impact remained. When using the different order of analysis, minimum and maximum potential impacts were often found to be negligible simultaneously. Hence, the relative difference between the minimum and maximum potential impact was kept more constant with the different order of analysis. In that sense, this methodology was found beneficial for finding more realistic results. However, the different order of analysis resulted in a substantial overlap of initiatives with the first three TERIs of analysis (i.e. the cities and regions initiatives). Although the aggregate result stayed almost identical to the initial result, the individual results of TERIs were affected greatly. When presenting such results in an aggregation study, this might lead to politically sensitive situations, where TERIs compete with each other, or debate the credibility of results.

Another notable result of this sensitivity analysis entails the applicability of the other order of analysis. Cities and regions TERIs overlap as unspecific target setting with other initiatives. In order to find the extent of overlap, the emissions coverage needs to be determined of the initiatives lower in the matrix. For sector-specific TERIs, this information is almost never available, or built on numerous uncertainties, where it is more often available for cities and regions. Therefore, for calculating the extent of unspecific target setting overlap, the order of analysis in the sensitivity analysis was more complicated for the calculations. To avoid mistakes, cities and regions need to be analysed last.

4.3.2 Sensitivity analysis 2: different height of indirect interaction overlap rates

The decrease of the indirect interaction overlap did not lead to any surprising results. On the other hand, the increase of indirect interaction overlaps gave substantially different outcomes, and the differences were far larger than after increasing the indirect interaction overlap rates. This is presumably due to the fact that more initiatives reach a negligible potential impact with higher overlap rates, which means that the decrease of the potential impact goes faster than the increase when applying higher or overlap rates (see chapter 5). In sum, using indirect interaction overlap rates which are on the rather low side do not lead to very divergent results. However, higher indirect interaction overlap rates may lead to a somewhat conservative aggregation result.

4.3.3 Sensitivity analysis 3: different height of final overlap rates

Similar to sensitivity analysis 2, the increase of final overlap rates led to a higher difference than the decrease with the same factor. Moreover, no large deviations were found with increasing or decreasing the overlap rates with 10%, which could mean that minor mistakes or uncertainties will not lead to any substantial deviations in the aggregate result.

In this analysis, the increase and decrease of 50% in the final overlap rates led to a difference of roughly 1.5 $GtCO_2$ on the low end, to roughly 3 $GtCO_2$ on the high end. This demonstrates that maximum results are affected more than minimum results. In addition, the rather high differences represent that the height of overlap rates has a substantial impact on the final result. Considering the past political impact of aggregation analyses, and perhaps more importantly, the future impact (as discussed in chapters 1 and 2), determining overlap rates require care and accuracy.

5 Discussion

Below, the research limitations, the shortcomings of the applied methods and to some extent the impact of the results are discussed. The chapter is divided into three sections. The first section elaborates on the shortcomings of the analytical framework and focuses on the general applicability, the elements which cannot be addressed by this framework and to what extent the developed framework contributes to the research field. In the second section, the shortcomings of the methods are discussed. Here, some general shortcomings are addressed, as well as case-specific issues. In the final section of this chapter, the impact of aggregation analyses and NSA in general are debated. In each section, points for future research are presented as well.

5.1 Limitations of analytical framework

5.1.1 Applicability of the analytical framework

Although the framework is developed to subtract overlaps in the sum of the potential impacts, it became evident during the analysis that avoiding overlaps before aggregating the potential impacts was found to be the most accurate and easiest in practice (see sections 3.2.2 and 4.1.2). Avoiding overlaps can be done in two ways: in the quantification, by deliberately quantifying certain mitigation elements of the TERIs and leaving out the overlapping elements, or by selecting TERIs for the aggregation which are unique in a sector or its mitigation efforts. If avoiding overlaps is not possible, the required effort is a limitation to the applicability of this analytical framework.

Another shortcoming of the analytical framework is that it is only applicable to quantifiable targets, which can be converted to GHG emission reductions in a target year. The framework was developed with a theoretical basis from other aggregation analyses, but also adjusted to be most applicable to the type of input data that was provided. Therefore, overlaps between initiatives with more qualitative targets cannot be analysed with the current state of the framework. This is related to the discussion in section 5.3, on biased selection of NSA initiatives for aggregation analyses.

Third, the framework is converted to an Excel model, which is based on the assumption that overlaps do not lead to reinforcements and that overlaps are always additional to each other (i.e. not overlapping). Although the total overlap rates can be adjusted before the correction for overlap rates is executed, it is difficult to automate in a tool and no clear guidelines are provided in the analytical framework to determine to what extent the overlap rate needs to be adjusted. In this research, the input values were already based on full implementation and target realization of the (already ambitious) TERIs. Therefore, adding reinforcements would have led to unrealistically high outcomes, but future research is required to determine how this can be done with inputs that do lead to reinforcements. Additionally, overlapping overlaps were accounted for to some extent (i.e. decreasing the total overlap rates), but some uncertainty about the correctness of this method remains and further research is required for this. This also applies to the way results are obtained from the framework. Because of the current assumption that overlaps do not overlap and build upon each other, the results of individual TERIs might be politically sensitive. Although the order of the analysis has been argued in section 3.2.1, it appeared to be of great influence on separate results. A better way of distributing (overlapping) overlaps might be a solution to overcome the political sensitivity.

The analytical framework is currently ideal to assess overlaps in one country or region. To find the aggregate results for several individual countries, the process needs to be repeated and adjusted each time, which is the fourth limitation of the framework. Especially determining the different overlap rates might be time-consuming. Therefore, developing quantitative categories for overlap rates might be useful to reduce the amount of required effort. In addition, categories might avoid mistakes or underestimates in the determination of overlap rates, as they are based on several assumptions (for example, see the overlaps between GGA and ETIP PV and SBTI and GFEI in the Excel appendix). Further research is required to conclude whether there is any theoretical basis for establishing categories of overlap.

Another shortcoming of the analytical framework is that it is aimed at finding rather direct overlaps between initiatives. This means that indirect overlaps are neglected, besides the indirect interaction in its current definition. Neglected indirect overlaps include for example the positive and negative side-effects from the implementation of renewable electricity – decreased methane emissions from fossil fuels mining, less developments of new fossil-fired power plants, or the emissions and ecological disadvantages from producing and installing wind turbines. Another example would be increased HFC emissions from replacing air conditioners under EE initiatives. Such indirect effects between were not considered in the quantification of the initiatives and overlap calculations, but do have a potential impact on the overall extent of overlap. However, indirect overlaps require a more in-depth analysis of initiatives and are difficult to capture in a broad-scoped aggregation analysis. Here, it is assumed that they do not lead to any substantial differences, but future research is required to ascertain this. In addition, the indirect overlaps should be considered when an aggregation analysis is done with a smaller (e.g. more local) scope.

Finally, the overlap calculations did not address overlaps with national and transnational policies. However, it might be plausible to assume that governments will perceive the implementation of TERIs as contributions to their national policies and pledges, which would mean that only the national policies scenario would be achieved and TERIs would not be additional (Widerberg & Pattberg, 2015). To avoid any major overlaps with national policies, the current policies scenario was chosen for baseline emissions. However, this does not guarantee that all overlaps with (inter)national policies were avoided. The analytical framework needs to be expanded to cover overlaps with national policies, which requires future research. In general, it would be a good addition to the current set-up of the framework to make the calculations (almost) fully automatic. Such a tool or model would be beneficial for the overall time consumption and possibly the accuracy of results.

5.1.2 Contribution to the research field

One of the most important features of a good research project is its replicability, which is closely related to the amount of reporting on applied methods, data input, assumptions etc. However, as shown in section 2.3, many existing aggregation analyses and especially the applied overlap calculations were not found to be replicable. With the development of the presented analytical framework, an attempt was made to make reporting on overlap calculations easier, more transparent and accurate. However, while going through the analysis, it became evident that documenting every single step was nearly impossible, would lead to a lot of repetition and meaningless results. In general, the (final) overlap rates are only useful for the analysed cases. Only the applied methods are possible to be transferred to other research projects. Hence, a more general style of documentation was chosen, which could function as an example of accurate yet accessible reporting. The developed analytical framework can contribute to accurate execution of future NSA aggregation analyses, but the process of developing the analytical framework affirmed that a lot uncertainty about the potential impact of NSA exists and that it requires more research. The Excel calculations are added for more transparency of this research and to open doors for future improvements and research into overlaps and NSA in general.

5.2 Limitations of methods

The majority of the input values (i.e. the ERPs without a correction for overlap) were given in a minimum and maximum value. Therefore, the Excel model in its current shape requires a minimum and maximum overlap rate. When the potential impacts were given without a minimum and maximum value, the minimum value was obtained by subtracting 20%. If this was not done, the maximum corrected potential impact would often be lower than the minimum. However, the application of 20% is rather arbitrary and sometimes the overall calculations still led to a higher minimum result than maximum which limits the consistency of the results. A possible solution might be to adjust the difference between minimum and maximum overlap proportionally to the height of the potential impacts, but this would make the overlap calculations a little more complicated. Future research is required to determine whether this would be a good solution or any other steps are needed.

The decision tree which was used to develop Step 1 of the analytical framework (identification of overlap) is almost entirely based on own interpretation of implicit assumptions from the ten aggregation analyses. Although most questions and corresponding next steps in the decision tree are highly intuitive, it is mainly not based on academic literature. It was used as a key figure to determine the overlaps and therefore might be a good first step for consistency in overlap identification, but requires a great deal of future academic basis.

The height of indirect interaction overlap (i.e. 5-10%) was determined in a rather arbitrary way (5-10%), due to data gaps and time constraints. However, it was used to reflect a major part of the overlaps that were found in the analysis, so its potential impact is high. Although it was tested for robustness in one of the sensitivity analyses, it is necessary to examine indirect interaction overlap in future research more extensively in order to obtain a more accurate estimate of its effect.

Barely any overlap was found between CCAC and other TERIs, which was based on the assumption that no other GHGs than CO_2 were quantified in the other initiatives. However, it was not entirely certain if this was the case for every TERI (e.g. the transport TERIs).

For the overlap between cities and regions TERIs with preceding initiatives (unspecific target setting overlap), the emissions coverage of the cities and regions initiatives was calculated. However, this was not corrected for the uneven distribution of sectoral emissions. It was assumed that this would balance with not accounting for the scale-up of the TERIs, but this is not completely certain. Additionally, it might not be a “fair” way of coping with both data inconsistencies.

5.3 General shortcomings and meaning of NSA and aggregation analyses

The large share of reduction that was found due to overlaps might indicate that non-state and subnational actors are copying each other's behaviour and generally do not target the policy areas where more difficult ambition and action is required – costly measures or far-stretching changes in lifestyle. NSA might become "hip" and a nice addition to actor's so-called 'green policies', possibly leading to green-washing, while the truly important sectors or changes are left untouched – for example, deep decarbonization of electricity generation and heat sources, dietary changes in Global North countries or far-stretching changes towards circularity (Guy et al., 2019; Widerberg & Stripple, 2016). Moreover, a great disbalance exists between the number of actions in the Global North and South, with a lot greater weight in the North (Chan, Falkner, et al., 2016). Transparency within and orchestration of global non-state and sub-national actions are required for less overlaps to begin with (Bäckstrand et al., 2017). However, NSA is often posed as a potential silver bullet in the (political) climate crisis (see chapter 1). One might wonder if it is the responsibility of non-state and subnational actors to solve the climate change, especially when they tend to avoid the "painful" policies and often have large overlaps.

The results in this thesis are not meant to demonstrate that NSA is the silver bullet for the global climate crisis. On the contrary: the ambitions that are behind the initiatives are of such great extent that the results should be somewhat alarming. If the seventeen TERIs under analysis all achieved their targets, their sum impact would consist of up to a quarter of overlap and the aggregate would still not be sufficient to meet the Parisian target of maximum 1.5 °C global temperature increase above industrial levels.

However, the results showcase the potential of non-state and subnational actors and illustrate the power of entities which are currently not part of official climate debates. Although it is not realistic to assume that the TERIs will fulfil the results presented in chapter 4, their enormous ambitions may be seen as catalysators for (inter)national climate policies. Their power should exemplify to what extent (inter)national governments can increase their ambition and that collaboration between all layers of society can cause a major shift towards carbon neutrality. Hence, with collaborative ambition and supportive actions and financing worldwide, the results do become realistic.

The aggregation analysis here has proven what is possible – in theory. Aggregation analyses are of great importance for the first step towards ex-post analyses – aggregation analyses show the value of NSA and provide in the initial estimates of actions. Tracking of NSA implementation would be a crucial addition to reliability of aggregation analyses and NSA in general. Moreover, overlap calculations in such ex-ante and ex-post studies are essential for credibility and accuracy, but also for finding 'action gaps' and fruitful targets. The framework presented in this thesis may be seen as the first step towards a more extensive and comprehensive framework for overlap calculations in bottom-up NSA quantifications. In short, the underlying message of the results in this thesis is not that NSA will solve the climate crisis, but is threefold 1) the ambitions of NSA are so great that they can function as an example to global climate politics 2) accurate and credible aggregation analyses are required for developing ex-post analyses and 3) overlap calculations are crucial for both the showcasing function and credibility and accuracy.

6 Conclusion

The research question of this thesis as presented in chapter 1 was as follows: *How can methods to account for overlaps in non-state and subnational action aggregation analyses be refined and what is the aggregate potential impact of key initiatives, using the proposed overlap calculation method?* The research question exists of two elements which are closely related: 1) a refinement of methods to account for overlaps between NSA initiatives and 2) the aggregated potential impact of these initiatives, when applying the refined overlap method. Based on seven good practices, an analytical framework was developed to account for overlaps between initiatives in an aggregation analysis.

The analytical framework was applied on the potential impacts of seventeen TERIs. Their summed emission reduction potential before overlap calculations was estimated at 20.4 – 27.2 $GtCO_2e$/year in 2030, compared to a CPS. In the first step of the analytical, an overlap matrix was developed to find and illustrate overlap and the types overlap, using an overlap decision tree. In step 2, the size of overlap was determined, based on the identified types of overlap and corresponding calculations, resulting in overlap rates. In step 3, these overlap rates were converted to overlap in terms $GtCO_2e$/year, which led to the total quantified overlap and subsequently the total overlap rate. This latter rate was adjusted for any overlapping overlaps (no reinforcement effects were found in this research). The summed potential impact was corrected for overlaps in step 4, which gave the aggregate emission reduction potential.

The analytical framework was found to be a suitable and useful way to refine the methods to account of overlaps in aggregation analyses. It resulted in a clear step-by-step approach, which seemed to avoid errors and increased the replicability of aggregation analyses. The presented analytical framework may be seen as a first step towards consistency in overlap calculations. Especially the developed decision tree and approach for determining overlap rates, considering data and time availability, might function as practical and applicable methods in addressing overlaps in aggregation analyses. Although several elements of the analytical framework require future research for a more thorough academic basis, the framework was found to be beneficial for transparency and replicability of methods for addressing overlaps. On the other hand, it requires a lot of effort and is rather time-consuming. Some quantitative elements are prone to mistakes, which raises the desire for a more category-based approach, but more research is required to determine whether this is possible or not.

The aggregate potential impact of the seventeen TERIs was found to be 17.7 – 20.9 $GtCO_2e$/year in 2030 after overlap calculations, compared to a CPS. Hence, accounting for overlaps led to a reduction of roughly 13-23% of the summed potential impacts. This illustrates the importance of addressing overlaps in an aggregation analysis, especially considering the current global expectations of NSA. Although a rather substantial part of the summed ERPs was indeed overlapping, the aggregate result is still quite large. However, this does not mean that NSA is the silver bullet for solving the global climate crisis. Rather, it exemplifies how far-reaching and extensive mitigation ambitions can be and to what extent non-state and subnational actors can shift the climate crisis, given that highly supportive circumstances are in place. In sum, the exemplary ambitions of NSAs can bridge the emissions gap, but chickens should not be counted before they hatch.

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