Global Aggregation of City Climate Commitments

Methodological Review

Version 2.0
Final White Paper

C40 CITIES
CLIMATE LEADERSHIP GROUP

ARUP

Contents

Appendices

Glossary of terms

Baseline	A historic or current emissions inventory for a city from which it sets its targets. Not necessarily used by every city.
BAU	Business as Usual. Used in this work to refer to a future emissions trajectory based on cities' emissions intensities continuing into the future, with emissions growth determined by population growth rates.
CCAP	City Climate Change Action Plan.
GHG	Greenhouse Gas. Covers all gas emissions with global warming potential. Usually reported as carbon dioxide equivalent.
Inventory	Breakdown of a city's GHG emissions in a given year. This can be reported in a number of ways, covering emissions scopes, sources or more.

1 Introduction

Arup and the C40 Cities Climate Leadership Group (C40), in partnership with ICLEI-Local Governments for Sustainability, United Cities and Local Governments (UCLG), UN-Habitat, the UN Secretary-General's Special Envoy for Cities and Climate Change and the World Resources Institute, have assessed existing voluntary carbon commitments of cities around the world. The work aims to demonstrate the robust actions cities are already taking to mitigate greenhouse gas (GHG) emissions.

GHG reduction commitments matter because they drive action and further investment in cites. City governments with emissions reduction targets report three times as many emissions reduction activities as cities without targets.[1]

This methodological white paper serves as a companion to the report *Working Together: Global Aggregation of City Climate Commitments* published during Climate Week NYC 2014. It presents a review of the methods used in the research in further detail.

1.1 Challenges and limitations

The scope and timescale of this study precluded a full bottom-up analysis of each city's current emissions and future emissions trajectories under Business as Usual (BAU) and target reduction scenarios.

To date, cities have reported their emissions targets in a variety of forms, which were often not directly comparable. Examples include targets against a historical emissions baseline, or as a reduction on some future emissions scenario. Therefore, it was necessary to establish a method for standardising the targets results for each reporting year.

The project partners believe the aggregation methodology employed in this study will be enhanced by taking key findings into account and by identifying future avenues for investigation. Section 5 further discusses the potential for additional work and possible solutions to the current limitations of this study.

1.2 Summary of approach

The following steps establish a robust set of results for cities with emissions and targets data, before aggregating target trajectories and setting these against a common baseline and BAU trajectory to estimate future savings.

The main steps of this process are summarised below:

1. Establish the rules and rationale for standardising reporting of GHG savings to allow consistent comparison and aggregation (see Section 2);
2. Collect GHG savings target and inventory data where available (see Section 3);
3. Combine the results for all cities to provide an estimate of total city committed savings.

[1] CDP Cities: Measurement for Management 2012 p 36

2 Aggregating GHG Targets

Review of city climate change action plans (CCAPs) and existing databases shows GHG emissions and GHG emissions targets can be measured and declared in a number of ways. To compile a total savings figure for all cities, GHG targets must be expressed in the same format, regardless of how they are reported in source documents. This section outlines the different approaches to measuring GHG levels and targets, and the method employed in this study to standardise them.

2.1 Emissions scopes

GHG emissions are measured and reported according to one of three "scopes", as defined by the IPCC[2] and GPC[3]. Table 1 below summarises the GHG emissions captured by each scope.

Table 1. GHG emissions reporting scopes

Scope	Description
1	GHG emissions from sources located within the geographic boundary of the city.
2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the geographic boundary.
3	GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Not all cities choose to report emissions inventories or targets against all three scopes. Of the cities investigated, the vast majority reported scope 1 and 2 emissions, but not scope 3. Many cities also did not explicitly break down their inventories or targets by scope, preferring to focus on total sector emissions (e.g., from housing, industry, and transport).

The question of emissions scopes does raise a challenge for the study, as the "completeness" of inventories may differ between cities. However, the focus of this work is on reporting emissions savings *commitments*; as long as targets include all scopes reported in inventories, this is not an issue for the aggregation. The effect is that some cities will have relatively larger total inventories (if including scope 3).

An issue for cities including scope 3 emissions in their targets is the potential for double-counting of emissions savings. For instance, one city may reduce its scope 3 emissions from purchase of goods by virtue of another city reducing its scope 1 emissions associated with the production of those goods. To an extent, such double counting is also possible, if rare, to an extent for scope 2 emissions, especially for cities that have both scope 1 and 2 targets and that account for emissions from electricity generated within the city in both scope 1 and 2.

At a minimum, cities included in this study were required to report inventories and targets against scope 1 and 2 emissions. The majority of cities did report via either scope 1, or scope 1 and 2. A very small number of cities also reporting

[2] Intergovernmental Panel on Climate Change
[3] Global Protocol for Community-Scale GHG Emissions

scope 3 emissions inventories have been included in the aggregation, as long as their targets also included scope 3 emissions.

As noted above, including scope 3 emissions reductions introduces a small possibility of double-counting. For instance, a target to reduce consumption of goods in one city may result in lower scope 1 and 2 emissions in the city in which they were manufactured. Under this approach both cities would report a saving for the same reduction. This is recognised as an issue for consideration in future aggregation work covering very large numbers of cities. However, given that such a small proportion of the 228 cities included in this analysis reported scope 3 emissions, this is considered to be of negligible impact for this investigation.

2.2 Different approaches to GHG targets

Broadly, there are three approaches to reporting GHG emissions targets:

1. Savings against a historical baseline (for instance London's commitment to reducing its GHG emissions by 80% of its 1990 baseline)
2. Savings against a projected business as usual trajectory
3. Intensity savings (e.g., Beijing's official target of reducing CO_2 emissions per unit GDP by 60% of 2005 levels by 2020)

Cities with fast-growing emissions (typically those with fast-growing populations, or rapidly industrialising cities) often target GHG savings differently than those with generally stabilised background emissions growth. To achieve a given future absolute annual emissions reduction versus historic levels is more challenging under these circumstances. In some cases, it is more likely to have significant slowing of emissions growth rather than an absolute reduction compared to today. This situation still represents a significant overall savings compared to a scenario where a city pursues no climate action.

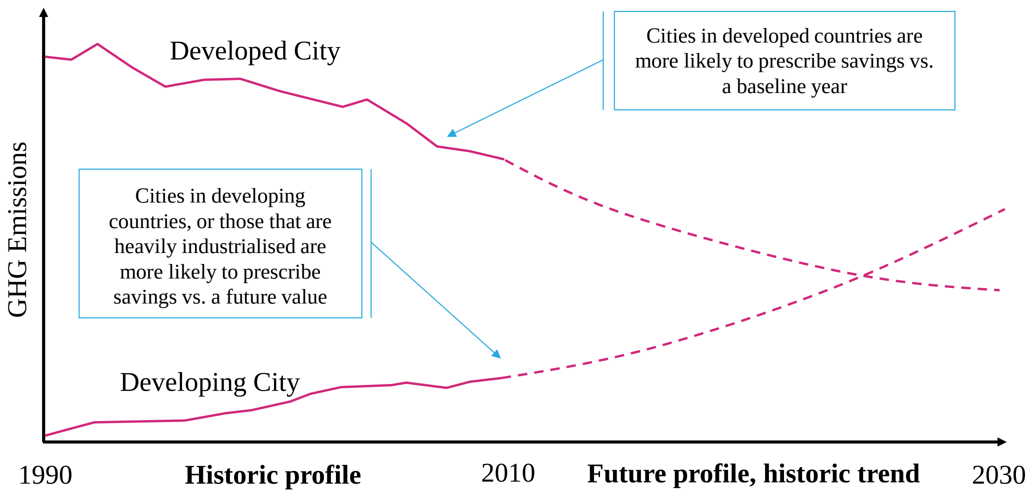


Figure 1. Examples of future GHG trends for developed and developing cities

Savings against a base year level relies on selecting a baseline year, measuring the emissions in the year, and then committing to delivering a lower level of emissions at some point in the future – the target year. This is illustrated in Figure 2 below. Notice that overall emissions have reduced over time.

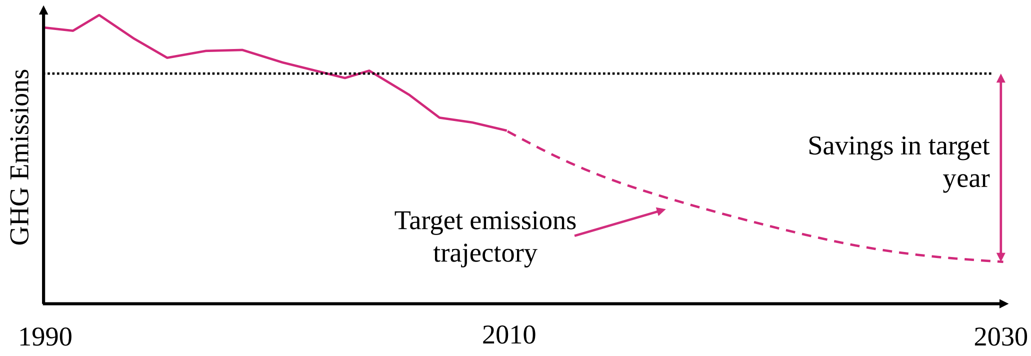


Figure 2. GHG reduction target against a base year level

For targeted savings against a business as usual trajectory, it is necessary to estimate how emissions levels would change were no further GHG mitigation policies introduced from this time onwards, thus enabling an estimation of the total emissions in the target year. There are various approaches for estimating the BAU (preferred approach discussed in Section 2.4). The GHG target is then expressed as a reduction in emissions in the target year as compared with the BAU case for that same target year.

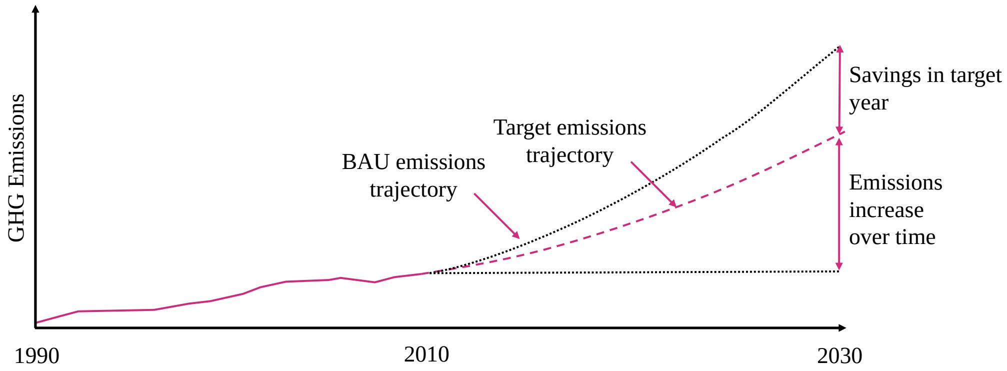


Figure 3. GHG reduction target against a business as usual projection

Note in Figure 3, reporting a saving relative to the BAU can still represent an increase in emissions relative to today.

Both of these approaches allow for the estimation of the important data for this study: the targeted GHG emissions ($MtCO_2$) in the target year. By adding this value for every city, we are able to estimate future GHG levels for all cities. Both of the above approaches allow this to be calculated.

However, the absolute savings calculated by each method are not directly comparable, due to the different reference points used. To account for this, a standard BAU scenario for each city must be defined; this is discussed further in Section 2.4.

For calculating intermediate emissions levels for years before a city's target, a linear interpolation has been used, as indicated in Figure 4. While some cities do present more complicated trajectories, for reasons of consistency this simpler approach has been adopted for all targets.

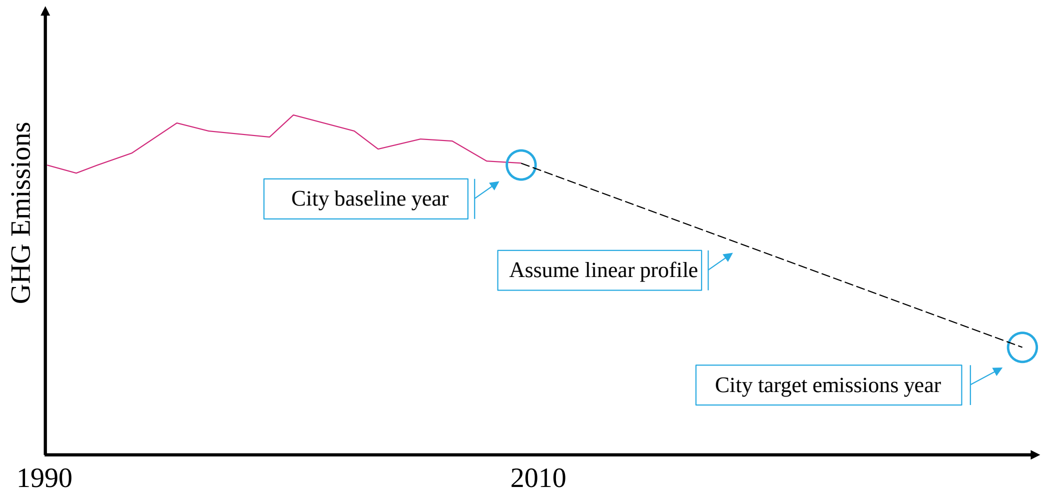


Figure 4. Determining intermediate GHG emissions for cities

2.3 Reporting GHG savings for this study

For the output of this study, there are a range of options for setting and presenting GHG emissions and savings, including:

- Absolute GHG savings against a baseline or BAU projection [$MtCO_2$]
- Percentage savings against a baseline or BAU projection [%]
- Annual emissions savings, i.e. the savings target considering only the target year (Reference A in Figure 7).
- Total emissions savings, i.e. a savings target considered from the present until the target year (Reference B in Figure 7).

These options require slightly different calculations. This particular study quantifies absolute savings (in $MtCO_2e$) relative to a BAU projection (see Section 2.4). The study has calculated both annual savings (**A** in Figure 5) and cumulative savings (**B** in Figure 5).

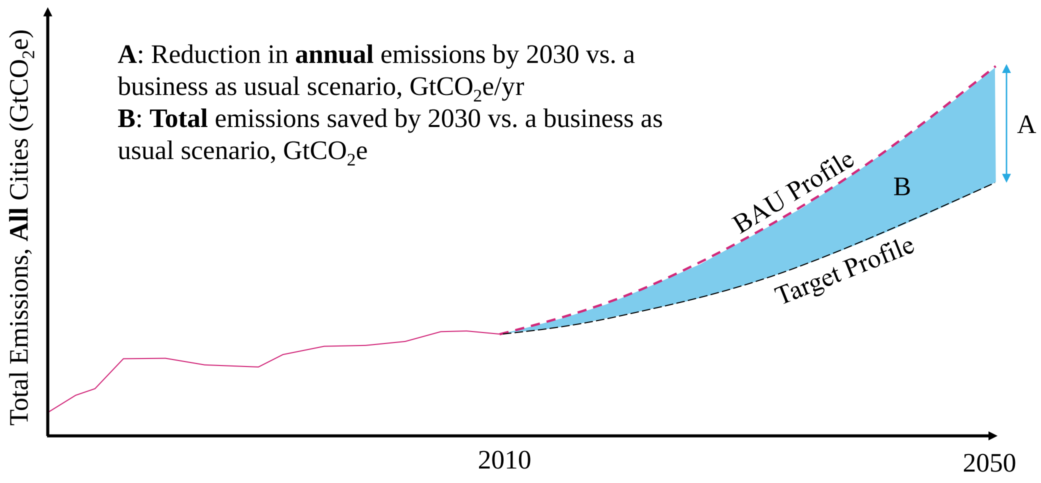


Figure 5. Visualisation of emissions savings reporting

2.4 Business as Usual projection

While interpreting cities' targets allows for the projection of absolute emissions for each city, a consistent definition of the BAU case for each city is required to allow for consistent estimation of GHG *savings*.

For this study, the BAU case for each city is defined as the future emissions growth that would occur if the 2010 per capita GHG emissions intensity for each city remained the same for every year in the future, with the city population growing according to current projections. The year 2010, therefore, is defined as the Study Baseline year.

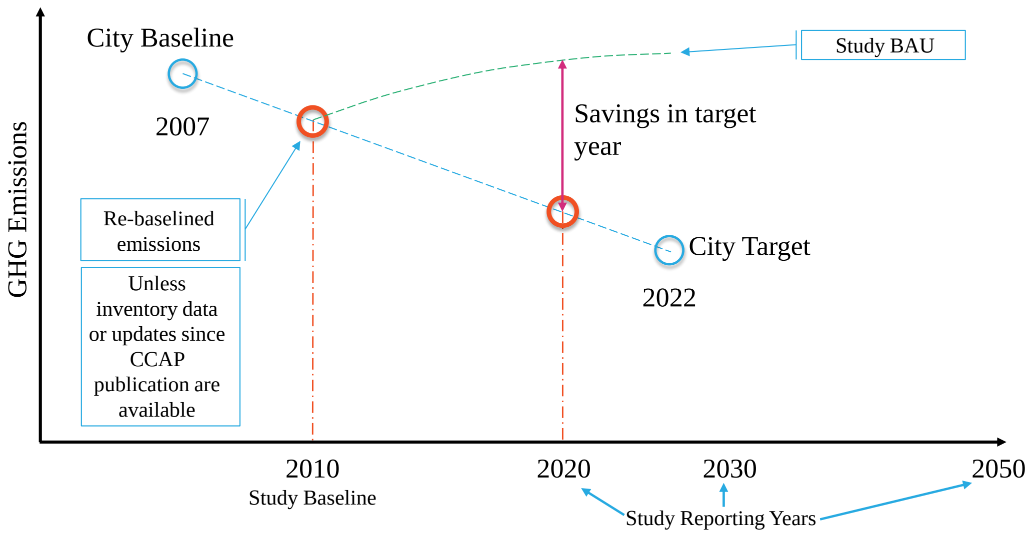
United Nations statistics[4] for projected urban populations were used as the basis for emissions projection. It is noted that the dataset only covers cities with populations of over 300,000; for those cities with smaller populations (at the time of publishing) it was necessary to project urban populations on the basis of national growth rates. Section 5.1 discusses the implications of this assumption further.

As previously mentioned, there are different methods for defining BAU GHG emissions trajectories, each with their own merits. Further discussion on this issue can be found in Section 5.1.

2.5 Standardising GHG trajectories

Cities report emissions inventories and targets in different ways. For instance, cities use a wide range of baseline years, ranging from 1990 up to 2014. Target years also vary widely, from 2015 up to 2050. To allow cities' targets to be compared fairly, a means of standardising is required. The following graph illustrates the approach used in this study.

[4] United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision



For each city, the analysis carries out the following steps:

1. Take city baseline and city target year emissions

    a. Target year emissions may need to be calculated, by multiplying baseline emissions by target reduction (e.g. 80% by 2050). Emissions intensity targets – for cities that have them – are converted into absolute emissions targets and trajectory, provided there is sufficient information to do so.

2. Interpolate between city baseline emissions and city targets to calculate necessary emissions trajectory.

    a. Where more recent inventory data is available, use this as the basis for the GHG trajectory.

    b. Intermediate targets, where available, are built into GHG trajectories.

3. Interpolating, use emissions trajectory to “re-baseline” the city’s emissions to 2010 (unless 2010 inventory data is available).

4. Based on population data, calculate 2010 per capita GHG intensity.

5. Based on population projections, project emissions forward using 2010 GHG intensity.

6. Annual savings in a given year are calculated as the difference between the BAU GHG value and the interpolated city target in that year.

7. Cumulative savings are calculated by summing up all annual savings.

It should be noted that no attempt has been made to extend city target GHG trajectories beyond their individual timeframes, i.e. a city with a target up to 2030 will not have that target extended or increased beyond that date. The results presented are focussed only on *committed* targets. The potential for extending the analysis is discussed in Section 5.

2.6 Aggregation of GHG savings

Once the steps in the above section have been carried out for all cities with suitable target information, a total estimated target GHG emissions trajectory is available for each city. These trajectories can then be aggregated to produce an overall GHG emissions trajectory, and savings can be calculated uniformly against the defined BAU. Savings can also be presented against the Study Baseline (i.e. % saved versus 2010), should this be desired. All that is required now is the data on baselines and targets to undertake these calculations.

The information required in order to undertake this analysis for each city is:

- GHG baseline (in $MtCO_2e/yr$)
- Date of baseline (latest published)
- Latest GHG inventory (in $MtCO_2e/yr$)
- Emissions scopes included (1, 2, and/or 3)
- Target information (type, baseline, baseline year, timespan, and magnitude)
- City population
- Projected population growth rate to 2050

The aggregator developed by Arup is a model containing all of the above relevant data, where available, for all cities in the analysis (data is described further in the next section). It carries out the calculations described in Section 2.5 for each city, outputting savings and trajectory information in a range of formats, allowing various queries to be run.

3 Data Collection

The previous section outlined the means for developing city GHG inventories and targets into a form suitable for consistent projection of GHG trajectories and calculation of savings versus BAU. This section presents the data collection process.

3.1 Available city carbon data sources

The majority of city GHG inventory and target data used in this study was provided by the following project partners:

- The C40 Database[5]
- The Carbon*n* Climate Registry[6]
- CDP's Cities Program[7]

Information in these databases was supplemented by desktop research from Arup on cities' own climate change action plans, bringing the total number of cities included in the aggregator to 228.

Between the available databases and Arup's additional research, data was collated for many more cities than the featured 228. However, data gaps existed for some of these cities, or information was not of sufficient resolution to perform the necessary calculations. There is high confidence in the potential to incorporate additional cities into the analysis at a later stage, and in more cities committing to future climate change action.

4 Summary of Key Results

4.1 Overall results

Two hundred and twenty-eight global cities, representing 436 million people, have GHG inventories and targets of a scope sufficient enough to be included in this emissions aggregation exercise. Annual and cumulative GHG savings that cities have committed to are shown in Table 2, with cities targeting a total savings of 13.0 GtCO_2e by 2050.

Table 2. Annual and cumulative GHG savings potential for cities analysed

Year	Annual savings (MtCO_2e/yr)	Cumulative savings (GtCO_2e)
2020	454	2.8
2030	402	6.1
2050	430	13.0

[5] http://C40.org/
[6] http://carbonn.org/
[7] https://www.cdp.net/cities

Figure 6 below shows the trajectory of annual committed GHG savings, splitting out the data by the timeframe of each city's commitments. While 144 cities have commitments ending by 2020, 57 cities have targets ending in the 2031 to 2050 timeframe, contributing 9.8 $GtCO_2e$ of savings to the 13.0 $GtCO_2e$ total. Notice the sharp falls in savings in key years; this is the result of some cities' targets not extending beyond these years.

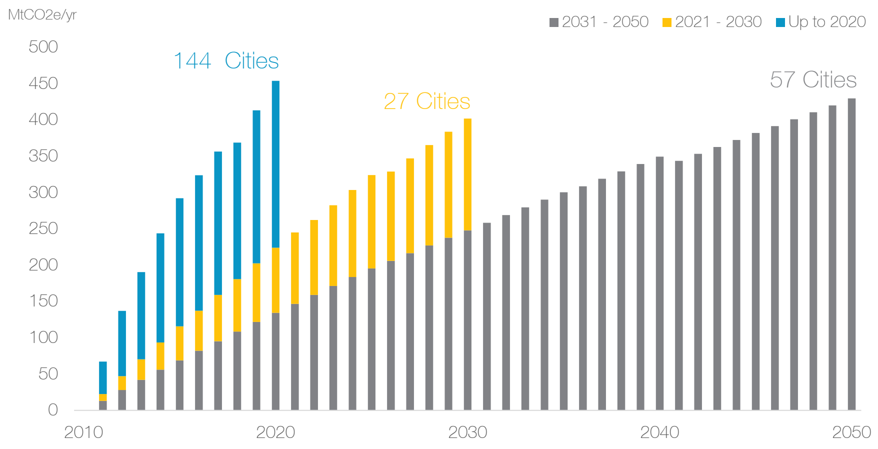


Figure 6. Committed annual GHG savings by commitment end date

Figure 7 provides an overview of the commitments and their associated timeframes for the 228 cities in this analysis. As cities approach this milestone year, it will be critical for them to make new commitments, creating an opportunity for them to increase their ambition. These new commitments, in turn, could encourage other cities around the world to follow suit in making commitments of their own.

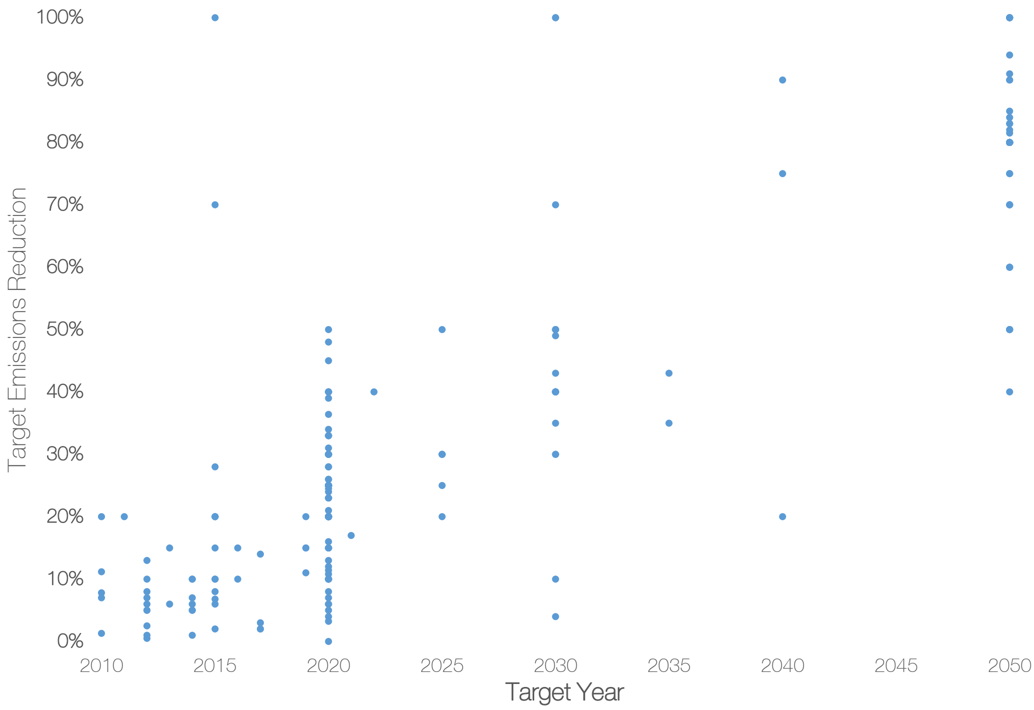


Figure 7. Commitment levels and timeframes of city GHG commitments

5 Future Opportunities for Analysis

This analysis has focussed only on current city commitments. There is significant potential for extending the analysis of this work, and for addressing the limitations associated with this research effort. This section outlines current limitations, before proposing additional areas of research.

5.1 Limitations in the current methodology

Reporting of scopes: Cities do not currently report scope consistently, or even compile their emissions inventories in the same way. While efforts are underway to standardise approaches through the Global Protocol for Community-scale Greenhouse Gas Emissions (GPC), further analysis of city inventories and targets would allow for improved confidence and consistency across the cities investigated. The potential for double-counting exists when considering scope 3 emissions in particular, and scope 2 emissions to an extent. See Section 2.1 for more detail.

Reporting only current commitments: The focus of this aggregation exercise has been to report cities' current commitments. This exercise has not accounted for the possibility that cities will continue to develop their commitments as targets are met or draw closer.

Exclusion of some Carbon*n* and CDP cities: Not all cities in databases have been drawn into this analysis, due to mismatches between inventory, baseline and target information, or missing information on population. Further targeted research to gather data to bring these cities into the analysis would better reflect current global cities' commitments.

BAU emissions projected based on population growth: GHG savings have been estimated by comparing the targeted GHG emissions value for each city with the projected BAU savings. The approach adopted for calculating the BAU was to align emissions with population growth, by assuming the emissions per capita remain constant after the study baseline year, and then allocating emissions equally per person as the population increases. This has the impact of underestimating the likely BAU case for developing countries, as these countries would likely see a significant increase in emissions per capita, largely due to increased wealth.

One alternative option would be to align the BAU against the countries' projected GDP growth rate. This results in a much larger BAU value (due to compound interest effects), and hence, savings. In this study population was chosen as the best basis for estimating the BAU because there is more robust data available for future population growth at the city level. GDP projections are highly uncertain and would rely on assuming the historical trend for GDP growth would continue for an indefinite period of time. Doing so results in very large BAU levels for high GDP-growth countries such as China.

Another alternative option for GHG BAU projection would focus on cities' historic *emissions* growth rates. However, there is no known data source that provides this information consistently for all cities in the study.

Growth rate data is not available for cities under 300,000: UN city population projections do not extend to cities below 300,000. National growth rates have been used in these circumstances. This may, however, underestimate population totals for cities in rapidly developing or rapidly urbanising countries. Similarly, UN projections per city do not extend beyond 2030. Therefore, this analysis supplemented this gap with national-level projections. Future work should look to acquire data from appropriate national statistics offices where available and of suitable quality, to more realistically model some of the smaller cities in the study.

Regional spread: Due to the membership profile of the city networks involved in this study, some regions see higher representation than others. For instance, the work includes commitments from more cities in Japan than in any other country. This is due to a growing number of cities reporting their emissions and targets, with some regions currently making more headway than others. As this work continues and input from a wider group of cities is collected, this regional focus will naturally reduce until all regions are represented proportionately.

5.2 Projection of GHG targets

Two prime avenues for further investigation include:

- Projecting cities' commitments beyond their existing target years; and,
- Applying the savings potential for cities currently with targets to all cities in the world to estimate global potential.

Both are possible with data currently available, and methodological steps are in place to produce estimates for these.

Appendix A

List of Cities Included in the Aggregation Exercise

A1 List of Cities with GHG Reduction Targets Included in the Analysis

Milan
Copenhagen
Stockholm
Seattle
Portland
Vancouver
Washington, D.C.
Minneapolis-St. Paul
Boston
New York-Newark
Oslo
Berlin
Yokohama
San Francisco-Oakland
London
Boulder
Amsterdam
Sydney
Austin
Bogotá
Chicago
Los Angeles-Long Beach-Santa Ana
Philadelphia
Toronto
Houston
Tokyo
Seoul
Madrid
Paris
Rome
Buenos Aires
Rio de Janeiro
Changwon
Barcelona
Heidelberg
Melbourne
Rotterdam
Venice
Singapore
Moscow
Nagoya
Hyderabad
Miami
Belo Horizonte
Ahmadabad
Alexandria
Atlanta
Montréal
Naples
Brussels
Hamburg
Durban
Lisbon
Cleveland
Goiania
Cincinnati
Kaohsiung
Toluca
Perth
Kansas City
Orlando
Turin
Montevideo
Porto
Hiroshima
Adelaide
Dublin
Florence
Calgary
Edmonton
Semarang
Aguascalientes
Okayama
Jerusalem
Hamilton
Nantes
Vilnius
Grand Rapids
Xalapa
Oita
Charleston-North Charleston
Knoxville
Monteria
Baltimore
Benicia
Burlington
South Carolina
Denver-Aurora
San Jose
Charlottesville
Colwood
Fredericton
Gothenburg
Kawasaki
Martinez
Paris
Richmond
Sunnyvale
Uppsala
Vaxjo
Villa di Serio
Maple Ridge
Saanich
Ehime
El Cerrito
Evanston
Fremont, California
Fukushima
Gangneung
Ghent
Gunma
Hamilton, Hyogo
Itabashi
Kawaguchi
Kochi
Kochi-konan
Koriyama
Kurashiki
Malmö
Quito
Miyoshi
Nagareyama
Nashville
Otsu
Puebla
Pyeongchang
Saffle
Sagamihara
San Jerónimo de Montería
Sandnes
Santa Cruz County
Santa Monica
Shibuya
Suwon
Tainan
Taito
Östersund
Ajax
Tsukuba
Västerås
Pinecrest
Yao
Yeosu
Antwerpen
Aomori
Arendal
Berkeley
Broward County
Buffalo Metropolitan
Charleston
Chigasaki
North Vancouver
San Rafael
Comune di Villa di Serio
Maple Ridge
Saanich
Edogawa
Eskilstuna
Fujinomiya
Gunma
Himeji
Ishikawa
Kitakyushu
Koto
Kumamoto
Lexington
Lørenskog
Meguro
Ancona
Nakano
Nerima
Niigata

North
Cowichan
Siena
Saitama
Prefectural
Government
Sakai
Sendai
Stavanger
Ajax
Toyama
Yamanashi
Government
Zapopan
Aichi
Akashi
Akita
Atsugi
Shiyakusyo
Chiba
Chiyoda
Chuo
Antioch
Hakodate
Kita
Okazaki
Sapporo
Shimonoseki
Flagstaff
Fuji
Fujisawa
Funabashi
Gifu
Hamamatsu
Hokkaido
Government
Kakogawa
Kobe
Kristianstad
Kushiro
Kyoto
Matsuyama
Minato
Nagahama
Nishinomiya
Odawara
Shiga
Shimane
Shinjuku
Shizuoka
Suita
Sumida
Tacoma
Takatsuki
Tokushima
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