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Thesis

Exploring the factors that correlate with the achievement of GHG emissions reduction targets of 59 cities from different continents

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Specialization: Urban Environment, Sustainability and Climate Change

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Summary

The global warming is one of the biggest problems which faced nowadays humanity. Acknowledging the critical role of urban areas in the process of generating the greenhouse gases, the achievability of climate mitigation goals acquires special importance and meaning.

The majority of cities as a significant player of producing GHGs has been coped against climate mitigation under the umbrella of national pledges, however, the new mechanisms established by Paris Agreement re-assessed the role of local actors and evaluate the potential of local governments mitigation plans and their value in limiting the rise of global temperature to 1.5^0C. In respect of this, it becomes more important the assessment of the level of achievement of GHG emissions reduction targets of cities, that is one of the main objectives of this thesis.

The research assessed the level of climate mitigation target achievement of 59 cities from different continents and delineate the external and internal factors that correlate with the achievement of GHG emissions reduction target. The assessment of climate mitigation for 59 cities highlighted the consistencies or inconsistencies of local authorities climate mitigation pledges and estimated results, the effectiveness of the local climate mitigation actions.

Different indicators have been measured to realize the level of achievement of GHG emissions reduction target in absolute and per capita terms. Trend analysis has been conducted for determining the GHG emissions reduction pathway of selected 59 cities. Thanks to the linear extrapolation have been assessed the target achievability in the targeted year. Correlation and T-Test analysis has been conducted by using SPSS, which helps to find the interrelation between the GHG emissions reduction target achievement and external, internal factors.

Among internal factors were studied: socioeconomic, demographic, urbanization degree, climate, biophysical factors. As an external factor has been analyzed the membership of international climate networks Covenant of Mayors, C40 climate leadership group and Local Governments for Sustainability.

The research findings indicate that 36% of cities will achieve the GHG emissions reduction target, 15% of cities are close to achieving and 49 % of cities will not achieve the committed target based on trend analysis. The cities with successful performances of the climate mitigation plans are mainly from European and North American continents.

One of the important findings of this research is the GHG emissions reduction per capita depends on the ambitious level of cities target commitments. Those cities that have ambitious target the level of trend emission per capita is low. It is also worth to mention that with ambitious target gives a possibility to have significant decrease of the GHG emissions.

The correlation analysis indicates a moderate correlation between cities achievement level of the GHG emissions reduction target and GDP per capita, cities geographical location, density. The T-Test analysis allows to exploring two external sufficient factor that are related to achievement of climate mitigation targets, that are a member of the Covenant of Mayors and being a member of more than one climate network. There is enough evidence to emphasize that CoM is the effective initiative among others in this used thesis sample, with its guidelines, coordination with local governments is more effective compared with other climate networks.

The key achievement of this research is the exploration of factors that mainly interrelated to the achievement of climate mitigation goals.

In total, the combination of socioeconomic, climate, the degree of urbanization factors with effective international cooperation for urban climate mitigation governance are essential elements to achieve climate mitigation goals.

The results of this research can contribute the efforts of local governments to chose the right climate mitigation policy, thereafter to have a significant investment in the process of coping against global warming.

Keywords

Climate Change, mitigation, GHG emissions, emissions reduction target, target achievement

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Forward

"We shall need a substantially new way of thinking if humanity is to survive."

(Albert Einstein, 1954)

(Presentation speech delivered by Egil Aarvik, Chairman of Norwegian Nobel Committee, on the occasion of the award of the Nobel Peace Prize for 1985, Oslo. December 10, 1985)

Abbreviations

IHS	Institute for Housing and Urban Development
AR5	Fifth Assessment Report
BAU	Business as Usual
CNCA	Carbon Neutral Cities Alliance
CoM	Covenant of Mayors
CDP	Carbon Disclosure Project
CDM	Clean Develop Mechanisms
cCR	Carbonn Climate Registry
C40	Climate Leadership Group
EU	European Union
FDI	Foreign Direct Investments
GHG	Greenhouse Gas
GDP	Gross Domestic Product
ICLEI	International Council for Local Environmental Initiatives (Local Governments for Sustainability)
INDC	Individual intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
OECD	Organizationfor Economic Co-operation and Development
UNFCCC	United Nations Framework Convention on Climate Change
RCP	Representative Concentration Pathway
SEAP	Sustainable Energy Action Plan
SPSS	Statistical Package for the Social Sciences
TMN	Transnational Municipal Networks

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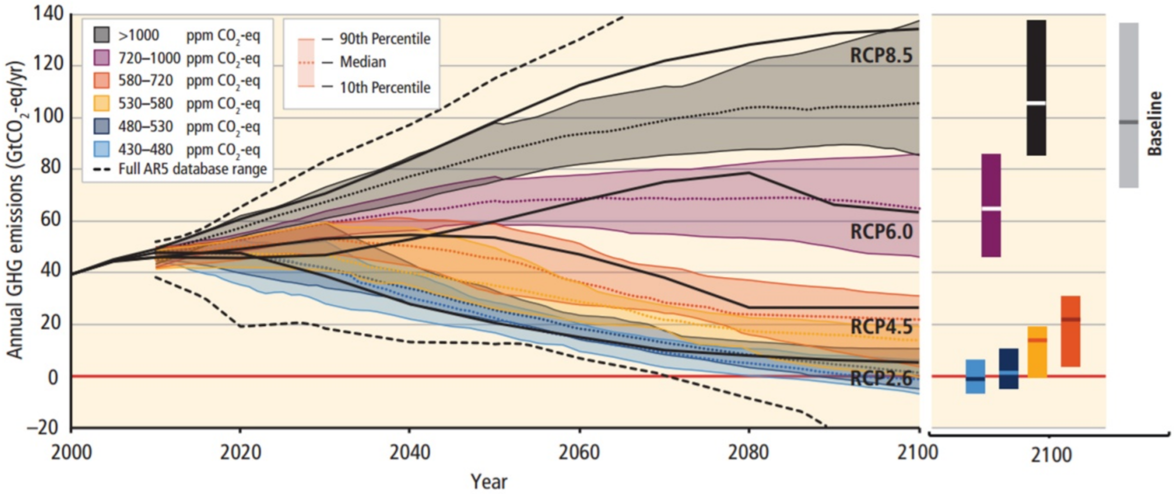
Chapter 1: Introduction

1.1 Background

Nowadays the world already faced the negative impacts of global warming. The weather anomalies, rising sea level, regularly increasing social and environmental changes are direct and indirect aftermaths of GHG emissions. According to the IPCC report (UNDP:, 2009), it is expected that the average increase of global temperature will rise 2°C by 2050s. One of the main factors which influence on global heating is the amount of emitted GHGs. As is mentioned in UN-Habitat 2011 Report the critical types of GHGs are (UN-Habitat, 2011, p.6) “CO_2, methane, nitrous oxide (N_2O), and the halocarbons (hydrofluorocarbons and perfluorocarbons) and other fluorinated gases’’. It should be noted that the carbon dioxide has significant great proportion among other GHGs. Despite cities cover about 2% of the Earth's surface, however, their responsibility in the process of initiating climate change is unequal compared with another part of the world (Dodman, 2009). 75 % of atmospheric GHGs (UN-Habitat, 2011, Seto, Dhakal, et al., 2014) emitted from urban areas. The electricity, transportation, industry, agriculture are the critical sectors which produced the majority of emitted CO_2 and its equivalents. Acknowledging that in general the main economic and social activities are concentrated in urban areas, thereby cities considered as a generator of GHGs.

Figure 1 shows Global GHG emissions by gigatonne (Gt CO_2-eq/year) in baseline and 5 possible mitigation scenarios from 2000 to 2100 according to the Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC) 2014 Fifth Assessment Report (AR5) (Pachauri, Allen, et al., 2014). The graph illustrates the trajectories of Carbon Dioxide Removal if the global temperature will limit to 3^0C, 2^0C, 1.5^0C, near 0^0C and the last scenarios without any additional mitigation actions. The results are warning and depending on what direction will develop the world, which coping mechanisms against global warming will be selected, the outcome can be disastrous or disturbing.

Figure 1: GHG emission pathways 2000-2100: 5 scenarios



Source: IPCC (2014) (Pachauri, Allen, et al., 2014)

Taking into account the unprecedented growth of urban population in contemporary times and meanwhile also paying attention the estimated growth in urban area, which will reach 6.7 billion (Gouldson, Colenbrander, et al., 2015) by 2050, therefore, in this context the mitigation of GHG emission as climate change abatement lever becomes an urgent intervention and translates as first priority of international agenda.

With the last results, 196 states have been ratified United Nations Framework Convention on Climate Change (UNFCCC). Almost all European countries have been ratified the UNFCCC starting from 1992. Since 2005 Europe intensified the fight against climate change by establishing European emission trading scheme (European Commission, 29/03/2017, Ostrom, 2010). After the launching of the Covenant of Mayor's initiative by the European Commission in 2008, which aim is to bring together European local and regional authorities, (they voluntarily implement EU climate mitigation policy directives in their own city) the coping mechanisms have become more substantial in Europe. The majority of European cities under the umbrella of Covenant of Mayor's have intensified their mitigation actions by adapting them to the EU climate and energy objectives. In the light of this plans, cities set their own GHG emissions reduction targets, which have to be achieved in conformity with specific actions. Some cities authorities set ambitious targets, which is higher than the minimum initial target (20%) is.

One of the most important networks is C40 Cities Climate Leadership Group, which includes 90 world cities with a large population (more than 650 million people). The aim of this network is to join cities' efforts against climate change, and regulate greenhouse gas emissions in the urban area, thereby to enhance the better well-being of the urban population.

Another large global network is ICLEI - Local Governments for Sustainability, which includes more than 1,500 cities. This network aims to help local governments to reduce carbon emissions by providing Guidelines for National Greenhouse Gas (GHG) Inventories (IPCC, 2006).

With the aim to reduce GHG emissions in atmosphere countries and achieve GHG emissions reduction targets by the help of Kyoto's Protocol (United Nations, 2014b) has been created special mechanisms, by which the developing countries have been involved in the process. More specifically, in order to control GHG emissions has been created Clean Development Mechanisms (CDM) accordingly. As D.Victor explains (2004) the architecture for regulating carbon emissions is not effectively implementable and he explains the basis of the paralysis of this mechanisms. One of the barriers as D. Victor mentions is "political difficulties" (2004, p.143) connected with the choice of responsible political body, more specifically; in some developing countries the ministries of environment are charged for implementing the CDMs, while the ministries or state agencies that are responsible for development have comparably powerful and can implement CDMs effectively. Next barrier has been highlighted in above-mentioned research is the difficulty of the complete monitoring of the GHGs flows during carbon trading and finally, the quality of national policy (carbon tax policy etc.) and level of democracy in developing countries.

The latest international treaty on climate change is Paris agreement (2015), according which in pursuit of minimizing the negative impacts of climate change the international society have agreed to **"Holding the increase in the global average temperature to well below 2ºC above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5ºC above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change"** (Article 2, Paris Agreement (United Nations, 2014c,p.3)). Taking into account the mainstreaming of this article to local authorities and also the importance of political will interweaving with local efforts for implementing international responsibilities having a concern to GHG emissions mitigation, nevertheless, it is impossible to deny the currently existing gap between mitigation action plans and its implementation (den Elzen M., Hof A., Roelfsema M., 2011, Sippel, 2011).

The Paris Agreement (United Nations, 2014c, Höhne, Kuramochi, et al., 2017) established a new mechanisms of cooperation for coping against global warming and to reach long-term global target that is limitation the increase of global average temperature to 1.5^0 C. By establishing "intended nationally determined contributions" (United Nations, 2014c,p.3, Höhne, Kuramochi, et al., 2017,p.16) can help to overcome the barriers, moreover developing countries pledge national realistic targets. One of the main acquisition of Paris agreement is the accounting of "Non-Party stakeholders" to recognize the role of cities and set the basis for the further cooperation. Taking into account that cities have a great contribution to the process of accumulation of the GHG in the atmosphere (Seto, Dhakal, et al., 2014, Krause, 2011), cooperation with local authorities will choose relevant political institutions that can effectively implement climate mitigation projects and set a realistic target. Höhne et al. also underlines that "**combined potential impact of mitigation initiatives** by non-state actors could make a significant contribution to achieving the 2^0 C or 1.5^0 C goal" (2017, p.25) (as "non-state" actors authors mean cities, regions, organizations etc.). In regard to this, it becomes more important the assessment of the level of achievement of GHG emissions reduction targets of global cities, which is one of the main objectives of this thesis.

Hereby, the acknowledgment of irreversible negative impacts of climate changes, having political will, becoming member of international networks, establishing appropriate institutions and schemes for coping with negative impacts of climate changes cannot be sufficient if there is no evidence of the correlation between local climate mitigation actions and the selected target, which anticipated to achieve during coming decades. Improving the local GHG emissions reduction target setting policy, namely taking into account the city's abatement potential, making cost-benefit analysis etc., cities will have not only environmental but also social co-benefits (Gouldson, Colenbrander, et al., 2015, Nemet, Holloway, et al., 2010).

1.2 Problem Statement

Despite the existence of different horizontal and vertical networks and institutions aimed to mitigate the GHG emission, also immense international political and scientific conferences, meetings, seminars dedicated to climate change and mitigation its possible future negative impacts, however those efforts do not have tangible effects on the results of global GHG emissions reduction and in global warming overall (Raciti, Fahey, et al., 2012b, Meinshausen, Meinshausen, et al., 2009).

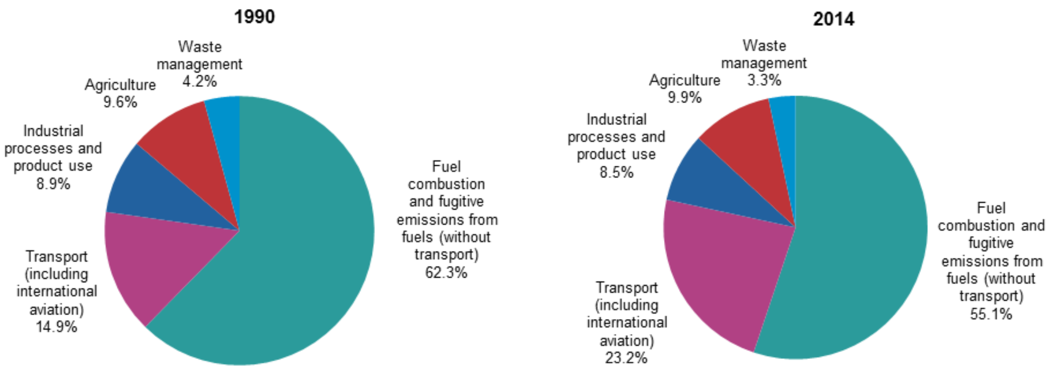
According to Eurostat Greenhouse gas emission statistics in 2014 absolute reduction of CO_2-equivalents was 1136 million tonnes and for some countries, the amount of GHG emission has been increased compared with baseline 1990 level (see chart 1). Figure 2 depicts the sectoral changes of GHG emission from 1990 to 2014 for 28 EU countries. It is obvious that after 25 years there are no significant changes.

Chart 1: Total greenhouse gas emissions by countries

(including international aviation and indirect CO2, excluding Land Use, Land Use Change and Forestry (LULUCF), 2014, (Index 1990 = 100)

Source: (Eurostat, 20 December 2016)

Figure 2: Greenhouse gas emissions, by source sector, EU-28, 1990 and 2014 (percentage total)



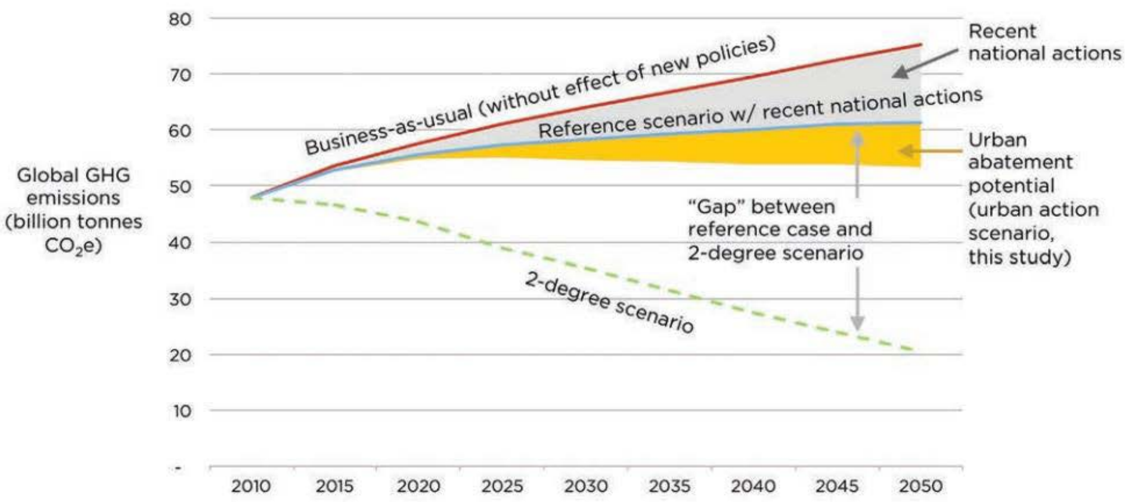
Source: (Eurostat, 20 December 2016)

The practice shows that the targets of mitigation policy which are indicated in local GHG emissions reduction plans are not realistic enough, in some cases they are not achievable (Sippel, 2011), while in other cases cities current mitigation potential is higher than announced mitigation pledges, therefore urban GHG emissions reduction targets are not ambitious (Erickson and Tempest, 2014), for instance the majority of European cities already met 2020 GHG emission mitigation target (Kona, Melica, et al., 2016). Thereby the announced targets do not always reflect the current reality. Still is not clear whether the selected mitigation target based on the cities' inner potential or not. In order to develop a realistic target, there is a need for conduct analyze of city's abatement potential for understanding the right level of emissions which is possible to reduce. The absence of proper information, whether cities' authorities have been calculated abatement potential before deciding the amount of mitigation target leads to a different interpretation of cities achievement of climate mitigation target. The thorough understanding of mitigation potential of cities, exploring the nature of correlation of the factors that are mainly related to urban GHG emissions reduction, more specifically, having clear apprehension whether this correlation is negative or positive, may help to set more realistic, sometimes even more ambitious targets. Erickson et al. (2013) argue that not all cities authorities implement beforehand assessment the actual scale of cities GHG emissions reduction potential and the target's value is most often determined due to political statements. Boswell et al. (2010) by analyzing 30 American cities, explain that even cities established reduction targets, but majority fail to meet the emissions reduction target as their cities do not have a clear justification of forecasting targets. They also found that 47% of cities do not have monitoring and evaluation programs, or it is not effective and does not incorporate with mitigation action plans (Boswell, Greve, et al., 2010). This could be the reason for not achieving GHG emissions reduction target.

With the intention of assessing the level of achievement of GHG emissions reduction target, it is necessary to have a complete view of possible factors which are interrelated with the achievement of mitigation targets. The academic literature gives a large number of factors which have an impact on GHG emissions. Kennedy et al. (Kennedy, Steinberger, et al., 2009) show a strong dependency of urban metabolism and GHG emissions on cities' location. Other scientists mention density, technology, economic activity (Creutzig, Baiocchi, et al., 2015) as main factors influencing on GHG emission, etc. However, there is no enough study which can give a clear understanding of the main factors that influence on the level of achievement of GHG emission reduction targets. This information may help cities' authorities before announcing pledges on climate mitigation, therefore also to set achievable or even ambitious GHG emission reduction target.

Disclosing the possible correlation between factors and the level of cities achievement of GHG emissions reduction targets may help to find the explanation how certain cities achieved climate mitigation targets, while others not, it will also better to develop and implement local mitigation action plans efficiently. Still needed to determine to which extent the cities' mitigation Action Plans reduce GHG emissions? do cities achieve GHG emission reduction targets? By analyzing 30 US cities Boswell et al. (2010, p. 451) come to conclusion that " the plans generally do a poor job of linking mitigation actions to reduction targets". It is crucial to analyze whether the climate mitigation actions actually reduce carbon emissions in reality or not? If not, what is the reason? For instance, Maike Sippel (2011) based on trend analysis by showing emissions pathway of 40 German cities find that majority of cities failed to achieve GHG emission reduction targets. He concludes (2011,p.60) "targets need to be realistic and derived from city-specific mitigation potentials". Other scientists Erickson P. and Tempest K. from Stockholm Environment Institute argue that (Erickson and Tempest, 2014) cities abatement potential of GHG emissions reduction is higher than GHG emissions reduction targets and it allows to set more ambitious targets than cities currently adopted (Figure 3). As Erickson P. and Tempest K. (2014,p.12) suggest the "aggressive urban action could help close the gap" among different scenarios and contribute to achieving global carbon reduction targets.

Figure 3: The potential impact of urban actions on global climate mitigation ambition



Source: Erickson and Tempest (2014)

Su et al. (2016) elucidate that from 1991 to 2012 European Union 28 countries overall decreased the average GHG emission and increased net decrease of GHG emission annually, which means that the target achievement potential of EU countries is high. Even more, the last report of Covenant of Mayors "Greenhouse Gas Emission Achievements and Projections" shows the results of 315 cities performed reports, according which 23% of GHG emission reduction had already been achieved in 2014 (Kona, Melica, et al., 2016), whereas the minimum target for 2020 is 20%. These results support the conclusion of Erikson T. and Tempest K., namely, the cities' abatement potential is higher than the current local climate mitigation target is. By studying cities carbon Climate Registry (cCR) reports, it is difficult to determine whether cities clearly justified their urban abatement potential not only before setting GHG emissions targets but also during implementation of local mitigation action plans, as completing one mitigation action could change the city's abatement potential and it may have impact on other actions which are in progress. Even the last report of Covenant of Mayors indicates "that the combination of effective urban energy policies and better coordination between national and local governments is crucial for the potential of the urban mitigation of climate change" (Kona, Melica, et al., 2016p. 40). However, despite the fact which is mentioned in this report that 315 European cities achieved emissions reduction targets, it is not clear whether urban abatement potential has been taken into account *per se*. There is no evidence for realizing to which extent mitigation target reflects the reality. There are no enough studies which thoroughly analyze above-mentioned issues, thereby exploring the scope of external and internal factors that interrelated to the achievement of GHG emissions reduction, disclose and scrutinize the possible correlation could illuminate the existing uncertainty.

In conclusion, exploring the possible correlation between factors (external, internal) and achievement level of GHG emissions reduction targets, first of all, could help cities authorities to reassess their opportunities before selecting targets, it could also help to minimize the barriers, which may prevent to achieve their targets. Secondly, it will assist to include more realistic and feasible actions on local climate mitigation projects. Finally, having clear explanation about the correlation of above mentioned factors with achievement of GHG emissions reduction targets also will prompt to make structural changes that are likely to be needed for increasing the efficiency and effectiveness of implementation of mitigation actions, more specifically it will help to meet GHG emissions target, thereby significantly to contribute the limitation of global warming.

1.3 Research objectives

The following objectives are at the core of this research:

- To assess the level of achievement of local climate GHG emissions reduction targets in a cluster of 59 cities from different continents,
- To explore the correlation between the external, internal factors and level of targets achievement for 59 cities,
- To explain whether those factors have positive or negative relation to the achievement of local GHG emissions reduction targets.

1.4 Research question(s)

In order to accomplish the research objectives, the main research question is:

Which factors correlate with achievement of local climate mitigation targets of 59 cities from different continents?

With the intention of answering the main question defined following sub-questions:

- What is the level of achievement of GHG emissions reduction targets?
- Which factors mainly correlate with achievement of GHG emissions reduction of European cities?
- Whether this correlation positively or negatively impacts on the achievement of GHG emissions reduction target?

1.5 Significance of the Study

Taking into account the fact that cities have a vital contribution to global GHG emissions (Seto, Dhakal, et al., 2014, UN-Habitat, 2011) the analysis about their achievability of GHG emission reduction target becomes more important for further considerations. Academic literature (Erickson and Tempest, 2014) gives basics to realize that not always the abatement potential had been taken into account before deciding the mitigation policy. The results of this study can help cities to choose more realistic and maybe in some cases to set even ambitious and achievable targets. Having a clear understanding of the correlation between factors and achievement level of GHG emissions reduction could have an essential impact on determining the obtainable targets, thereby cities can have the real contribution in the process of holding global warming under the rise of 2^0 C.

The environmental decision-making theory helps to assess cities' mitigation reports and understand the vulnerable places of the rational policy cycle.

This research aims to explore the main factors that correlate with the achievement of GHG emission reduction targets. By using desk research strategy, has been conducted emissions trend analysis based on the multiple GHG emissions inventories being reported the last years by cities that adopted local climate mitigation targets and admitted carbonn Climate Registry (cCR) reports.

By analyzing the negative or positive interrelation between factors and GHG emissions reduction level, this thesis will provide a new approach for urban climate policy making. Disclosure of this correlation could be an essential factor for cities' authorities before GHG emissions targets setting, thereby also for increasing the level of achievement of climate mitigation targets.

1.6 Scope and Limitations

This research relies on a quantitative desk research approach. The research analysis the 59 cities from different continents that have climate mitigation action plan and the results of GHG inventory have been reported.

There is a large variety of factors which can have an impact on the implementation of local climate mitigation actions. The research explores those factors which have the main influence on the achievement of cities' GHG emission reduction target. The study is focusing on the factors which correlation based on literature *per se* is stronger or positively or even negatively.

Due to the possible multitude of factors that may be barriers of climate actions, the research concentrate on those, which cities generally has been faced during implementation of mitigation actions, which stimulate or become an obstacle to achieving GHG emission reduction targets and finally those, which has strong correlation with achievement of GHG emissions reduction targets.

The main limitation of this research is the lack of information about cities GHG inventories for each year. For conducting trend analysis has been used the data of GHG emissions in the measured year. As not all cities' municipalities had properly reported the inventory permanently it was not possible to have the data of carbon emissions for 59 cities for the same investigating period and not all of them used the same methodologies. Taking into account this limitation has been used comparable last reported inventories.

Chapter 2: Literature Review

2.1 Introduction

This chapter presents concepts related to achievement of GHG emissions reduction targets. The Chapter starts by referring to literature which assesses the importance of local mitigation action plans. Then, continuing to present the concept of abatement potential of cities.

This chapter also includes the concept of a rational model of the policy cycle, which shows the steps of environmental decision making. After citing the literature which identified the GHG inventory by sectors and sub-sectors and the role of each sub-sector in overall emissions reduction, the chapter refers to the factors which mainly impact on GHG emissions reduction and achievement of emissions reduction target.

The chapter concludes with the explanation of conceptual framework, which illustrates all concepts related to achievement of GHG emissions reduction target and its correlation to external and internal factors that have the vital impact on achievement level.

2.2 The importance of the local mitigation action plans

The acceleration pace of climate change in recent times significantly affected on reanalyzing and reassessing the local mitigation action plans. As Hunt, A. and Watkiss P. mention (2011, p.14) “the trend in global emissions of greenhouse gases and associated climate change will continue”. In this regard, the selection of appropriate city-scale responses will help to mitigate the negative impact of climate change. Based on 2009 data almost 100 countries have GHG emissions limitation policy (Meinshausen, Meinshausen, et al., 2009), with the results of 2016 September 6201 European cities (Kona, Melica, et al., 2016) and 527 US cities “as of June 2007” (Ramaswami, Hillman, et al., 2008,p.6455) have committed to adopting mitigation policy.

Krause (2011) evaluated the role of cities, their involvement in the process of GHG abatement and contribution on global climate change overall. The local climate mitigation action plans boost the national capacities to combat climate change. Adam Millard-Ball (2012) underlined the importance of local climate plans by mentioning that the cities with clear mitigation plans can easily reach the reduction of GHG emissions, unlike the cities which do not have a climate plan. He emphasized the role of citizens’ environmental preferences during the implementation of local climate plans, thereby their impact on the achievement of local GHG emissions targets, consequently also on the limitation of global warming.

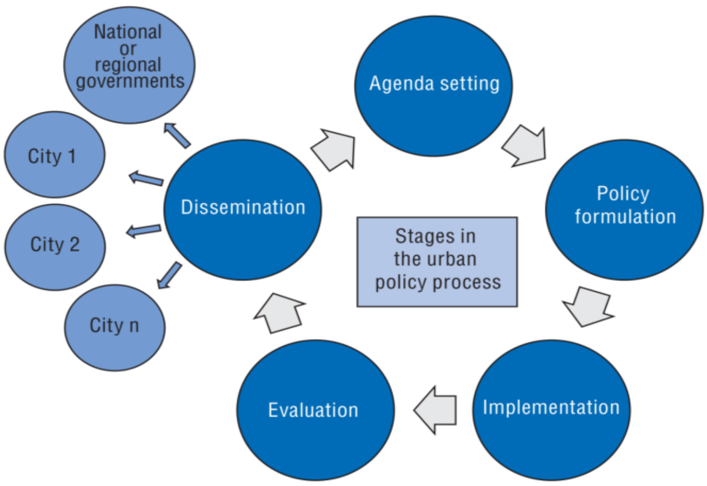
The debate of framing climate change in global scale (Krause, 2011) and concentrating mitigating responses only in state level still is continuing, however, the number of researchers that delineating the importance of city-scale mitigation strategy for achieving GHG emissions reduction targets is growing. For instance, one of last OECD publications (2010) discuss the importance of encouraging “bottom-up” approach, mainly, motivating local municipalities voluntarily to take part in climate mitigation will contribute to achieving emissions reduction.

Also, the last report of Covenant of Mayors (Kona, Melica, et al., 2016) proves the significant role of cities for achieving GHG emissions reduction targets. The next section shows the steps for formation of the climate mitigation policy.

2.3 The Environmental Decision Making

For improving cities' potential of achievement GHG emissions reduction target it is important to understand the policy cycle of environmental decision making and also to recognize the factors that mainly create climate mitigation. Jann et al. (2007) describe the theories of the policy cycle, which consists of different phases of decision-making processes, namely "agenda-setting, policy formulation, decision making, implementation and evaluation" (2007, p. 43). The main idea of this theory is that each step is followed by another and the authors explain the causal links between different stages. This cycle elaborated by different authors and research centres of the international organizations. Below Figure 4 depicts the main stages of an urban policy adopted by OECD (2010, p. 181).

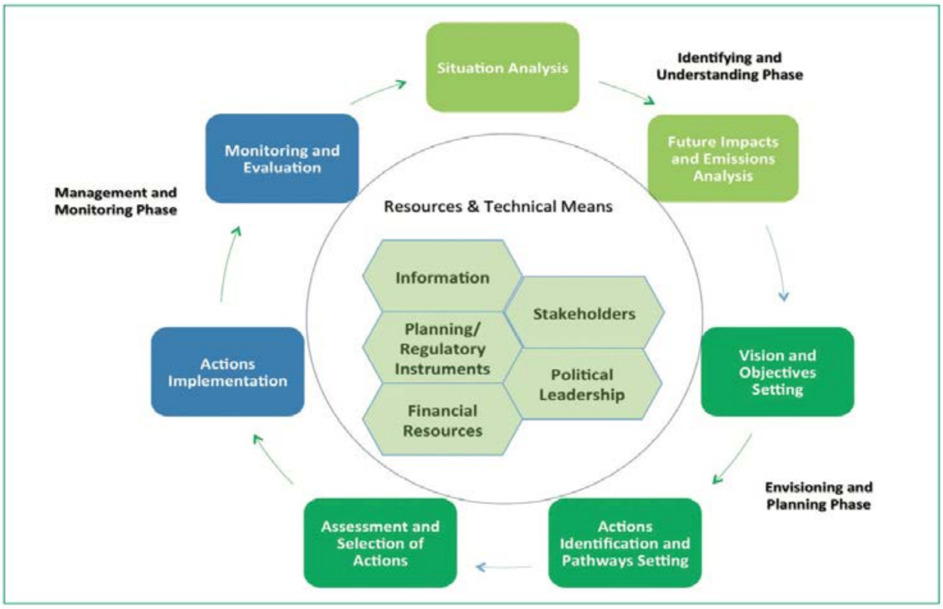
Figure 4: Urban policy cycle



Source: OECD (2010)

UN-Habitat suggests policy cycle for smart climate planning (UN-Habitat, 2014). As mention in the description of the policy cycle, the climate change planning process is nonlinear and it gives a room for new stakeholders, new information, thereby new opportunities in each step. The main steps of the rational model of policy cycle are followings, first to determine the problem and set policy agenda, then to formulate appropriate policy, documents, normative, based on this the following step is adoption of formulated policy, after which is policy implementation, the final step is policy monitoring, evaluation of achieving the goals. Un-Habitat approach for climate policy making has been developed recently. The authors of Second Assessment Report of the Urban Climate Change Research Network (Grafakos, Pacteau, et al., 2017) offer more comprehensive environmental planning cycle, which adopts integrated approach to mitigation and adaptation. The integration of mitigation and adaptation actions can synergize the efforts of city authorities to meet climate mitigation targets. In this research discussing, analyzing and assessing the implementation, evaluation and monitoring phases of climate policy cycle regarding the achievement of GHG emissions reduction targets. Figure 5 illustrates this approach.

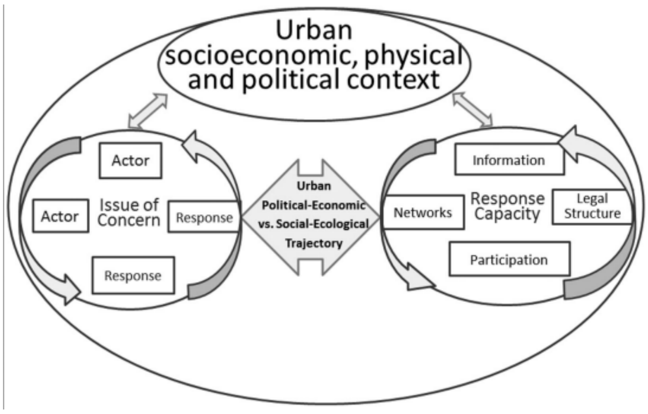
Figure 5: Main resources and technical means that can be used by cities in their planning cycle for integrating mitigation and adaptation



Source: Climate Change and Cities: Second Assessment Rport of the Urban Climate Research Network (Grafakos, Pacteau, et al., 2017, p.8)

Romero-Lankao at al. (2013, p. 787) creates "a framework to identify the components of urban institutional response capacity" (Figure 6). By arguing that multi-resource use increased the response capacity, and in the aforementioned framework they show the importance of integrative approach of creating environmental policy, namely mitigation and adaptation plans (Romero-Lankao, Hughes, et al., 2013). They claim that urban political, economic, social, biophysical aspects are the factors that influence on the climate change, those are creating the same atmosphere for formulating response policy (mitigation, adaptation) (2013). The authors describe (2013, p. 787) "The results of the competition among actors are filtered through the particulars of the urban socioeconomic, physical, and political context and manifest themselves in the institutional features of governance for the issue of concern, with the potential to create barriers to or opportunities for effective policy implementation".

Figure 6: Conceptual framework for local response capacity



Source: Romero-Lankao at al. (2013)

As in this research assessed the monitoring and evaluation phase of the urban policy cycle, therefore it is important to discuss the general mitigation potential of an urban area, which is presented in the next section.

2.4 Urban abatement potential

The urban abatement potential is one of the newest terminologies has been invested in the literature of urbanization. Based on the definition of Yu et al. (2015, p. 46) "carbon abatement potential is the untapped emission abatement capacity of the emitter". In this study, the authors classified abatement potential for GHG emissions reduction in two major parts: technical and economic. Taking into account the technological and economic factors as essential internal factors for growing cities' abatement potential, it worth to mention also the importunateness of the external factors (Kern and Bulkeley, 2009). For instance, being a part of different networks (regional, continental, transnational) gives an opportunity to be informed about climate mitigation methodologies, know-how, cost-effective actions, possibilities for establishing an achievable ambitious target. In this thesis is analyzed the correlation between achievement of climate mitigation target and external factors, which can give the evidence for understanding to what extent the external factors are interrelated to the GHG emissions reduction, therefore to increase the cities' abatement potential.

Having ambitious local mitigation plans is important both for local and global level, more specifically for slowing down the acceleration pace of global climate change, however, before making the local climate mitigation plans, it is essential to take into account the local abatement potential, which will stimulate to set more feasible and achievable target (Erickson, Lazarus, et al., 2013). Understanding the interrelation between abatement potential and mitigation action plans has strategic meaning. Increasing the awareness about the existing correlation between external, internal factors and the GHG emissions reduction target achievement can help local-scale authorities to understand the real boundary of their abatement potential. Being a part of the international networks will help to be informed about a new, more effective methodology of the GHG emissions reduction, which may increase cities' mitigation potential.

Some scientists claim that not only costly technological advancement, but also right selected sectoral policy can increase the achievement of mitigation targets, for instance, the results of Deetman et al. (2013) study show the possibilities for increasing the abatement potential of European countries, thereby to achieve deep GHG emissions reduction. They study different scenarios for different sectors which are cost-effective and they proposed that (2013, p.153) "it is useful to also focus on more realistic mitigation pathways". This study underlines the importance of bottom-up sectoral modeling policy for having a high contribution to GHG emissions reduction, therefore to increase the level of GHG emission reduction. Deetman et al. (2013) conclude that by distinguishing trade-offs among policies implemented in diverse sectors, the ambitious GHG emissions reduction targets can be achieved. Table 1 shows the result of Deetman et al. (2013) study, which illustrates potential sectoral CO_2 emission reduction in 2050 for Europe.

Table 1: European CO_2 emission reductions from the mitigation options, individually and combined per sector in 2050

Sector	Measure	Percentage reduction of total European emissions in 2050 (%)	Percentage reduction in sectoral emissions 2050, compared to baseline
Transport	50% tax increase on fossil fuel combined with a 35% subsidy on electric cars	3.0	13%
	25% subsidy on high speed rail combined with a departure tax for air travel	1.4	
Residential	Enforcing advanced heating technologies and highest building insulation standards	7.6	32%
	Banning traditional light bulbs	0.2	
	Enforcing only "A" Label appliances	0.6	
Industry	lower clinker ratios in cement production	0.3	15%
	Enforcing advanced type steel furnaces	0.7	
	enforcing good housekeeping	3.4	
Power generation	"decarbonization" scenario	33.7	97%
	"negative emissions" scenario (incl. BECCS)	42.8	115%
Agriculture[a,b]	Crop yield increase	0.9	43% of CO_2-eq emissions
	Feed conversion and supply chain efficiency	1.8	
	Changing Dietary preferences	1.4	
	Improving forest and nature management	0.6	
Non-CO_2[a]	Methane control measures on fossil fuel production, animal waste, landfills and wastewater	6.7	38% of non CO_2 emissions
	BC control measures (mostly transport)	0.1	

Source: Deetman et al. 2013

There is a point of view that ambitious climate mitigation actions, especially for developing countries, may lead the slowing-down of economic growth, but Sudmant et al. (2015) show the cost-effective opportunities for cities with developing economies. By using the bottom-up approach in a case study of four cities they explore the possibilities for low-carbon local mitigation actions and represent the efficient financial schemes with low cost. In the World Bank Policy Research (Working Paper No. 7742) Sue Wind and Timilsina show that for countries with transition economy like Armenia and Georgia (2016, p 26) "mandated increases in the penetration of bottom-up energy efficiency technology options can mitigate CO2 up to around 4 % of baseline emissions without adversely impacting real GDP or welfare". While developed countries economy, the abundance of resources, thereby the abatement potential lead to set more ambitious target. However, it worth to mention that mainly in emerging countries the level of democracy, the economic dependence on regional superpowers can be the barrier for increasing the abatement potential, more specifically, the state-centred and lobbies around infrastructures, energy, water sources.

Above mentioned studies specify the possibilities of increasing climate mitigation level by country level, there is also a number of studies which indicate it at the local level. Some cities adopted cautious policy for setting GHG emission target, because of the cost of ambitious actions, however Sudmant et al. (2016, p.686) show that "ambitious urban climate action can be seen as an investment opportunity rather than a cost", they also indicate that package approach of carbon reduction actions can be cost-effective and surmountable, which has been proved earlier also (Sudmant, Gouldson, et al., 2015). Analyzing five case study Gouldson et al. (2015, p. 103) summarize that "economically attractive investments in cities could lead to globally significant reductions in carbon emissions" and also those actions can help to meet their targets. The abatement potential should be calculated also by taking into account external and internal factors. For example, being part of different networks (regional, continental, international) gives an opportunity to be informed about different methods and possibilities for increasing the level of GHG emissions reduction, thereby to improve cities' abatement potential. International networks (C40, Covenant of Mayors for Climate & Energy etc.) are ideal platforms for sharing worthwhile and successful practices. Multi-level governance, horizontal and vertical co-ordinations in national and transnational networks gives an opportunity for both beneficial collaborations on climate mitigation issues (Teasdale, 2010). According to Vuuren et al. (2011), the abatement potential can be increased more if the urban potential for decreasing non-CO_2 greenhouse gases emission is high. This is one of the internal factors which can help to increase urban abatement potential.

By assessing GHG abatement potential of ***transportation and buildings, energy supply, food choice and waste generation*** areas in city-scale Erickson et al.(2013) identify technologies and practices that have high abatement potential and show their influence on the local level. With this study, they develop a typology which can help urban planners to improve assessment of local abatement potential and adopt appropriate policy and measures for meeting GHG emission reduction targets. In another research Erickson and Tempest (2014) analyze the local abatement potential and assess urban scale actions for decreasing global GHG emissions in medium-term (2030) and long-term (2050) timescale. By analyzing any urban actions targeted to climate mitigation, such as decreasing **energy use in residential and non-residential buildings, urban commuters transport, urban road freight transport, urban waste disposal**, they show how is possible to increase climate mitigation capacity by sectors. Erickson and Tempest show that (2014, p. 11) "aggressive urban actions could reduce annual GHG emissions by about 3.7 Gt CO_2e in 2030, and by about 8.0 Gt CO_2e in 2050". Table 2 shows the abatement potential of those actions by sectors.

Table 2: **Urban abatement by sector in 2030 and 2050**

Sector	Technology or practice	Annual abatement, Gt CO_2e		Share of total abatement, %	
		2030	2050	2030	2050
Buildings, residential	New building heating efficiency	0.6	1.2	16%	15%
	Heating retrofits	0.4	0.5	12%	7%
	Appliances and lighting	0.4	0.9	12%	11%
	Fuel switching / solar PV	0.1	0.2	3%	3%
Buildings, commercial	New building heating efficiency	0.3	0.5	7%	7%
	Heating retrofits	0.2	0.2	6%	3%
	Appliances and lighting	0.3	0.7	8%	8%
	Fuel switching / solar PV	0.1	0.2	3%	3%
	Subtotal, buildings	2.4	4.5		
Transport, passenger	Urban planning - reduced travel demand	0.2	0.5	5%	6%
	Mode shift and transit efficiency	0.4	1.0	11%	12%
	Car efficiency and electrification	0.2	0.9	7%	11%
Transport, freight	Logistics improvements	0.1	0.2	2%	2%
	Vehicle efficiency	0.1	0.3	4%	4%
Subtotal, transport		1.1	2.8		
Waste	Recycling	0.2	0.3	4%	4%
	Landfill methane	0.0	0.3	0%	4%
	Subtotal, waste	0.2	0.6		
Total		**3.7**	**8.0**		

Source: Erickson and Tempest, 2014

To summarize this section, the correlation between external and internal factors and achievement of the GHG emissions reduction target, which is the main objective of this research, can help to understand general abatement opportunities for climate mitigation from technical and economic perspectives.

2.5 GHG Inventory

It is well-known fact that GHGs play a central role in global warming. It is also discovered the scope of chemical elements (carbon dioxide equivalents) that are including in GHG (United Nations, 2014b) and for having productive coping mechanisms for decreasing annual GHG emissions and achieving global target there is a need of constant and periodical quantification of the GHGs. For quantifying the annual volume of the emitted GHGs it is necessary to have a clear awareness of GHG inventories by sectors, therefore to possess comprehensive knowledge on the concept of urban metabolism (Kennedy, Steinberger, et al., 2009). This is substantial for building right strategy for reduction of GHG emission.

There is no single approach for inventorying the local GHGs emissions. The vast majority of cities are following the "IPCC guidelines" (IPCC, 2006). Different international city networks have been proposed the standards, which are distinguishing the consumption and production based GHG emissions accounting methodologies which are used by cities including in that networks. For instance, the "International Emissions Analysis Protocol" (ICLEI, 2009) and the "Protocol for Community-Scale Greenhouse Gas Emissions (GPC)" (ICLEI and C40, 2012) prepared by C40 (Cities Climate Leadership Group) and ICLEI (Local Governments for Sustainability) with the support of World Bank and UN-Habitat.

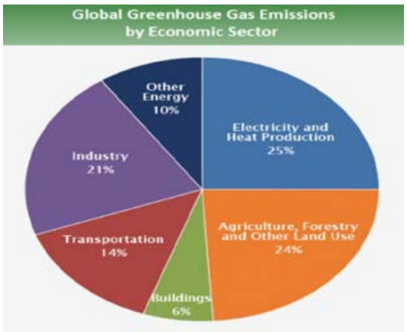
In this section explained the types of GHG emissions inventories by sectors in global and local level and the importance of cities to measure their emissions periodically.

2.5.1 GHG emissions inventories in global level

Based on IPCC guidelines the main sectors emitted GHGs are energy; industrial processes and product use; agriculture, forestry and other land use; and waste. The global GHG emissions by sectors in 2010 based on IPCC Fifth Assessment Report 2014 can be found in Figure 7.

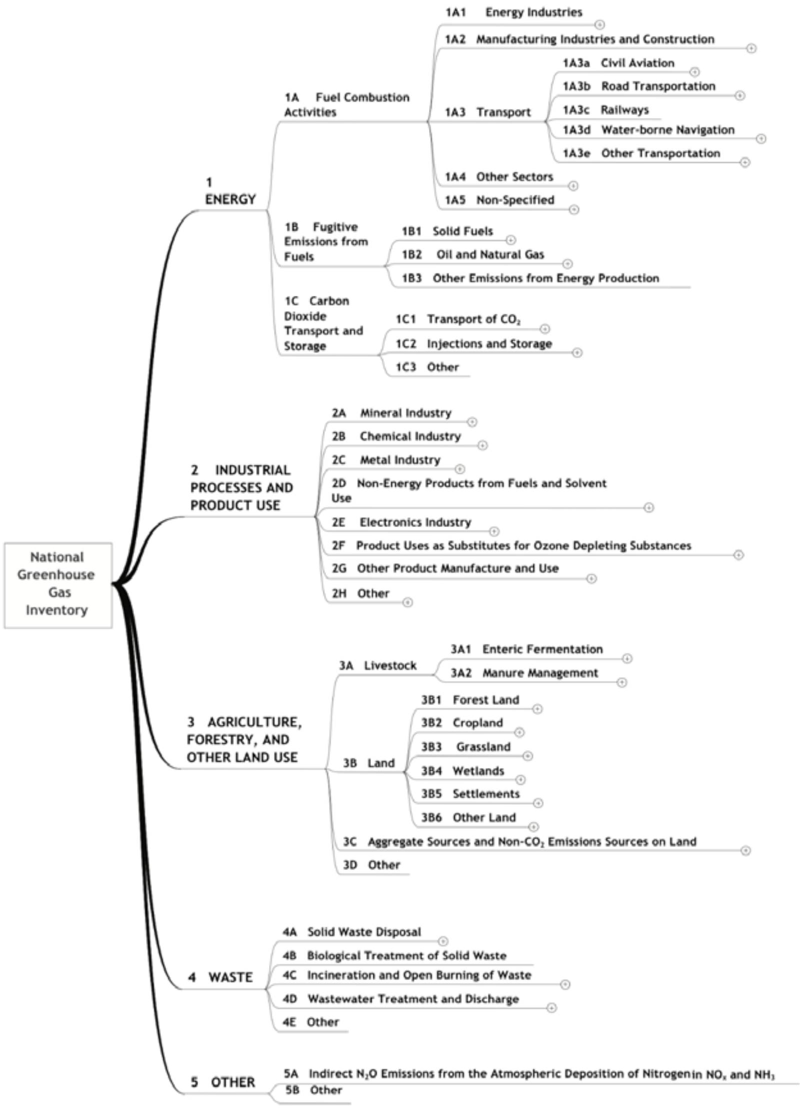
According to the United Nations Framework Convention on Climate Change (UNFCCC), each partner country should provide an annual report on GHG emissions inventory, namely the inventory of emissions which are the result of anthropogenic activities by separating them in critical sectors (Dodman, 2009, D'Avignon, Carloni, et al., 2010). The Intergovernmental Panel on Climate Change in 2006 (IPCC, 2006) provided the guidelines of revised national GHG inventories, which is methodological support and landmark for national governments for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases (Figure 8).

Figure 7: Global GHG emissions by sectors in 2010 (IPCC report 2014).



Source: IPCC (2014) Fifth Assessment Report

Figure 8: **GHG emissions inventory, sectors, sub-sectors**



Source: IPCC, 2006

Energy sector: This sector has the greatest proportion of overall GHG emissions in the world (Romero-Lankao, 2012). Hoornweg et al. claim (2011, p.208) “urban areas currently account for more than 71 per cent of energy-related global greenhouse gases and this is expected to rise to 76 per cent by 2030”. In urban area main energy used in building, transportation sphere and during an implementation of economic activities. The energy consumption in an urban area is higher than in rural, because of the concentration of industries and economic activities in cities (Satterthwaite, 2008), which in fact gives grounds to assert that cities are the main generator of GHG emission. Weisser (2007) research shows that the replacement of energy supply technologies with advanced technologies will have a vital impact on a decrease of GHG emission. Studying 274 worldwide cities, which differ with size, typology, urban form Creutzig et al. (2015) conclude that especially Asian cities which have a rapid tendency of urbanization are able to lessen energy use by 25% in comparison with BAU (business-as-usual) scheme, thereby to contribute the GHG emission.

Transport sector: Transportation is the sector which has a significant contribution to GHG emission, hence also on global warming (Fuglestvedt, Berntsen, et al., 2008). Nowadays, 20 % of energy-related carbon dioxide emitted from transport sector (Deetman, Hof, et al., 2013). Transportation has many sub-sectors and emission mechanisms, types of GHGs are various and have a crucial direct negative impact on climate. Road sub-sector has a significant contribution to carbon emission.

Industrial processes and product use: The quantity of emitted GHGs from industrial processes and product use sector depends on the urban fabric, the economic profile of cities, nevertheless, in general, the contribution from this sector is more than from waste management sector (Dodman, 2009). Cities from developing countries were more industrialized and as a result of industrial activities cities from developed countries generate significantly more GHGs than cities from developing countries, however due to trading schemes established by Kyoto Protocol (Clean Development Mechanism and Joint Implementation) changed the existing balance, which also will change when the Sustainable Development Mechanisms ("intended nationally determined contributions (INDCs)" (United Nations, 2014c,p.3, Höhne, Kuramochi, et al., 2017,p.16)) according to Paris Agreement Article 6.4 (United Nations, 2014c) will become a reality.

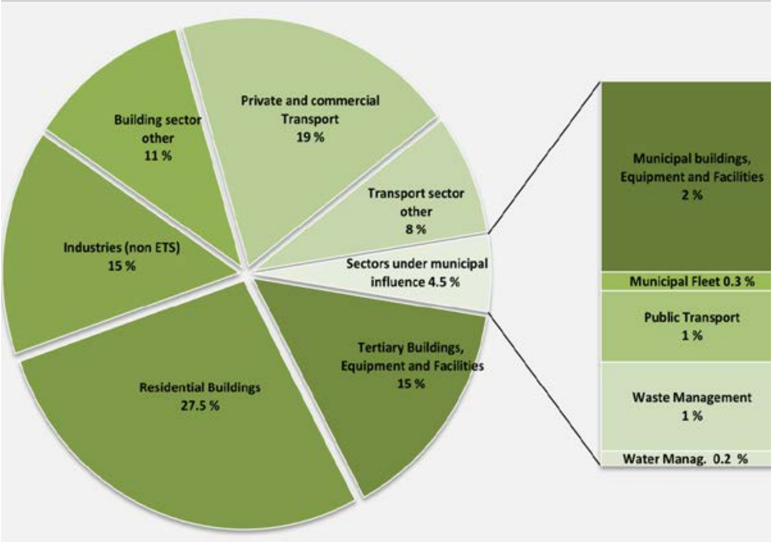
Waste management: The part of anthropogenic GHG emission rises from waste disposal, waste transport, and waste treatment. In US total GHG emissions the proportion of GHGs emitted from the waste sector is 4% (Weitz, Thorneloe, et al., 2002). The main sources of anthropogenic GHGs (CH_4, CO_2 and its equivalent, N_2O) emitted from waste management are landfill, incineration and composting (Bogner, Pipatti, et al., 2008), where the landfill has a significant role (more than 50%) for producing methane. Depends on the level of technological advancement of the country the GHG emission from waste management sector will be different.

Agriculture, forestry, and other land use: The agriculture is one of the sectors which produce CH_4, CO_2, N_2O (Smith, Martino, et al., 2008). Mainly from the agricultural sector to the atmosphere is emitted methane (CH_4), which is the result of the metabolism of ruminant animals, livestock, rice cultivation, savannas' burning etc. (D'Avignon, Carloni, et al., 2010, UN-Habitat, 2011). From agriculture, land use change and forestry sector the proportion of GHG emission was 31 % in 2004 (Satterthwaite, 2008). The decrease of GHG emissions from this sector can be crucial, which can become a contributor of the achievement of the GHG emissions reduction targets especially from developing countries as unlike the developed countries, land use in agricultural purposes in cities from developing countries is much larger than cities from developed countries.

Figure 9 shows the GHG inventories of 315 cities, which are a member of Covenant of Mayor's, based on 2016 database (Kona, Melica, et al., 2016).

Having a clear idea about the sectors from where is collected the GHG inventories, it is also important to know the necessity of their frequent measurement, factors that can influence on climate mitigation, which is presented in following sections.

Figure 9: **315 CoM European cities GHG inventory by subsectors, 2016**



Source: JRC 2016, Covenant of Mayors' dataset

2.5.2 Urban GHG emissions inventories and the importance of cities to measure their emissions periodically

Taking into account that cities have significant contribution to global GHG emissions (UN-Habitat, 2011, Seto, Dhakal, et al., 2014, Krause, 2011) therefore developing city-scale GHG emissions inventories and measuring them periodically is very important for bettering accuracy of inventories (Ramaswami, Hillman, et al., 2008). Ramaswami et al. (2008) mention that in 2006 ten American cities measure the GHG inventories and the number of cities which measuring and reporting their GHG emissions inventories increasing year by year and "developing a more standardized GHG inventory method that is consistent with national-scale and state-level data becomes critically important" (2008, p. 6455).

As GDP per capita in urban areas is higher than rural, therefore the income level directly activates urban economy, industry and logically high personal income influence also urban energy use (Kennedy, Steinberger, et al., 2009), which means that the GHG emissions level is high in cities. Kennedy et al. analyzing global cities "by developing an inventorying procedure broadly based on a city's metabolism" (2009, p. 7301) they found that the results of their study could influence the acknowledgment of cities' activities targeted on urban climate mitigation. The periodical measurement of urban GHG emissions inventories can influence other cities level of achievement of the GHG emissions reduction targets, more specifically cities with the same metabolism, or the same urban fabric, density etc. can make value judgments about their possibilities of achievement of emissions reduction targets.

Emphasizing the dynamism socio-economical activities of urban areas and their significant contribution to GHG emissions Hoornweg et al. (2011) affirms the importance of measuring GHG emissions inventories by sectors in city scale. They underline the interrelation of urban day-to-day life with climate change, more specifically they mention that "per capita estimates of urban GHG emissions largely reflect the nature and economic structure of their respective cities" (2011, p.222). Hoornweg et al. (2011) suggest the use of IPCC methodology (which is at the country level) for measuring urban GHG emissions inventories. This approach already used by many cities (Kennedy, Steinberger, et al., 2010). By accentuating the importance of measuring the GHG emissions inventory on city scale Kennedy et al. underline the necessity of "robust and transparent inventory procedure" (2010, p. 4829). Authors of above-mentioned study by analyzing 10 global cities inventories measurement technologies for each sector separately sum up the usefulness of the appraisal of urban life-cycle GHG emissions inventories.

Having correct data of urban GHG inventories is a crucial investment for re-assessing climate mitigation targets and changing strategic plans or, in some circumstances changing only tactics for making GHG emissions reductions targets achievable. Measuring GHG emissions inventories both national and regional level is important for understanding the causal links between actual level of GHG emissions reduction target and achievability of global climate mitigation target. This is essential especially the cities from developing countries as the majority of cities from developed countries are implementing the measurement of cities GHG emissions inventories. Based on the recent analysis of GHG inventories of European cities, we can conclude that cities are able to set achievable or more ambitious targets (Kona, Melica, et al., 2016). It is also important to study the critical factors which have great influence on the achievement of GHG emissions reduction targets.

2.5.3 Modelling approaches for measuring the projected emissions for cities

There is a different approach for projecting GHG emissions and estimate the emissions in a targeted year. Based on OECD methodology focused on emissions estimation based on the "forward-looking baseline" (U.S. EPA, 2013, p.5). This policy is recommended for projecting the progress of climate mitigation policy and determining the achievability of emissions reduction goals.

The US Environmental Protection Agency has the following approach for estimating GHG emissions. The future emissions determined by projecting the "changes in activity data and emissions factors from that base year" (U.S. EPA, 2013, p.3). The change of socio-economic factors such as populations, GDP, energy consumption etc. are considered as an activity data. The future GHG emissions are estimated based on past trend of GHG inventories that have been measured after adopting climate mitigation policy.

The next methodology is used by Joint Research Centre is a determination of future GHG emissions by identifying "the main factors that drive the trends in GHG emissions in cities and project the interim results of the monitoring subset to the missing Monitoring Emissions Inventories" (Kona, Melica, et al., 2016, p.17).

Trend analysis gave an estimated picture of achievement level of GHG emissions reduction targets for the targeted year and also it shows the difference between committed emissions reduction and actual emissions reduction for each reported year. Linear extrapolation shows the emissions pathway of cities in a targeted year. By using simple linear regression model (Wooldridge, 2015, p.22) can be calculated the estimated emission for each city. The pros of using trend analysis are finding the functional relationship between years and GHG emissions has been reported. The cons of this methodology are that the historical data of the GHG emissions may not give an exact picture of the real trend. One of the main problems that can be arise when identifying the turning points, if the investigating time period is not big enough, it can be difficult to realize whether the turning point outlier or the sign of the upcoming new trend.

2.6 General idea of factors influencing on urban climate mitigation

Each IPCC Assessment report gives new information about the current situation of climate mitigation and highlights new factors that have an impact on climate mitigation, which is the reflection of climate mitigation efforts in the existing reality. The chronology of this factors shows metamorphosis of anthropogenic actions for achieving GHG emissions reduction. First, second, third and fourth IPCC Assessment Reports (IPCC, 1995, IPCC, 2001, IPCC, 2007, IPCC, 1990) analyse and give information about influential factors on climate mitigation which eventually are related to global and national level and there is no clear information about factors that interrelated to local GHG emissions reduction and contribute to meet emissions reduction targets.

Further analysis of the IPCC assessment reports it becomes clear that the role of local implication in climate mitigation has been in the centre of scientists' attention during preparation of IPCC Fourth Assessment Report by concluding that local initiatives may influence the achievement of GHG emission reduction in national level (IPCC, 2007, p. 792). IPCC Fourth Assessment Report analyzed mitigation potential in national level. Whereas the Fifth IPCC Assessment Report (Pachauri, Allen, et al., 2014) includes the factors which refer to cities abatement potential. Exploring the factors that correlate with achievement of GHG emissions reduction targets in urban level is more important as cities has a significant contribution to GHG emissions.

IPCC assessment reports led to development different studies that targeted to disclose and analyze the factors that have the main influence on local abatement potential. For instance, after IPCC Third Assessment report Winkler et al. (2007) suggested **economic, institutional and technological factors** as the main phenomenon which influences on the mitigate capacity of cities. As an economic factor, they consider income, abatement and opportunity costs, as an institutional factor has been considered rules and regulations, the awareness mechanisms and finally, as a technological factor, they study the ability of cities to make technological changes and its advancement.

By analyzing IPCC Fourth Assessment Report Dodman (2009) focused on following factors; **cities economy, air-conditioning system, and compactness of urban structure** as the critical factors in GHG emissions mitigation.

IPCC Fifth Assessment Report underlines that there is a large potential of cities to achieve GHG emissions reduction target.

To unfold the future uncertainty connected to climate change, first of all, it is important to expose all possible factors, which can have a great impact on urban climate mitigation, secondly, to scrutinize all possible interactions between factors and level of achievement of GHG emissions reduction targets. Then to build model based climate mitigation scenarios which will reflect nature response on anthropogenic activities and also possible climate chain changes for future moderation of the intensity of influential factors that have a negative impact on mitigation.

This thesis conducts for understanding to which extent cities produce GHG emissions and also to assess to which extent cities achieved the GHG emissions reduction targets. For finding the answer of following research sub-question "Which factors are interrelated to the achievement of GHG emissions reduction of European cities?", examined those studies which are discussed or refer to this issue. Based on literature those factors can divide into two big parts; **internal** (del Río González, 2008, Kennedy, Steinberger, et al., 2009, Moss, Edmonds, et al., 2010, Raciti, Fahey, et al., 2012b, Kriegler, Weyant, et al., 2014, Reckien, Flacke, et al., 2014, Reckien, Flacke, et al., 2015, Creutzig, Baiocchi, et al., 2015, Höhne, Kuramochi, et al., 2017) and **external** (Romero-Lankao, 2012, Lee and Koski, 2014, Kona, Melica, et al., 2016).

Internal and external factors are differentiated in the light of different directions of governance. Internal factors relate to the local public policy having a concern on domestic affairs, whereas external factors connected to both foreign affairs of governance and horizontal dimension of multi-level governance (Teasdale, 2010). Quite a large number of internal factors raised because of weak governance, for instance socioeconomic, demographic, technological advancement. Other parts of internal factors are interconnected to biophysical and geographic conditions of urban deployment. External factors generally depend on public interests, willingness to cooperate international projects aimed to prevent climate mitigation.

In literature, scientists separated a large number of factors ((Reckien, Flacke, et al., 2015); (Kennedy, Steinberger, et al., 2009); (Creutzig, Baiocchi, et al., 2015); (Krause, 2011); (Raciti, Fahey, et al., 2012a); (Kern and Bulkeley, 2009); (Lee and Koski, 2014), however, not all of them have great influence on GHG emissions reduction and still is not clear to which extent those factors are able to change the level of GHG emissions. It is important firstly to explore all possible factors that are a driving force on climate mitigation, secondly to disclose the interrelation between those factors and GHG emissions reduction, finally to realize whether this correlation is able to increase or decrease the severity of those factors. This will help to build up a robust decision for achieving a deep decrease of the GHG emissions, thereby maximal reduce the future climate uncertainty.

2.6.1 Internal factors

In this section analyzed the internal factors which have an influence on urban mitigation in a different phase of the policy cycle, more specifically in urban mitigation planning, implementation, and GHG emissions reduction. As this thesis concentrates on factors that correlate achievement of GHG emissions reduction target, therefore implementation and monitoring phases of mitigation policy cycle are the main areas where conducts this analysis. Taking into account that mitigation policy cycle is a complex system and the factors affecting each previous stage may indirectly influence the next stages, for that reason below listed the studies which refer to factors that influence to local mitigation planning. This will help to see all spectrum of internal factors that have direct and indirect relation to climate mitigation.

It is notable to realize how the mitigation projects, scenarios developed, in which circumstances mainly which factors involved, do they have synergizing effects or not? The answer to this questions will help to distinguish how to change plans according to the change of given situation for making urban GHG emissions reduction targets more achievable. For that reason, it is necessary to schematically determine the factors that are related to the different phase of policy cycle of urban mitigation: planning, implementation of climate actions, reduction of GHG emissions (Figure 10).

Figure 10: **The influence of factors on climate mitigation**

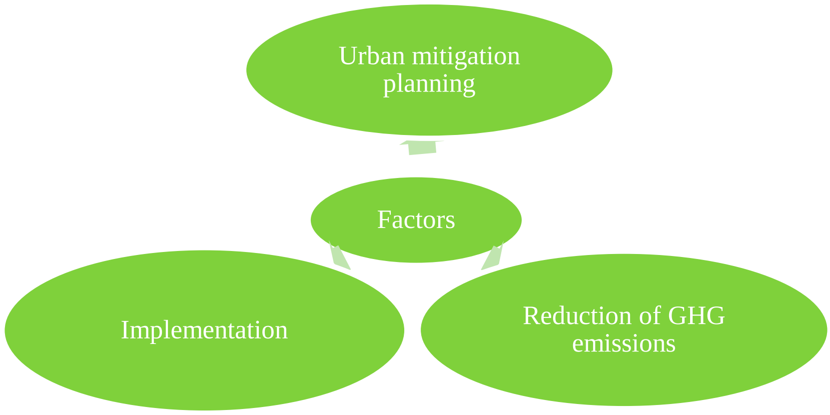
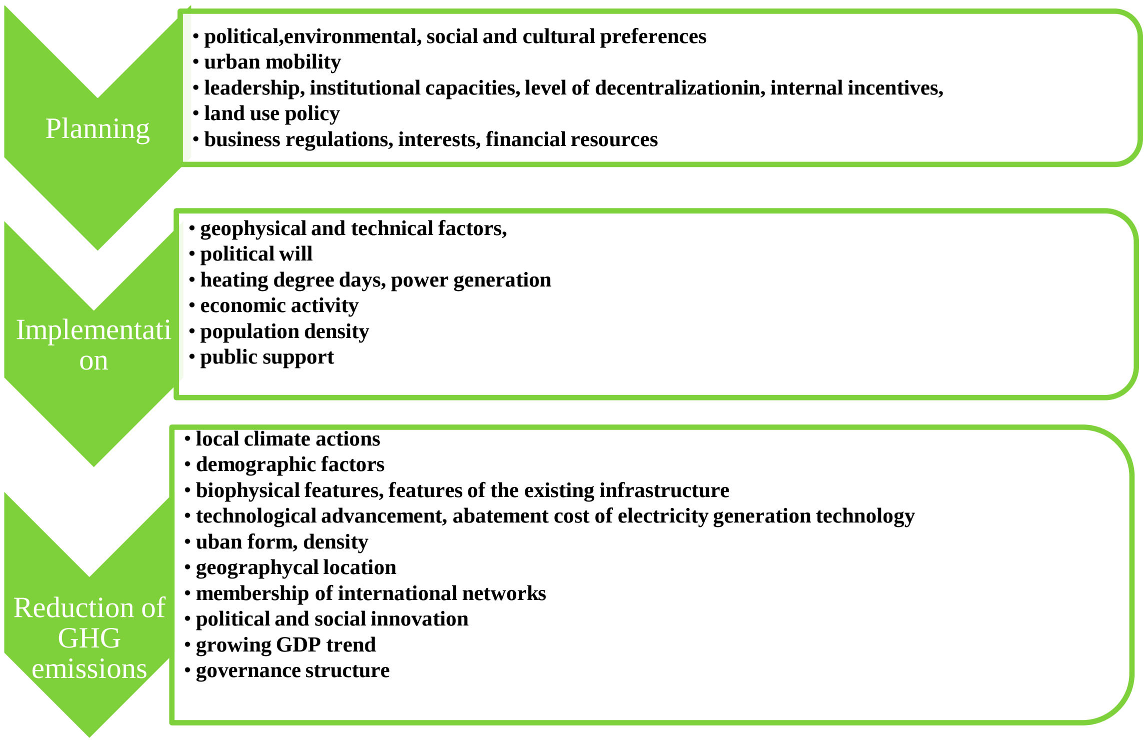


Figure 11 reflects the factors that mainly has been identified in the academic literature. Considering a large number of factors that directly and indirectly influencing on mitigation policy this study concentrates on those factors which mainly correlate with the achievement of GHG emissions reduction.

Figure 11: Factors that influence on climate mitigation planning, implementation of mitigation plans and related to reduction of GHG emissions



The factors which are mentioned in this figure are based on literature which is listed below.

Factors influencing on urban mitigation planning

Millard-Bill, Adam (2012,p. 290) explains "how **political preferences** affect local planning and regulatory decisions". He underlines that accepting the importance of **environmental preferences** might stimulate cities to grow their impact on mitigation of GHG emission in the global level, he also highlights environmental preferences as an important driver, even more as a control variable for implementing GHG emissions reduction strategies.

Patricia Romero-Lankao (2012) listed a number of factors as a driver which shape urban mitigation. She highlighted **local concerns and priorities**, **urban mobility issues, leadership, internal incentives, business regulations, interests, institutional capacities, financial resources, the level of decentralization, inertia (cultural and social preferences)** etc.

Studying American large metropolitan cities Stone et al. (2012) underline the **land use policy** as one of the main factors influencing on the emission of GHG gases. Changing the functions of land surface automatically changed its energetic balance.

Reckien et al. (2015) analyzing 200 European cities addressing **institutional, socio-economic and environmental factors** as drivers for climate change planning. They mention the weak leadership, the absence of political will has a negative impact on mitigation planning, this becomes a barrier for recognizing the possible measures that can help to mitigate future climate anomalies as well as to convince and agreed on the necessity of certain actions.

Factors influencing on implementation of urban mitigation actions

Political will and institutional capacity are crucial factors that can have an impact on the implementation of GHG emissions reduction actions (Reckien, Flacke, et al., 2015). Kennedy at al. describe (2009) **geophysical and technical factors** influencing on the implementation of GHG emissions reduction for global cities, they are highlighting those factors as essential factors for having an appropriate level of the GHG emissions.

Creutzig et al. identify (2015, p. 6283) "**heating degree days, economic activity, population density, power generation and technology"** as the factors that correlate with GHG emissions in city level, they also mention the **fossil fuel price** as driver factor**.**

Raciti et al. (2012b) underline the **political will and public support** as the essential factors for having a tangible reduction of CO_2 emission.

Factors that related to the reduction of GHG emissions

The literature gives a few number of factors which are related to achievement of climate mitigation. Underneath of this section is represented the possible factors that can influence on the achievement of GHG emissions reduction targets.

Acknowledging the role of urban areas as drivers of climate change Krause (2011) delineate the importance of **local climate actions** in achieving ambitious GHG emissions reduction. Analysing 329 US cities, she mentions that part of this cities implements *ad hoc* GHG emissions reduction actions without any specific action plans, however having local climate protection action plans gives an opportunity to institutionalize the climate mitigation, therefore to promote maximum GHG emissions reduction.

The next internal factor which can influence on GHG emissions is **urban form**. As Kennedy et al. mention (2009, p. 7301) "Urban form also has a strong bearing on urban metabolism". As an urbanization factor in literature is mentioning the role of **density for GHG emissions reduction** (Dodman, 2009), which also considered in the last report of the Joint Research Centre (Kona, Melica, et al., 2016).

The study of North-Eastern American cities accomplished by Raciti et al. (2012b, p.23) separated following local factors "**biophysical features**, such as climate, soils, topography, and vegetation; **demographic factors**, such as population density and distribution; **features of the existing infrastructure**, including transportation networks, heat and power supplies, housing, commerce, and industry; and the **governance structures** in which policies must be positioned", which have influence on climate mitigation and reduction of CO_2 emissions.

Moss et al. (2010, p. 748) referred to the **"patterns and rates of economic growth, demographic change, technology, policy"** as national and regional-scale "drivers of change, which can have significant impact on climate change", thereby depends on those factors can be determine the level of future GHG emissions reduction.

According to the last report of European Commissions' Joint Research Centre (Kona, Melica, et al., 2016) based on 315 submitted SEAPs full reports, the main factors that influence on urban GHG emissions are **climate factor, the degree of urbanization, Baseline Inventory Year** and **target ambitious level.** As climate factor (different aspects of geography) has been measured heating degree days for cities which have cold climate and cooling days for cities with warm climate because those days the GHG emissions are high and electricity consumption is related to use of air-conditioning and heating systems. The degree of urbanization associated with the density of the city, and it is assumed that because of accumulation of services the GHG emissions per capita is reducing. Different European cities Baseline for Inventory Year is different, for some cities it starts from 1990, for others from 2005.

Neumayer E. (2004) highlighted the **geographical** location as a climate factor, by analyzing its role and meaning in GHG emissions. By analyzing cities GHG emissions with high and low temperature Neumayer found that "a higher minimum temperature during the cold season is associated with lower CO2 emissions" (2004, p.36).

Factors relate to the achievement of GHG emissions reduction target

Reckien et al. (2014) show that **urban-led emission reduction target** "provides an estimate of national GHG reduction action based on 'bottom-up' reduction intentions" (2014, p.338). By analyzing 200 cities from 11 European Union countries' Reckien et al. (2014) claim that nationally representative mitigation actions within cities can lead to achieving EU GHG emissions reduction target in 2020. Therefore Reckien et all conclude that the nationally representative mitigation actions are one of the essential factors which can have an influence on GHG emissions reduction and making the emissions reduction targets achievable.

The level of achievement of the GHG emissions reduction, consequently also climate mitigation target substantially depends on the level of ambition of the climate mitigation target. If the ambitious level is low then the emissions reduction target is achievable, which has been proved for European cities by Joint Research Centre (Covenant of Mayors, 2017). Erickson et al. (2014) show the gap between the non-ambitious target and global target.

Höhne et al. (2017) underline the following factors that can have a significant impact on achieving climate mitigation goals. This study shows that "lack of experience in setting targets" (2017, p. 21), the poor performance of economic activities, technological capacities can be the cause for failing to meet emissions reduction target. So **growing GDP trend** leads to assume that ambitious targets can be achieved, therefore it is one of the factors that are interrelated with an achievement of ambitious GHG emissions reduction targets. Finally, **renewable energy technologies** (more specifically solar and the wind) can help to meet climate mitigation targets. Höhne et al. (2017) suggest that for reaching Paris goals, therefore ambitious climate mitigation, there is a need to advocate non-state actors, support for developing new technologies (" Zero-energy buildings, efficient electrical appliances, electricity storage, zero-emissions aviation and zero-emissions cement and steel" (2017, p. 27)).

Kriegler et al. (2014) claim that the absence of climate mitigation actions increases GHG emission (2014, p. 357) thereby we can assume that it can have a negative impact on the achievement of GHG emissions reduction target. Discussing of target feasibility Kriegler et al. mention that “a target is feasible if any set of actions exists that could cause the target to be met” (2014, p. 357). This study enlightened the role of technology on climate mitigation, the authors emphasize that the “**Technology** is a key element for reaching climate targets”(2014, p.365). Another study also like Hübler at al. (2013) come to conclusion that “technological solutions are necessary to achieve ambitious climate targets” (2013, p. 205). A number of other studies also emphasize the role of technologies, technological and social innovations for achieving ambitious targets, mitigating GHG emissions reduction (Luderer, Pietzcker, et al., 2013, Budde, 2013).

Peters et al. also underline (2013) the essential role of **technological advancement, political and social innovation factors** for keeping the rise in global temperature below 2^0 degrees, thereby to meet GHG emissions reduction targets.

Underlining the importance of technological advancement, however taking into account the existence of limited data in city level, the analysis of this research will not conduct for this factor.

2.6.2 External factors

One of the main external factors which influence to achievement level of GHG emissions reduction is the existence of horizontal networks, more specifically the **membership of international networks**. As Lee T. and Koski C. (2014) argue the participation in transnational networks stimulate and help to achieve universally accepted targets. This also helps to reassess local mitigation policy and to follow the contemporary tendency of realistic policy making. Being a member of environmental transnational organizations cities authorities have a chance to exchange the experience of successful mitigate policy making, thereby to set achievable GHG emission reduction target, or even to set more ambitious target. The correlation analyze for 200 European cities implemented by Reckien et al. (2015) shows that the membership of international platforms like Covenant of Mayors (CoM) and Climate Alliance are the most influential factors and being member of C40 and ICLEI is more influential for large cities. Even in this study is argued that being the member of climate network is as a driver for climate mitigation and it does not refer to implementation, however the results of the latest JRC Science for Policy Report (Kona, Melica, et al., 2016) shows that 315 European cities 23 % GHG emissions reduction targets already have been achieved. This means that the membership of climate networks as an external factor stimulates to have achievable targets and annual reports, periodically monitoring may help to set even ambitious targets by making global climate mitigation target more achievable.

By analyzing 329 US cities Krause (2011) mentions that there is not enough evidence whether non-network cities have more emissions than network cities (MCPA, ICLEI), however being part of network encourage to institutionalize the climate protection and develop sectoral GHG inventorying policy. Further, Krause underlines “in order to reduce emissions effectively and efficiently, it is essential to know where the bulk of local emissions come from, and thus what sectors should be targeted to achieve maximum reduction” (2011, p. 208).

Kern et al. (2009) underline that being a member of Transnational Municipal Networks (TMN) is crucial for having a successful climate policy. The analysis of this study gives an argument that using multi-level governance tool and joining to international networks is critical for climate mitigation policy it can help to succeed in achieving emissions reduction.

Romero-Lankao mention (2012) **external incentives** as a driving factor for forming mitigation.

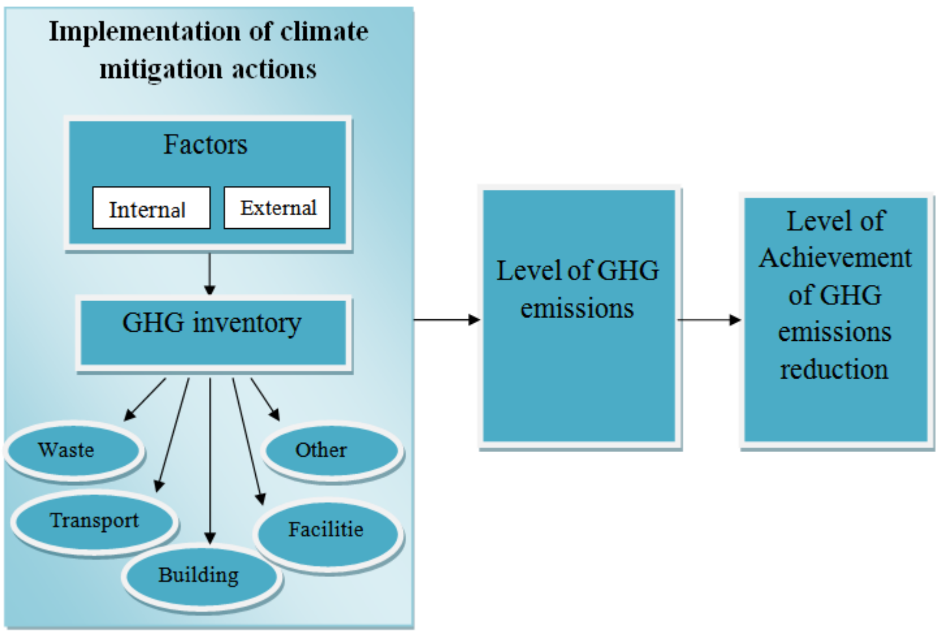
The next essential factor for achieving GHG emissions reduction is **foreign direct investments** (FDI), **financial flows** (Lee, 2013, United Nations, 2014a). Acknowledging the role of FDI in urban mitigation potential, however, the analysis of this factor is out of the scope of the current study. Taking into account of non-homogeneity and multilayered nature of this factor, which thorough analysis will require extra time and resources and also be noting thesis time limitations, to conduct the correlation analysis of the FDI with GHG emissions reduction will not be possible to implement.

2.7 Conceptual Framework

The objectives of this thesis is to assess the level of achievement of local GHG emissions reduction and identify the possible factors that interrelated to achievement of GHG emissions reduction targets, therefore to explore the correlation between those factors and achievement of the GHG emissions reduction target, to explain whether those factors have positive or negative impact on achievement of local GHG emissions reduction target.

The link between concepts of Implementation of climate mitigation actions and level of GHG emissions used for building the conceptual framework of this research. Based on academic literature the conceptual framework illuminates the external and internal factors which may have a correlation with the achievement of GHG emission reduction and also have a direct or indirect influence on the dependent variable.

Figure 12: Conceptual framework



Chapter 3: Research Design and Methods

3.1 Revised Research Question(s)

The main question for this research for achieving research objective is:

Which factors correlate with achievement of local climate mitigation targets of 59 cities from different continents?

The answer of following sub-questions will support to have a complete and clear answer of the main question:

- What is the level of achievement of GHG emissions reduction targets in a cluster of 59 cities from different continents?
- Which factors mainly influence the achievement of GHG emissions reduction of 59 cities?
- Whether this correlation positively or negatively impacts on the achievement of GHG emissions reduction target?

3.1.1 Operationalization: Variables, Indicators

Operationalization of the dependent variable

In order to conduct the research and operationalize the concepts which are depicted on conceptual framework in Chapter two, has been chosen dependent and independent variables. The theoretical concepts have been transformed by making them measurable. For measuring each variable have been chosen a number of indicators, which are able to quantify the variables. The dependent variable of this research is the level of achievement of GHG emissions reduction, which related to the **Level of Emissions** concept. After joining to UNFCCC countries starts to measure the annually emitted GHG. According to Kyoto Protocol, each Party of the convention should measure annual level of GHGs emissions: Annex A (United Nations, 2014b, IPCC, 2006) Carbon dioxide ($C0_2$) Methane (CH_4) Nitrous oxide (N_2 0) Hydrofluorocarbons (HFCs) Perfluorocarbons (PFCs) Sulphur hexafluoride (SF_6). The level of GHG emissions shows the development of climate mitigation policy in each city.

As mentioned in Chapter 2, section 2.5 based on IPCC guidelines cities are conducting GHG inventories from following sectors (IPCC, 2006) Energy, Industrial process and product use, Waste, Agriculture, Forestry and other land use and other sectors.

For measuring the dependent variable the following indicators have been measured; the absolute level of GHG emission (by metric tonnes), the level of GHG emissions reduction target, and the GHG emission (by metric tonnes) per capita. Using this data by calculating below mentioned indicators helps to delineate the assess the real achievement of GHG emissions reduction targets. The degree of the achievement of GHG emissions reduction targets illustrates the status of climate mitigation. The lower the level of GHG emissions, the more effective is climate mitigation policy.

The following indicators measured for operationalization of dependent variable:

- GHG emissions reduction based on trend analysis compared to baseline emissions
- Percent of emissions reduction target has been achieved
- Emissions reduction target achievement based on trend analysis.

Those indicators have been measured based on the absolute level of GHG emissions, last year GHG emissions and GHG emissions per capita. The calculation of those indicators made possible to measure the dependent variable, which is achievement level of GHG emissions reduction targets.

Table 3 illustrates the operationalization of concept, dependent variable achievement of GHG emissions reduction target.

Table 3: **Operationalization: Dependent variable achievement GHG emissions reduction target, indicators**

Concept	**Definition**	**Dependent variable**	**Indicators**	**Values**
Level of emissions	Level of GHG emissions is annual measured amount of emitted greenhouse gases based on Kyoto Protocol Annex A (United Nations, 2014b, IPCC, 2006) The GHG inventories indicate the level of emission, measured based on IPCC guidelines (IPCC 2006)	Achievement GHG emissions reduction	Absolute level of GHG emissions (total emissions of GHG inventories) ➢ GHG emissions reduction based on trend analysis compare to baseline ➢ Percent of emissions reduction target achieved ➢ Emissions reduction target achievement based on trend ➢ Emissions reduction target achievement based on last year achievement	**Metric tonnes** The degree of the achievement of GHG emissions reduction targets illustrates the status of climate mitigation. The lower the level of GHG emissions, the more effective is climate mitigation policy.
			GHG emissions per capita ➢ GHG emissions reduction per capita based on trend analysis compare to baseline ➢ Percent of emissions reduction target achievement (per capita) ➢ Per capita emissions reduction target achievement based on last year emissions per capita	**Metric tonnes/per capita** The low is the emissions per capita the higher is the level of achievement of GHG emissions reduction target
			The level of GHG emissions reduction targets	**Percent compare to baseline** The ambitious is emissions reduction target the higher is the level of carbon emissions reduction.

Operationalization of the independent variable

The Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC) gives a definition of “**implementation of climate mitigation actions”** concept: “…limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs” (United Nations, 2014d, Klein, Schipper, et al., 2005). Another definition of “**implementation of climate mitigation actions”** concept is based on UN-Habitat report and is the “implementing policies to reduce GHG emissions and enhance sinks” (UN-Habitat, 2011, p.5).

As the Erickson et al. (2013) define the implementation of climate mitigation actions in city scale is conducting GHG emissions inventories and adopting climate mitigation targets. According to them (2013, p. 38) “City climate action plans typically identify a series of priority actions – policies and measures often selected based on stakeholder consultation processes – as well as implementation strategies and progress indicators”. Socioeconomic, technological, policy, biophysical, demographic, climate groups of factors will be measured for operationalizing the concept of implementation of climate mitigation actions.

The outcome of climate mitigation actions depends on the circumstances and pre-conditions where emissions reductions action plans formulated and implemented, which highly related to internal and external factors. For answering research question “Which factors mainly correlate with the achievement of GHG emissions reduction of European cities?”, based on literature described in subsection 2.6.1 and 2.6.2 following indicators will measure the internal factors:

- As a **socioeconomic** factor’s indicator selected “GDP/per capita”
- As **climate** factor the geometrical location of cities (latitude)
- As a **policy** factors’ indicator “number of climate mitigation actions”
- As a **biophysical** factor’s indicator “size of cities”
- As a **demographic** factor’s indicator used population, density, age composition (0-14, 15-64, 65+).

For measuring socioeconomic factor will be used panel data from cities policy documents collecting during the investigating time period of this research, namely, will be assembled cities’ GDP/per capita carbon emissions last reported year.

The geographical location, the latitude of cities has been chosen as a climate factor, as depends on the geographical location the average temperature during the year is changing with the change of latitude. More specifically, the heating and cooling degree days during the year are significantly different compared to Northern and Southern hemispheres. Depends on how many heating and cooling degree days have cities during the year the consumptions of energy is differed, therefore the GHG emissions could be significantly different. Taking into account the limitation of cities data on heating and cooling degree days, especially they were not reported in city level and country level data will not give clear information in local level as cities in this study do not have the same geographical coordinates (latitude, longitude) as countries, therefore the latitude has been chosen as a climate indicator.

For collecting data of cities’ latitude used cities carbon registry reports.

For measuring **external** factors’ as an indicator has been chosen “membership of the international networks” such as Covenant of Mayors, C40, and ICLEI. Table 4 illustrates the operationalization of “**factors influencing implementation of climate mitigation actions”** concept. According to the UN definition, the implementation of climate mitigation action is "…limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs" (United Nations, 2014d, Klein, Schipper, et al., 2005, IPCC, 2006). The concept of independent variable is the factors that influence the efforts to reduce the GHG emissions.

The indicators are selected by taking into account the research and analysis time limitations. For measuring the demographic factor used population growth and age composition indicators based on O'Neill et al. (2012) study.

Table 4: **Operationalization: Independent variables- External and internal Factors, indicators**

Concept	Definition	Independent variables	Indicators	Values
Factors influencing the implementation of climate mitigation actions	Circumstances that resulted in efforts to reduce the GHG emissions	**Internal factors** Socio-Economic Climate Demographic Policy Biophysical feature **External factors**	 GDP/ per capita Cities location latitude Population Age composition Density Number of climate mitigation actions Cities' size (km2) Membership of the international networks (C40, CoM, ICLEI)	If the correlation coefficient is higher than "+1", then there is a strong positive correlation, if " -1" strong negative. Between "+3" to "+5" –moderate positive, "-5" to "-3"- moderate negative, less than "+3" or "-3" weak positive or negative, 0- no correlation. Strong relation with emissions reduction will indicate the positive correlation, the weak relation of factors with the level of emissions reduction will indicate negative correlation.

3.1.2 Research strategy

For answering the main research question "Which factors correlate with achievement of local climate mitigation targets of 59 cities from different continents?", the desk research used as the main research strategy. The strategy has been chosen based on the specifications of research objectives. For analyzing and assessing the achievement level of climate mitigation of 59 global cities' during a time period the desk research is the optimal choice. Desk research gives possibility both to make analyze during a long period of time and to see the changing character of variables, their fluctuation value over a period. Being time and cost effective this strategy is the most suitable for this research taking into account time and cost requirements of thesis conducting period.

Desk research is the strategy which characterized with a high quality of data and has the high external validity. As this research is exploratory and tends to generalize the results, therefore by using desk research strategy and analyzing the change of variables over a period of time can be generalized the findings. Using secondary data, already collected statistic quantitative data enables to statistically analyze the changes over a period of time by discovering trends. As Sandra Van Thiel mentions (2014, p.119) "cannibalizing" datasets by conducting different analysis helps to find interrelations between variables and explore a new theory.

By the help of this strategy has been collected and analyzed secondary data regarding the status of implementation of climate mitigation policy, thereby will be assessed the achievement level of GHG emissions reduction targets during the reported period of carbon emissions reduction.

Will be used also content analysis type of desk research for finding out cities' membership of international projects. This will conduct by analyzing cities' policy documents.

3.1.3 Data Collection Methods

The Research used secondary quantitative data collection method for indicators of dependent and independent variables. The scope of GHG inventories has been chosen based on the literature which discussed in Chapter two. Secondary data collected based on cities climate mitigation reports SEAP monitoring reports, Carbon reductions Reports from different platforms' databases; Covenant of Mayors (CoM), C40 cities (Climate Leadership Group), Carbon Disclosure Project (CDP), Carbon Climate Registry(cCR), Compact of Mayors.

The cities data (the absolute level of GHG emission (by metric tonnes), the level of GHG emissions reduction target and GHG inventory (IPCC, 2006) collected by cities in each reporting year) that are missing from the above-mentioned database has been collected from their government web page. From local government's official web page's has been collected also the independent variables (cities' population, GDP per capita).

Secondary data related to external and internal factors conducted based on cities annual policy reports, census reports. For collecting the secondary data on external factors, such as cities' participation in international networks has been analyzed policy documents, intergovernmental contracts, treaties.

Data has been collected from 26 June to 30 July.

3.1.4 Data Analysis Methods

The collected secondary data has been analyzed by using Microsoft Excel program and statistic software SPSS.

3.1.4.1 Trend Analysis

In order to answer the main research question by help of Microsoft Excel "Trend" function has been conducted trend analysis for 59 cities that have been reported the urban GHG emissions inventories from 1991 to 2016 time period. For assessing the level of emissions reduction during the reporting period has been conducted linear extrapolation which gives the value of the GHG emissions in the target year. Using secondary statistic information by conducting trend analysis gave a complete picture of achievement level of GHG emissions reduction targets for the targeted year and also it shows the difference between committed emissions reduction and actual emissions reduction for each reported year.

Linear extrapolation shows the emissions pathway of cities in a targeted year. By using simple linear regression model, the Equation 1 (Wooldridge, 2015, p.22) has been calculated the estimated emission for each city.

Equation 1: Linear Regration

$$“\ y = \beta_0 + \beta_1 x + u\ ” \ .$$

Where “y” and “x” are two variables, target year emissions and target year,

“β_0” is the intercept parameter or constant,

“β_1” is the slope parameter.

The Equation 1 calculates the estimated emissions in ceteris paribus. Namely, the functional relationship between years (x) and GHG emissions (y) has been illustrated in last year emissions calculation under the conditions business as usual (BAU), more specifically if the last year climate mitigation policy status will not be changed during the target adopted and target year period.

The trend analysis helps to find the answer of first sub-question of this thesis, that is “What is the level of achievement of GHG emissions reduction target?”.

3.1.4.2 The methodology for calculation dependent variable based on trend

Indicator 1 - GHG emissions reduction based on trend (compare to baseline)

In order to calculate the percents of baseline emissions that have been reduced after adopting the climate mitigation target, has been calculated the *GHG emissions reduction based on the results of linear extrapolation, namely the results of trend analysis.* The calculation is presented below:

Firstly have been calculated the actual emissions reduction compared with the trend emissions results, that have been calculated by “TREND” function of Excel programme and the results are indicated in Annex 2. The difference between trend emissions (TrE) and baseline emissions (BE) is the actual GHG emissions reduction (AER) which estimated that cities will achieve in the target year.

$$BE – TrE = AER$$

Then, have been calculated the ratio of AER compared to BE in percentages.

Indicator 2 Percent of the GHG emissions reduction target has been achieved

In order to realize how many percents of the declared target could be achieved based on trend emissions has been calculated the next indicator, which is “percent of the emissions reduction target has been achieved”. For determining this indicator the following calculation has been conducted: Firstly has been calculated **actual emissions reduction** (AER) based on trend, namely the difference between baseline emissions (BE) and trend emissions (TrE).

BE – TrE = AER

Then has been calculated emissions which have to be reduced in target year according to cities commitment: that is the difference between **baseline emissions** (BE) and **target year emissions** (TgE).

BE – TgE = Emissions to be reduced

Afterwards, the ratio of actual emissions was calculated to the volume of GHG emissions that have to be reduced, in percentages:

Equation 2: Percent of GHG emissions reduction target achieved

$$\text{Percent of target achieved} = (BE-TrE) / (BE-TgE) \qquad \text{(Equation 2)}$$

If the ratio is one, then the target can be achieved, if the ratio is higher than one (>1), then the target can be achieved and emissions reduction will exceed the planned one. Finally, if the ratio is less than one (<1), then the target is not achievable.

Indicator 3 GHG emissions reduction target achievement based on trend analysis (trend emissions &target emissions)

The calculation of *GHG emissions reduction target achievement based on trend analysis* indicator has been done by calculating the percentage of trend analysis results to commitment emissions in the target year. This indicator shows the ratio of trend emissions compare to target emissions (Trend emissions/ Target emissions).

3.1.4.3 The methodology for calculation dependent variable based on last year emissions

The target achievement based on last year emissions has been calculated by proceeding from the following circumstances: ***first of all*** taking into account the limitations of the thesis, that not all cities have been reported the GHG emissions inventories permanently after adopting the climate mitigation target, moreover, analysing the database of the Climate Disclosure Project from 2012 to 2016, it becomes clear that majority of cities even have been reported the GHG inventory annually, however the reported year they have been repeated the total amount of GHG emissions which have been measured earlier. This leads to conclude that the reporting year emissions cannot be considered as the same year emissions. Thereby, the repeated amount of emissions from cities report has been excluded for the cities that are included in the sample of this thesis. ***Secondly***, as year by year the cities improve the GHG emissions inventory methodology, therefore the accuracy and trustworthiness of last inventories are higher than each previous year, for that reason calculating target achievement based on last year emissions can more accurately describe the level of GHG emissions reduction.

The calculation of this indicator has been conducted as follows: the indicators has been mentioned in this subchapter has been calculated based on last year GHG emissions, namely has been calculated: 1) Last year GHG emissions reduction comparing to baseline, 2) Percent of the target has been achieved based on last year emissions and 3) Emissions reduction target achievement based on last year emissions.

3.1.4.4 The methodology for calculation dependent variable based on the GHG emissions reduction per capita

This section presents the methodology used for measuring the achievement of GHG emissions reduction per capita. Based on the Guidebook of JRC “The “per capita” option is recommended when the scenarios until 2020 show either a sharp decrease or a sharp increase in population within the territory of the local authority” (JRC, 2013, p.25). As in the sample of this thesis for one-third of cities compared to baseline it is estimated to have a sharp increase in population, that is the reason for analyzing GHG emissions reduction per capita.

Has been calculated baseline emissions per capita, committed emissions per capita, trend emissions and last year emissions per capita. By comparing those three values has been made comparison the level of achievement GHG emissions reduction target per capita among 59 cities.

The estimated emissions per capita have been calculated by using the methodology adopted by European Commission’s, Joint Research Centre (JRC, 2013). The emissions per capita have been calculated by dividing the total amount of baseline, last year and target years CO_2e emissions by the number of city's inhabitants respectively in the baseline, last year and targeted year.

For having the number of cities' population in the target year has been used the data from Euromonitor. For cities which population data is absent in Euromonitor, has been conducted linear extrapolation by using data from World Bank (Manchester, Bristol, Toronto,Tokyo, Wonju, eThekwini), Statistiska Centralbyrån, Sverige (Swedish cities), Statistics Belgium (Brussels), US Census Bureau (North American cities), Municipality Data (city North Vancouver), Indian census (ceicdata) (Indian cities).

3.1.4.5 Correlation Analysis

Thanks to an SPSS software has been conducted correlation analysis by calculating Pearson's correlation coefficient, and also has been conducted the T-Test analysis for exploring the interrelation between dependent and non-continues independent variables ("member of Covenant of Mayors", "member of C40", "member of ICLEI", "member of more than one network"). More specifically, this analysis helps to find the correlation between factors and achievement of GHG emissions reduction target, thereby to find the answers to both main research question and sub-questions based on research objectives of this study.

3.2 Sample size and selection

The sample size of cities selected has been chosen by taking into account the following criteria; adoption of climate mitigation targets, the existence of Local Climate Mitigation Action Plans and presence of GHG emissions reduction reports, which reported cities GHG emissions inventory.

Next group of criteria is the size of cities' population ("big" - more than 250,000 inhabitants, "medium"- from 250,000 to 50,000 inhabitants and "small"- less than 50,000 inhabitants).

3.3 Reliability and validity

In order to achieve internal validity of this research, the selected independent and dependent variables and indicators have been chosen in the way of measuring the concepts, which are the **level of emission** and **implementation of climate mitigation actions**. The desk research strategy and secondary data collection method have been used in this study. The secondary data collected based on cities' carbon registry reports, policy documents. The independent variables measured periodically by cities' authorities, which increase the accuracy of data and excluded the coincidental factor by making the study more reliable. In order to increase the reliability of research conducted triangulation by comparing the GHG inventories from the different database including data on cities' carbon emissions. Has been compared the GHG emissions inventories data from Carbon Disclosure Project, Eurostat, Covenant of Mayors, ICLEI. For making the GHG emission inventories comparable and increasing the reliability of data has been calculated the emissions reduction per capita for each city.

The study conducted trend analysis, which brings extra reliability to research. A desk research has high external validity, therefore this research has high external validity.

Chapter 4: Research Findings

This chapter presents the analysis based on the collected data and main findings, which are the outcome of elaboration of the raw data. Data has been collected from different carbon registry projects. The main sources of the dependent variables indicators, GHG inventories have been collected from Carbon Disclosure Project (CDP), carbonn.org database Carbon Registry reports, Covenant of Mayors' database, Cities' climate mitigation reports, Action Plans, Euromonitor, Urban Audit. Part of the indicators of the independent variables collected from above-mentioned sources (population, city's area, location). The information about cities membership on climate networks collected from international treaties, contracts, cities' municipalities declarations.

Table 5 shows the main sources from where has been collected the GHG inventories for selected 59 cities.

Table 5: The main sources of data collection

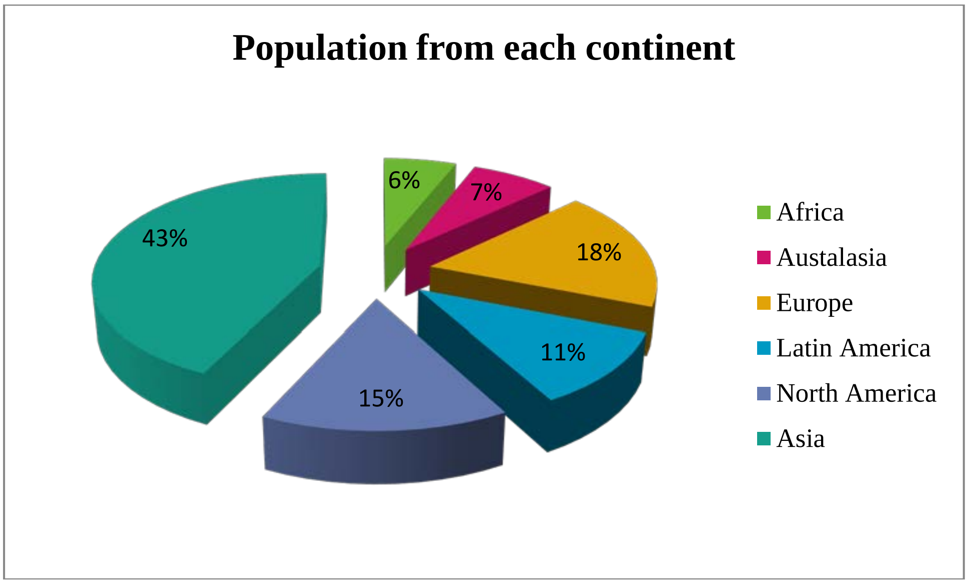
1	Carbon Disclosure Project	Local governments reports (CDP, 2017)
2	Carbonnn.org Project	Carbon Climate Registry reports (Carbonn Climate Registry, 2017)
3	Covenant of Mayors	SEAP reports (Covenant of Mayors, 2017)
4	Erasmus Library Databases	Euromonitor, World Bank (Erasmus University Rotterdam, 2017)
5	ICLEI (Local Governments for Sustainability)	Cities government reports (ICLEI, 2017)
6	C40	Official web page (C40, 2017)
7	Compact of Mayors	Official web page (Compact of Mayors, 2017)
8	Cities climate mitigation reports	
	Des Moines	Iowa climate change advisory council final report 2008. Des Moines: Iowa Government (ICCACFR, 2008)
	Denver	Action Plans (Denver Environmental Health, 2015, PAG, 2014)
	Evanston	Action Plan (Citizens' Greener Evanston, 2017)
	Hamburg	The Hamburg Climate Action Plan (HMUDE, 2011)
	eThekwini, Durban	Energy Strategy 2008 (eThekwini Municipality, 2008)
	Flagstaff	Greenhouse Gas Emissions Management Program (Trinity Consultants, 2008)
9	Cities' Statistic Services	
	Brussels	Brussels population (City Population, 2017)
	Östersund, Vajxo, Umeå, Västerås, Saffle	Sweden population (City Population, 2017)
	Thane	India census (CEIC, A Euromoney Institutionsl Investor Company, 2017)
10	Eurostat	Urban Audit (Eurostat, 2017)
11	Regional Greenhouse Gas Inventory	
	Tucson	Regional greenhouse gas inventory (PAG, 2014, PAG, 2008, PAG, 2017)
	Boulder	City of Boulder 2015 greenhouse gas emissions inventory, summary report (Lotus Engineering & sustainability, 2017)
12	US Census Bureau	(United States Census Bureau, 2017)

Source: Author

4.1 Research sample

Research sample comprises cities from a different continent and includes 59 cities from 25 countries; 19 European cities, 3 Latin American cities, 16 North American cities, 16 Asian cities, 2 African cities and 3 cities from Australian and New Zealand. The population of 59 cities covering 122,181,427 inhabitants (Asia 43%, Europe 18%, Latin America 11 %, North America 15 %, Africa 6 %, Australasia 7%).

Figure 13: Percentage of population by continents



Based on Covenant of Mayors' classification (Shiwei, Y., Zhang, J., Zheng, S., Sun, H., 2015) of urban cities by their population size the thesis sample size includes: 7 "small (S)", 8 - "medium (M)", 5 - "large (L)" and 11-"extra large (XL)", 22 "extra extra large (XXL) sized cities and 6 cities with "Global" size cities. As the population size in this thesis sample is big that is the reason for grouping 59 cities on the following logic :

- 20 cities with less than 500,000 population,
- 11 cities with population more than 500,000 and less than 1,000,000 population,
- 22 cities with more than 1,000,000 and less than 5,000,000 population,
- 6 cities with more than 5,000,000 population.

71 % of cities have a high density (Shiwei, Y., Zhang, J., Zheng, S., Sun, H., 2015) more than 1500 inhabitants per $km^{2,}$ 25% have between 300 to 1500 density, and 4% with low density.

Based on city's area size, from where has been collected GHG inventories, cities comprises on "small", "medium" and "large" size cities:

- 22 cities with less than 200 km^2 area,
- 17 cities between 200 to 500 km^2 area,
- 20 cities with more than 500 km^2 area.

32% of cities from investigating sample size are members of C40 cities network, 27% are members of Covenant of Mayors and 75% are a member of ICLEI.

59 cities including in the sample size of this thesis, has been used the following GHG emissions inventories primary methodologies: 24 cities has been used the "**2006 IPCC Guidelines for National Greenhouse Gas Inventories"** (IPCC, 2006), 8 cities **International Emissions Analysis Protocol (ICLEI),** 3 cities **U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (ICLEI)**, 16 cities **Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (ICLEI),** Copenhagen used **National Danish Carbon Emissions methodology for municipalities,** 7

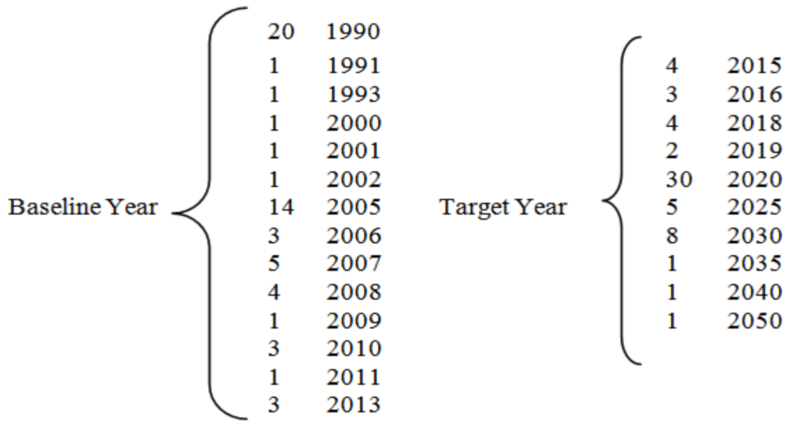
cities have been used other methodologies. This information collected from Carbon Disclosure Project open data (CDP). There was no specific clarification about the other methodology which had been reported.

4.2 GHG emissions reduction target

In research sample 59 cities for setting GHG emissions reduction target has been chosen different baseline year, also there was a difference between targeted year. Figure 14 shows how many cities out of 59 has the same baseline year. As it can be seen from the figure 14 the majority of cities declared 1990 and 2005 year as a baseline year. In general Asian cities has been joined to UNFCCC late and started to implement climate mitigation plans comparably late, that is the reason for applying late baseline year.

The second part of Figure 14 indicates the number of cities that have the same target year. Mainly the cities after meeting emissions reduction target they had changed the GHG emissions reduction target year and had set a new more ambitious target. The majority of cities had 2020 year as a target year.

Figure 14: Number of cities with the same baseline and target Year



Source: Author

Part of cities has been adopted more than one GHG emissions reduction target. Table 6 depicts those cities that have been committed more than one GHG emissions reduction target in their climate mitigation plans. 22 % of the sample are cities with more than one emissions reduction target.

Table 6: Cities' with ambitious GHG emissions reduction targets

City	Target year	Target (%)
New York	2025 2030 2050	35 40 80
Toronto	2012 2020 2050	6 30 80
Bogota	2016 2038	10 56
Oslo	2020 2030	50 95
Uppsala	2020 2030	45 72

	2040 2050	84 94
Västerås	2020 2050	50 90
Vaxjo	2015 2030	55 100
Stockholm	2050 2040	24 100
Hamburg	2030 2050	50 80
Wellington	2020 2030 2050	10 40 65
Hiroshima	2030 2050	50 70
Taipei	2030 2050	25 50

Source: CDP 2017, cCCR, 2017

4.3 The results of trend analysis

As it is mentioned in Chapter 3 for 59 cities has been conducted trend analysis by using "TREND" function of the Microsoft Excel programme. The results of the linear extrapolation expressed the emissions pathway of cities from baseline to the targeted year.

Trend analysis resulted that 36 % of cities from the selected sample will achieve their target, 15% of cities close to achieving committed target and 49% of cities will not achieve the target, which can be seen in Table 7, Table 8 and Table 9 respectively.

The results indicated that the vast majority of cities which achieved the committed emissions reduction target are from developed countries, mainly from Europe and North America continents. The results once again proved the hypothesis that European cities already achieved the 2020 target. These results are close to the results that have been conducted by Joint Research Centre 2016, according which 315 European cities already achieved 23% reduction in 2014 (the goal for 2020 is 20% reduction) (Kona, Melica, et al., 2016). All European cities which achieve the GHG emissions reduction target, they are a member of Covenant of Mayors.

Table 7: **Cities that will achieve the GHG emissions reduction target based on trend analysis**

City	Baseline Year	Target Year	Baseline year emissions (metric tonnes CO_2e)	Target year emissions (metric tonnes CO_2e)	Target year emissions based on trend analysis (metric tonnes CO_2e)	Difference between baseline and trend analysis (metric tonnes CO_2e)	Difference between target and trend emissions (metric tonnes CO_2e)
Copenhagen	2010	2025	2,515,250	0	-656,761	3,172,011	656,761
Stockholm	1990	2020	3,668,000	2,787,680	1,979,537	1,688,463	808,143
Madrid	1990	2020	12,653,000	10,122,400	6,216,096	6,436,904	3,906,304
Lisbon	2002	2020	3,887,013	3,109,610	1,532,031	2,354,982	1,577,579
Kadiovacik	2011	2016	655.0	628.0	358.0	297.0	270.0
Brussels	1990	2025	4,057,300	2,840,110	2,086,021	1,971,279	754,089
Turku	1990	2020	1,475,000	1,180,000	996,670	478,330	183,330
Bogota	2013	2016	16,077,576	14,469,819	12,955,113	3,122,463	1,514,706
Toronto	1990	2020	27,051,617	18,936,132	9,305,993	17,745,624	9,630,139
New York	2005	2025	55,616,668	36,150,834	36,098,770	19,517,898	52,064

Boston	2005	2020	7,440,000	5,580,000	5,303,306	2,136,694	276,694
Minneapolis	2006	2015	5,700,000	4,845,000	4,398,949	1,301,051	446,051
Portland	1990	2030	8,989,460	5,393,676	3,037,792	5,951,668	2,355,884
Philadelphia	2006	2015	22,837,228	18,269,782	14,645,562	8,191,666	3,624,220
Denver	1990	2020	11,800,000	9,440,000	1,994,171	9,805,829	7,445,829
Taipei	2005	2030	15,500,000	11,625,000	11,383,441	4,116,559	241,559
Nagoya	1990	2020	17,390,000	13,042,500	10,898,038	6,491,962	2,144,462
Kaohsiung	2005	2020	64,339,200	51,471,360	48,093,338	16,245,862	3,378,022
Wellington	2001	2020	1,310,705	1,179,635	1,158,445	152,260	21,190
Portland	1990	2030	8,989,460	5,393,676	3,037,792	5,951,668	2,355,884
Des Moines	2008	2020	2,398,445	2,134,616	1,941,149	457,296	193,467

Source: Author

Table 8: Cities that are close to achieving the GHG emissions reduction target

City	**Baseline Year**	**Target Year**	**Baseline year emissions** (metric tonnes CO_2e)	**Target year emissions** (metric tonnes CO_2e)	**Target year emissions based on trend analysis** (metric tonnes CO_2e)	**Difference between baseline and trend analysis** (metric tonnes CO_2e)	**Difference between target and trend emissions** (metric tonnes CO_2e)
Amsterdam	1990	2025	3,417,000	2,050,200	3,225,500	191,500	-1,175,300
Vajxo	1993	2015	326,738	147,032	216,628	110,110	-69,596
Östersund	1990	2030	428,000	0	2,045	425,955	-2,045
Manchester	1990	2020	21,200,000	11,024,000	13,418,129	7,781,871	-2,394,129
City Vancouver	2007	2020	2,805,000	1,879,350	2,286,730	518,270	-407,380
Bristol	2005	2020	2,405,000	952,476	1,556,607	848,393	-604,131
Flagstaff	1990	2020	1,116,738	446,695	573,673	543,065	-126,978
Panaji	2013	2019	154,912	117,212	135,764	19,148	-18,552
Belo Horizonte	2007	2030	3,176,966	2,541,573	2,604,905	572,061	-63,332
Västerås	1990	2020	918,500	459,200	655,534	262,966	-196,334

Source: Author

Table 8 illustrates above-mentioned assertion that European cities tend to achieve their climate mitigation targets. From Table 9 and Table 10 is obvious that the cities that achieve or close to achieve the target are from countries with developed economies based on the World Bank classification.

Based on this results can be explained the fact that some cities changed the target as they already met the committed target. The change of baseline year also can be explained by the good performance of cities emissions reduction activities.

The comparison of the data in the Tables 7, 8 and 9, becomes clear that 42 % of European cities in sample size will achieve the committed GHG emissions reduction target and 26% are close to achieving the target, while only 18 % of Asian cities can achieve their target and 82% cannot achieve.

Table 9: Cities cannot achieve the GHG emissions reduction target

	Baseline Year	Target Year	Baseline year emissions (metric tonnes CO_2e)	Target year emissions (metric tonnes CO_2e)	Target year emissions based on trend analysis (metric tonnes CO_2e)	Difference between baseline and trend analysis (metric tonnes CO_2e)	Difference between target and trend emissions (metric tonnes CO_2e)
Hamburg	1990	2020	20,727,000	10,363,500	20,270,972	456,028	-9,907,472
Oslo	1991	2020	1,168,000	584,000	1,394,228	-226,228	-810,228
Uppsala	1990	2020	1,289,300	709,115	1,236,427	52,873	-527,312
Umeå	1990	2018	545,003	272,502	516,523	28,480	-244,021
London	1990	2025	45,000,000	18,000,000	29,185,354	15,814,646	-11,185,354
Buenos Aires	2008	2020	11,000,720	9,900,648	15,182,523	-4,181,803	-5,281,875
North Vancouver	2005	2020	223,127	167,345	199,494	23,633	-32,149
Edmonton	2005	2035	15,862,000	10,310,300	17,771,850	-1,909,850	-7,461,550
Atlanta	2009	2020	7,656,727	6,125,382	11,568,275	-3,911,548	-5,442,893
Tuscon	2007	2020	7,560,728	7,560,728	8,244,058	-683,330	-683,330
Seoul	2005	2020	49,467,000	37,100,250	46,684,987	2,782,013	-9,584,737
Tokyo	2000	2030	62,100,000	43,470,000	73,282,269	-11,182,269	-29,812,269
Yokohama	2005	2020	19,540,000	16,413,600	23,175,728	-3,635,728	-6,762,128
Hiroshima	1990	2030	8,525,221	4,262,611	9,821,916	-1,296,695	-5,559,305
Hong Kong	2005	2020	42,000,000	21,000,000	43,187,671	-1,187,671	-22,187,671
Durban	2007	2040	22,186,187	16,167,499	24,256,459	-2,070,272	-8,088,960
Sydney	2006	2030	4,536,712	1,361,014	3,103,947	1,432,765	-1,742,933
Melbourne	2008	2020	4,934,000	0	5,499,624	-565,624	-5,499,624
Thane Municipality	1990	2019	2,327,233	623,723	2,969,136	-641,903	-2,345,413
Rajkot	2007	2020	882,103	451,825	3,116,947	-2,234,844	-2,665,122
Shimla	2010	2018	186,316	167,684	314,763	-128,447	-147,079
Gwalior	2008	2018	591,963	532,767	1,690,963	-1,099,000	-1,158,196
eThekwini	2005	2020	15514200	11,480,508	40,542,645	-25,028,445	-29,062,137
Wonju	2005	2018	1,471,393	1,088,831	2,884,307	-1,412,914	-1,795,476
Pimpri Chinchwad	2013	2030	1,913,797	2,098,800	8,414,379	-6,500,582	-6,315,579
Tainan	2010	2020	25,620,952	18,959,504	25,064,423	556,529	-6,104,919
Boudler	2005	2050	1,949,796	389,959	1,691,777	258,019	-1,301,818

Source: Author

By summarizing, the trend analysis helps to find the answer of first sub-question of this thesis, that is “What is the level of achievement of GHG emissions reduction target for 59 cities from a different continent?”. 42 % of European cities in sample size will achieve the committed GHG emissions reduction target and 26% are close to achieving the target, while only 18 % of Asian cities can achieve their target and 82% cannot achieve, 50% of North American cities will achieve the emissions reduction target and 21% of them are close to the achievement level and only 29% will not achieve the target.

Annex 2 graphically illustrates the results of cities trend analysis based on their reported GHG emissions inventories.

4.4 Level of achievement of the GHG emissions reduction target

For the thorough judgment of the dependent variable in the conceptual framework, namely the level of GHG emissions reduction, and answering research questions, has been calculated below mentioned 3 indicators based on trend analysis and last year emissions accordingly:

- GHG emissions reduction based on trend (compared to baseline)
- Percent of the emissions reduction target has been achieved
- Emissions reduction target achievement based on trend (comparing trend emissions with target emissions).

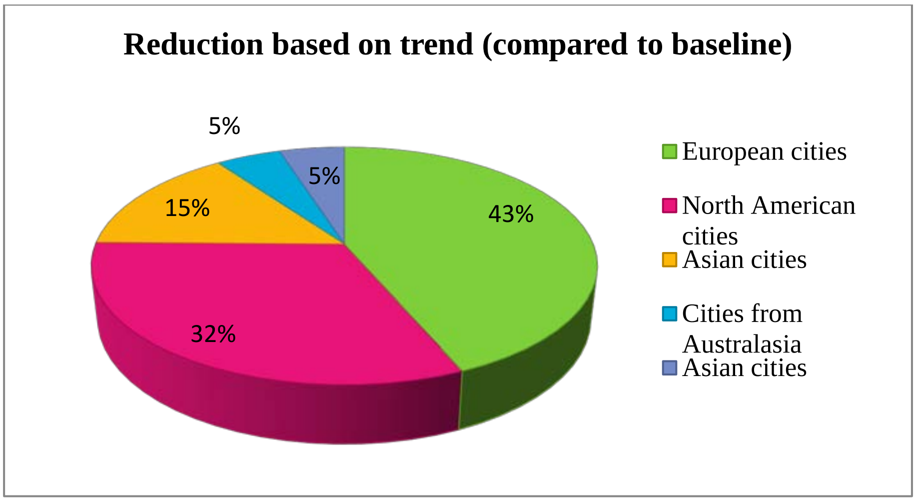
Above-mentioned indicators have been calculated in two directions, the first calculation has been conducted taking into account in the absolute level of GHG emissions, then has been calculated the dependent variable based on GHG emissions per capita.

By conducting the overall comparative analysis of above-mentioned indicators has been assessed the level of GHG emissions reduction for 59 cities.

4.4.1 The results of 1st indicator (GHG emissions reduction based on trend compared to baseline emissions)

The results specified that 69.5 % of cities including in sample of this study, in target year will reduce GHG emissions compared with baseline, 30.5 % of cities will not decrease the carbon emissions compared to baseline year emissions.

Figure 15: **Cities by continents achieved GHG emissions reduction based on trend**



Source: Author

This outcome again indicated that cities from developed countries (European and North American) succeeded to reduce GHG emissions compared with developing countries.

Table 10: Cities will reduced GHG emissions compared to baseline year emissions

City	Baseline Year	Target Year	Baseline emissions	Target emissions (metric tonnes CO_2e)	Trend emissions (metric tonnes CO_2e)	Actual emissions reduction based on trend (metric tonnes CO_2e)	Reduction based on trend (% compared to baseline)
Copenhagen	2010	2025	2,515,250	0	-656,761	3,172,011	1.26
Östersund	1990	2030	428,000	0	2,045	425,955	1.00
Denver	1990	2020	11,800,000	9,440,000	1,994,171	9,805,829	0.83
Saffle	1990	2015	638,100	191,430	163,549	474,551	0.74
Portland	1990	2030	8,989,460	5,393,676	3,037,792	5,951,668	0.66
Toronto	1990	2020	27,051,617	18,936,132	9,305,993	17,745,624	0.66
Lisbon	2002	2020	3,887,013	3,109,610	1,532,031	2,354,982	0.61
Madrid	1990	2020	12,653,000	10,122,400	6,216,096	6,436,904	0.51
Flagstaff	1990	2020	1,116,738	446,695	573,673	543,065	0.49
Brussels	1990	2025	4,057,300	2,840,110	2,086,021	1,971,279	0.49
Stockholm	1990	2020	3,668,000	2,787,680	1,979,537	1,688,463	0.46
Kadiovacik	2011	2016	655	628	358	297	0.45
Nagoya	1990	2020	17,390,000	13,042,500	10,898,038	6,491,962	0.37
Manchester	1990	2020	21,200,000	11,024,000	13,418,129	7,781,871	0.37
Philadelphia	2006	2015	22,837,228	18,269,782	14,645,562	8,191,666	0.36
Bristol	2005	2020	2,405,000	952,476	1,556,607	848,393	0.35
London	1990	2025	45,000,000	18,000,000	29,185,354	15,814,646	0.35
New York	2005	2025	55,616,668	36,150,834	36,098,770	19,517,898	0.35
Vajxo	1993	2015	326,738	147,032	216,628	110,110	0.34
Turku	1990	2020	1,475,000	1,180,000	996,670	478,330	0.32
Sydney	2006	2030	4,536,712	1,361,014	3,103,947	1,432,765	0.32
Boston	2005	2020	7,440,000	5,580,000	5,303,306	2,136,694	0.29
Västerås	1990	2020	918,500	459,200	655,534	262,966	0.29
Taipei	2005	2030	15,500,000	11,625,000	11,383,441	4,116,559	0.27
Kaohsiung	2005	2020	64,339,200	51,471,360	48,093,338	16,245,862	0.25
Minneapolis	2006	2015	5,700,000	4,845,000	4,398,949	1,301,051	0.23
Bogota	2013	2016	16,077,576	14,469,819	12,955,113	3,122,463	0.19
Des Moines	2008	2020	2,398,445	2,134,616	1,941,149	457,296	0.19
City Vancouver	2007	2020	2,805,000	1,879,350	2,286,730	518,270	0.18
Belo Horizonte	2007	2030	3,176,966	2,541,573	2,604,905	572,061	0.18
Evanson	2005	2016	1,003,807	803,046	831,833	171,974	0.17
Boudler	2005	2050	1,949,796	389,959	1,691,777	258,019	0.13
Panaji	2013	2019	154,912	117,212	135,764	19,148	0.12
Wellington	2001	2020	1,310,705	1,179,635	1,158,445	152,260	0.12

North Vancouver	2005	2020	223,127	167,345	199,494	23,633	0.11
Seoul	2005	2020	49,467,000	37,100,250	46,684,987	2,782,013	0.06
Amsterdam	1990	2025	3,417,000	2,050,200	3,225,500	191,500.00	0.06
Umeå	1990	2018	545,003	272,502	516,523	28,480	0.05
Uppsala	1990	2020	1,289,300	709,115	1,236,427	52,873	0.04
Hamburg	1990	2020	20,727,000	10,363,500	20,270,972	456,028	0.02
Tainan	2010	2020	25,620,952	18,959,504	25,064,423	556,529	0.02

Cities decrease the baseline emissions with the value has been depicting in 8 column of table 10, which means that even cities will decrease the emissions in target year, but it does not indicate that they will achieve the target. The variety of baseline emissions is very big from 126% to 2%. 69.5 % of cities in this thesis sample (41 cities) in target year will have a decrease of baseline GHG emissions, but it does not indicate that they can achieve the committed target.

The complete results can be seen on Annex 3.

4.4.2 The results of 2nd indicator (Percent of the emissions reduction target has been achieved)

Calculation of this indicator gave the following results: As it can be seen 22 cities in target year exceeded the emissions reduction target, 5 cities were close to achieving the target, 14 cities had a low level of the GHG emissions reduction (Table 11). Finally, according to the results 17 cities (10 Asian, 2 African, 3 North American, 1European, 1 Australasian) cannot achieve the target and will have the increase of GHG emissions (Table 12). The significant proportion of cities that had high percentage of target achievement are European and North American cities, from Asian cities only 3 cities (Nagoya, Kaohsiung and Taipei) had achieved high percentage of target, the rest Asian cities were not even close to achieving the target as the trend of GHG emissions showed that instead of reducing the GHG emissions estimated the increase of emissions during the investigating period, which resulted in a negative level of achievement of target (Table 11 and Table 12).

Table 11: Percent of GHG emissions target has been achieved

City	Baseline year emissions (metric tonnes CO_2e)	Target year emissions (metric tonnes CO_2e)	Trend emissions (metric tonnes CO_2e)	Percent of target has been achieved (%)
Cities will achieve emissions reduction target				
Kadiovacik	655	358	27	1100.0
Denver	11,800,000	9,440,000	1,994,171	415.5
Lisbon	3,887,013	3,109,610	1,532,031	302.9
Madrid	12,653,000	10,122,400	6,216,096	254.4
Toronto	27,051,617	18,936,132	9,305,993	218.7
Bogota	16,077,576	14,469,819	12,955,113	194.2
Stockholm	3,668,000	2,787,680	1,979,537	191.8

Philadelphia	22,837,228	18,269,782	14,645,562	179.3
Des Moines	2,398,445	2,134,616	1,941,149	173.3
Portland	8,989,460	5,393,676	3,037,792	165.5
Turku	1,475,000	1,180,000	996,670	162.1
Brussels	4,057,300	2,840,110	2,086,021	162.0
Minneapolis	5,700,000	4,845,000	4,398,949	152.2
Nagoya	17,390,000	13,042,500	10,898,038	149.3
Kaohsiung	64,339,200	51,471,360	48,093,338	126.3
Copenhagen	2,515,250	0	-656,761	126.1
Wellington	1,310,705	1,179,635	1,158,445	116.2
Boston	7,440,000	5,580,000	5,303,306	114.9
Taipei	15,500,000	11,625,000	11,383,441	106.2
Saffle	638,100	191,430	163,549	106.2
New York	55,616,668	36,150,834	36,098,770	100.3
Cities close to achieve emissions reduction target				
Östersund	428,000	0	2,045	99.5
Belo Horizonte	3,176,966	2,541,573	2,604,905	90.0
Evanson	1,003,807	803,046	831,833	85.7
Flagstaff	1,116,738	446,695	573,673	81.0
Manchester	21,200,000	11,024,000	13,418,129	76.5
Cities with low level of achievement				
Vajxo	326,738	147,032	216,628	61.3
London	45,000,000	18,000,000	29,185,354	58.6
Bristol	2,405,000	952,476	1,556,607	58.4
Västerås	918,500	459,200	655,534	57.3
City Vancouver	2,805,000	1,879,350	2,286,730	56.0
Panaji	154,912	117,212	135,764	50.8
Sydney	4,536,712	1,361,014	3,103,947	45.1
North Vancouver	223,127	167,345	199,494	42.4
Seoul	49,467,000	37,100,250	46,684,987	22.5
Boudler	1,949,796	389,959	1,691,777	16.5
Amsterdam	3,417,000	2,050,200	3,225,500	14.0
Umeå	545,003	272,502	516,523	10.5
Uppsala	1,289,300	709,115	1,236,427	9.1
Tainan	25,620,952	18,959,504	25,064,423	8.4
Hamburg	20,727,000	10,363,500	20,270,972	4.4

Table 12: Cities do not decrease GHG emissions or have negative achievement of target

City	Baseline year emissions (metric tonnes CO_2e)	Target year emissions (metric tonnes CO_2e)	Trend emissions (metric tonnes CO_2e)	Percent of target has been achieved (%)
Tuscon	7,560,728	7,560,728	8,244,058	0.0
Hong Kong	42,000,000	21,000,000	43,187,671	-5.7
Melbourne	4,934,000	0	5,499,624	-11.5
Hiroshima	8,525,221	4,262,611	9,821,916	-30.4
Durban	22,186,187	16,167,499	24,256,459	-34.4
Edmonton	15,862,000	10,310,300	17,771,850	-34.4
Thane Municipality	2,327,233	623,723	2,969,136	-37.7
Oslo	1,168,000	584,000	1,394,228	-38.7
Tokyo	62,100,000	43,470,000	73,282,269	-60.0
Yokohama	19,540,000	16,413,600	23,175,728	-116.3
Atlanta	7,656,727	6,125,382	11,568,275	-255.4
Wonju	1,471,393	1,088,831	2,884,307	-369.3
Buenos Aires	11,000,720	9,900,648	15,182,523	-380.1
Rajkot	882,103	451,825	3,116,947	-519.4
eThekwini	15514200	11,480,508	40,542,645	-620.5
Shimla	186,316	167,684	314,763	-689.4
Gwalior	591,963	532,767	1,690,963	-1856.5

European, North American cities and city of Melbourne included in this table have been adopted ambitious target compared to the Asian cities. Melbourne, Oslo, and Yokohama are a member of Carbon Neutral Cities Alliance (CNCA) and have adopted a deep carbon emissions reduction policy, namely "0" carbon emissions in the targeted year. That is the reason for appearing in the table with negative emissions, even comparing with other cities including in table 12, those cities have decreased GHG emissions, but as the committed target is ambitious that is the reason for considering as cities with a negative achievement of the target in percentages. From further analysis (where the indicators are calculated the GHG emissions reduction per capita) can be seen that Melbourne and Oslo had better performance compared to other cities including in Table 12.

In this analysis as an outlier has been excluded the results of Indian city Pimpri Chinchwad. The difference between baseline and trend years emissions has negative value, also negative value has the difference between baseline and target years emissions and the ratio of this differences gave not a realistic picture of emissions reduction.

The complete results can be seen on Annex 3.

4.4.3 The results of 3rd indicator GHG emissions reduction target achievement based on trend analysis (trend emissions &target emissions)

The calculation of *GHG emissions reduction target achievement based on trend analysis* indicator has been done by calculating the percentage of trend analysis results to commitment emissions in the target year. Analyzing the results of this indicator can be underlined that 35 percent of cities in thesis sample will achieve the emissions reduction target on targeted year in the case of Business As Usual (BAU) scenario. The first part of Table 13 in the seventh column can be seen the percentage of emissions which cities will exceed the adopted target in the targeted year. Thus, analysis gave the evidence to insist that 21 cities will decrease GHG emissions more than the value of the committed target is, 3 cities were very close to the target emissions and 35 cities were not achieve the target.

As 3 cities emissions reduction target is "0" (Copenhagen, Melbourne and Östersund), therefore the ratio of trend and target emissions was not giving the real value, that is the reason the absence of the value of the 7th column of Table 13 for this cities. However, analyzing the actual value of target and trend year emissions, it became obvious that Copenhagen will exceed the planned emissions reduction, Östersund was close to target and Melbourne is was far from achieving the target.

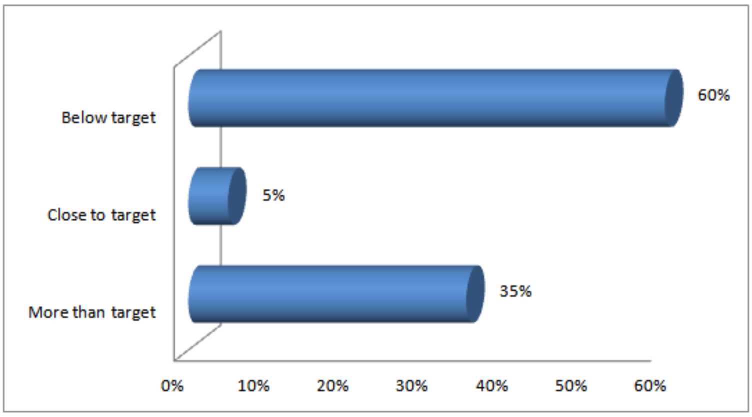
Table 13: Trend emissions & target emissions

City	Baseline Year	Target Year	Baseline Emissions (metric tonnes CO2 e)	Target emissions (metric tonnes CO2 e)	Trend emissions (metric tonnes CO2 e)	Level of achievement (%)
Cities with a high level of emissions reduction						
Denver	1990	2020	11,800,000	9,440,000	1,994,171	78.9
Toronto	1990	2020	27,051,617	18,936,132	9,305,993	50.9
Lisbon	2002	2020	3,887,013	3,109,610	1,532,031	50.7
Portland	1990	2030	8,989,460	5,393,676	3,037,792	43.7
Kadiovacik	2011	2016	655	628	358	43.0
Yokohama	2005	2020	19,540,000	16,413,600	23,175,728	41.2
Madrid	1990	2020	12,653,000	10,122,400	6,216,096	38.6
Stockholm	1990	2020	3,668,000	2,787,680	1,979,537	29.0
Brussels	1990	2025	4,057,300	2,840,110	2,086,021	26.6
Philadelphia	2006	2015	22,837,228	18,269,782	14,645,562	19.8
Nagoya	1990	2020	17,390,000	13,042,500	10,898,038	16.4
Turku	1990	2020	1,475,000	1,180,000	996,670	15.5
Bogota	2013	2016	16,077,576	14,469,819	12,955,113	10.5
Minneapolis	2006	2015	5,700,000	4,845,000	4,398,949	9.2
Des Moines	2008	2020	2,398,445	2,134,616	1,941,149	9.1
Kaohsiung	2005	2020	64,339,200	51,471,360	48,093,338	6.6
Boston	2005	2020	7,440,000	5,580,000	5,303,306	5.0
Taipei	2005	2030	15,500,000	11,625,000	11,383,441	2.1
Wellington	2001	2020	1,310,705	1,179,635	1,158,445	1.8
New York	2005	2025	55,616,668	36,150,834	36,098,770	0.1
Copenhagen	2010	2025	2,515,250	0	-656,761	
Cities with a moderate level of emissions reduction (close to target achievement)						
Belo Horizonte	2007	2030	3,176,966	2,541,573	2,604,905	-2.5
Evanson	2005	2016	1,003,807	803,046	831,833	-3.6
Östersund	1990	2030	428,000	0	2,045	
Cities with a low level of emissions reduction						
Tuscon	2007	2020	7,560,728	7,560,728	8,244,058	-9.0
Panaji	2013	2019	154,912	117,212	135,764	-15.8

North Vancouver	2005	2020	223,127	167,345	199,494	-19.2
City Vancouver	2007	2020	2,805,000	1,879,350	2,286,730	-21.7
Manchester	1990	2020	21,200,000	11,024,000	13,418,129	-21.7
Seoul	2005	2020	49,467,000	37,100,250	46,684,987	-25.8
Flagstaff	1990	2020	1,116,738	446,695	573,673	-28.4
Tainan	2010	2020	25,620,952	18,959,504	25,064,423	-32.2
Saffle	1990	2015	11,186,419	3,355,926	4,447,255	-32.5
Västerås	1990	2020	918,500	459,200	655,534	-42.7
Vajxo	1993	2015	326,738	147,032	216,628	-47.3
Durban	2007	2040	22,186,187	16,167,499	24,256,459	-50.0
Buenos Aires	2008	2020	11,000,720	9,900,648	15,182,523	-53.3
Amsterdam	1990	2025	3,417,000	2,050,200	3,225,500	-57.3
London	1990	2025	45,000,000	18,000,000	29,185,354	-62.1
Bristol	2005	2020	2,405,000	952,476	1,556,607	-63.4
Tokyo	2000	2030	62,100,000	43,470,000	73,282,269	-68.6
Edmonton	2005	2035	15,862,000	10,310,300	17,771,850	-72.4
Uppsala	1990	2020	1,289,300	709,115	1,236,427	-74.4
Shimla	2010	2018	186,316	167,684	314,763	-87.7
Atlanta	2009	2020	7,656,727	6,125,382	11,568,275	-88.9
Umeå	1990	2018	545,003	272,502	516,523	-89.5
Hamburg	1990	2020	20,727,000	10,363,500	20,270,972	-95.6
Hong Kong	2005	2020	42,000,000	21,000,000	43,187,671	-105.7
Sydney	2006	2030	4,536,712	1,361,014	3,103,947	-128.1
Hiroshima	1990	2030	8,525,221	4,262,611	9,821,916	-130.7
Oslo	1991	2020	1,168,000	584,000	1,394,228	-138.7
Wonju	2005	2018	1,471,393	1,088,831	2,884,307	-164.9
Gwalior	2008	2018	591,963	532,767	1,690,963	-217.4
eThekwini	2005	2020	15514200	11,480,508	40,542,645	-253.1
Pimpri Chinchwad	2013	2030	1,913,797	2,098,800	8,414,379	-300.9
Boudler	2005	2050	1,949,796	389,959	1,691,777	-333.8
Thane Municipality	1990	2019	2,327,233	623,723	2,969,136	-376.0
Rajkot	2007	2020	882,103	451,825	3,116,947	-589.9
Melbourne	2008	2020	4,934,000	0	5,499,624	

Figure 16 shows the ratio of trend and target emissions, cities that will achieve, close to achieve or will not achieving the GHG emissions reduction target which are 35%, 5%, and 60% respectively.

Figure 16: The percent of cities with level of emissions reduction target achievement



Source: Author

As in previous 3 cases, the vast majority of cities that could achieve more than their climate mitigation pledges are European and North American cities. In the group “close to target” the target is included cities with deep achievement targets and “No achievement” group includes mainly the Asian, African and Latin American cities. The complete results can be seen in Annex 3.

4.4.4 Comparative analysis of 3 indicators for determining the achievement of GHG emissions reduction of 59 cities

The analysis of 3 indicators mentioned in subchapters 4.1, 4.2 and 4.3 gave the similar picture of the emissions reduction target achievement. Table 14 depicts the level of achievement by expressing the colours. By bringing together the results of 3 indicators it becomes obvious that the majority of cities that achieved or close to achieve the GHG emissions reduction target were European and North American cities. As it can be seen in 3 column the tones (dark, half mild and light) for all 3 colours (blue, green and red) they almost coincide, which in its turn confirms the assumption that cities from developed countries more prone to achieve climate mitigation target. From this table, it becomes clear that the achievability of the target depends on the level of ambitious of the target. If the target is not ambitious then it is easy to achieve.

Table 14: Comparing 3 indicators

City	Baseline Year	Target Year	Baseline emissions (metric tonnes CO2e)	Target emissions to be achieved (metric tonnes CO2e)	Trend emissions (metric tonnes CO2e)	Reduction based on trend (% comparing to baseline) 1st ind.	Percent of the emissions reduction target has been achieved 2nd ind.	Emissions reduction target achievement based on trend 3rd ind.
Copenhagen	2010	2025	2,515,250	0	-656,761	126.1	126.1	
Östersund	1990	2030	428,000	0	2,045	99.5	99.5	
Denver	1990	2020	11,800,000	9,440,000	1,994,171	83.1	415.5	21.1
Saffle	1990	2015	638,100	191,430	163,549	74.4	106.2	85.4
Portland	1990	2030	8,989,460	5,393,676	3,037,792	66.2	165.5	56.3
Toronto	1990	2020	27,051,617	18,936,132	9,305,993	65.6	218.7	49.1
Lisbon	2002	2020	3,887,013	3,109,610	1,532,031	60.6	302.9	49.3

Madrid	1990	2020	12,653,000	10,122,400	6,216,096	50.9	254.4	61.4
Brussels	1990	2025	4,057,300	2,840,110	2,086,021	48.6	162.0	73.4
Flagstaff	1990	2020	1,116,738	446,695	573,673	48.6	81.0	128.4
Stockholm	1990	2020	3,668,000	2,787,680	1,979,537	46.0	191.8	71.0
Kadiovacik	2011	2016	655.0	628.0	358.0	45.3	1,100.0	57.0
Nagoya	1990	2020	17,390,000	13,042,500	10,898,038	37.3	149.3	83.6
Manchester	1990	2020	21,200,000	11,024,000	13,418,129	36.7	76.5	121.7
Philadelphia	2006	2015	22,837,228	18,269,782	14,645,562	35.9	179.3	80.2
Bristol	2005	2020	2,405,000	952,476	1,556,607	35.3	58.4	163.4
London	1990	2025	45,000,000	18,000,000	29,185,354	35.1	58.6	162.1
New York	2005	2025	55,616,668	36,150,834	36,098,770	35.1	100.3	99.9
Vajxo	1993	2015	326,738	147,032	216,628	33.7	61.3	147.3
Turku	1990	2020	1,475,000	1,180,000	996,670	32.4	162.1	84.5
Sydney	2006	2030	4,536,712	1,361,014	3,103,947	31.6	45.1	228.1
Boston	2005	2020	7,440,000	5,580,000	5,303,306	28.7	114.9	95.0
Västerås	1990	2020	918500	459,250	655,534	28.6	57.3	142.7
Taipei	2005	2030	15,500,000	11,625,000	11,383,441	26.6	106.2	97.9
Kaohsiung	2005	2020	64,339,200	51,471,360	48,093,338	25.3	126.3	93.4
Minneapolis	2006	2015	5,700,000	4,845,000	4,398,949	22.8	152.2	90.8
Bogota	2013	2016	16,077,576	14,469,819	12,955,113	19.4	194.2	89.5
Des Moines	2008	2020	2,398,445	2,134,616	1,941,149	19.1	173.3	90.9
City Vancouver	2007	2020	2,805,000	1,879,350	2,286,730	18.5	56.0	121.7
Belo Horizonte	2007	2030	3,176,966	2,541,573	2,604,905	18.0	90.0	102.5
Evanson	2005	2016	1,003,807	803,046	831,833	17.1	85.7	103.6
Boudler	2005	2050	1,949,796	389,959	1,691,777	13.2	16.5	433.8
Panaji	2013	2019	154,912	117,212	135,764	12.4	50.8	115.8
Wellington	2001	2020	1,310,705	1,179,635	1,158,445	11.6	116.2	98.2
North Vancouver	2005	2020	223,127	167,345	199,494	10.6	42.4	119.2
Amsterdam	1990	2025	3,417,000	2,050,200	3,225,500	5.6	14.0	157.3
Seoul	2005	2020	49,467,000	37,100,250	46,684,987	5.6	22.5	125.8
Umeå	1990	2018	545,003	272,502	516,523	5.2	10.5	189.5
Uppsala	1990	2020	1,289,300	709,115	1,236,427	4.1	9.1	174.4
Hamburg	1990	2020	20,727,000	10,363,500	20,270,972	2.2	4.4	195.6
Tainan	2010	2020	25,620,952	18,959,504	25,064,423	2.2	8.4	132.2
Hong Kong	2005	2020	42,000,000	21,000,000	43,187,671	-2.8	-5.7	205.7
Tuscon	2007	2020	7,560,728	7,560,728	8,244,058	-9.0	0.0	109.0
Durban	2007	2040	22,186,187	16,167,499	24,256,459	-9.3	-34.4	150.0
Melbourne	2008	2020	4,934,000	0	5,499,624	-11.5	-11.5	
Edmonton	2005	2035	15,862,000	10,310,300	17,771,850	-12.0	-34.4	172.4
Hiroshima	1990	2030	8,525,221	4,262,611	9,821,916	-15.2	-30.4	230.4
Tokyo	2000	2030	62,100,000	43,470,000	73,282,269	-18.0	-60.0	168.6
Yokohama	2005	2020	19,540,000	16,413,600	23,175,728	-18.6	-116.3	141.2

Oslo	1991	2020	1,168,000	584,000	1,394,228	-19.4	-38.7	238.7
Thane Municipality	1990	2019	2,327,233	623,723	2,969,136	-27.6	-37.7	476.0
Buenos Aires	2008	2020	11,000,720	9,900,648	15,182,523	-38.0	-380.1	153.3
Atlanta	2009	2020	7,656,727	6,125,382	11,568,275	-51.1	-255.4	188.9
Shimla	2010	2018	186,316	167,684	314,763	-68.9	-689.4	187.7
Wonju	2005	2018	1,471,393	1,088,831	2,884,307	-96.0	-369.3	264.9
eThekwini	2005	2020	15,514,200	11,480,508	40,542,645	-161.3	-620.5	353.1
Gwalior	2008	2018	591,963	532,767	1,690,963	-185.7	-1,856.5	317.4
Rajkot	2007	2020	882,103	451,825	3,116,947	-253.4	-519.4	689.9
Pimpri Chinchwad	2013	2030	1,913,797	2,098,800	8,414,379	-339.7		400.9

	reduce emissions more than target		reduce emissions more than target		reduce emissions more than target
	close to target		close to target		close to target
	increase emissions		increase emissions		increase emissions

Source: Author

4.4.5 The results of GHG emissions target achievement based on last year emissions

As it is mentioned in Chapter 3, has been calculated the GHG emissions reduction target achievement based on last year emissions. Three indicators have been calculated in a place of trend emissions the last year emissions. According to above-mentioned calculation the 17% of cities with the last year report inventory already achieved GHG emissions reduction target (Table 15). The complete results of this analysis can be seen on Annex 3.

Table 15: GHG emissions reduction based on last year emissions inventories (LYE)

City	**Reduction based on LYE (% comparing to baseline)**	**City**	**Percent of the target achieved based on LYE**	**City**	**Level of GHG emissions target achievement (%)**
Saffle	70.7	Kadiovacik	781.5	Boudler	62.2
Lisbon	50.2	Pimpri Chinchwad	684.4	Rajkot	70.7
Copenhagen	42.3	Lisbon	251.2	Thane Municipality	85.4
Östersund	36.9	Bogota	231.3	Flagstaff	90.1
Vajxo	36.6	Wellington	172.2	Sydney	92.0
Toronto	32.3	Stockholm	131.4	eThekwini	93.9
Kadiovacik	32.2	Turku	124.6	Gwalior	94.7
Stockholm	31.5	Denver	121.1	Bristol	96.8
Manchester	29.8	Toronto	107.6	Saffle	97.7
Turku	24.9	Minneapolis	105.9	London	99.0
Denver	24.2	Saffle	101.0	Oslo	100.1
Bogota	23.1	Evanson	95.2	Amsterdam	101.2
Nagoya	22.8	Madrid	94.7	Hiroshima	101.3
Portland	22.4	Nagoya	91.3	Hong Kong	102.8

Sydney	21.6
Evanson	19.0
Madrid	18.9
Brussels	18.8
Boston	18.5
Wellington	17.2
Västerås	17.1
Minneapolis	15.9
Philadelphia	15.9
Hamburg	15.2
Thane Municipality	12.9
Bristol	11.6
Melbourne	11.4
New York	11.2
City Vancouver	10.8
London	10.7
Uppsala	9.7
Belo Horizonte	9.4
Kaohsiung	8.7
Des Moines	8.5
Panaji	6.7
North Vancouver	6.0
Boudler	5.2
Umeå	4.4
Seoul	3.7
Taipei	3.5
Tuscon	-0.1
Hong Kong	-1.7
Hiroshima	-1.8
Durban	-1.8
Tainan	-4.1
Edmonton	-4.5
Flagstaff	-6.6
Oslo	-11.1
Yokohama	-12.3
Tokyo	-12.9
Shimla	-17.5
Atlanta	-26.0
Amsterdam	-30.8
Wonju	-37.0

Philadelphia	79.4
Des Moines	77.2
Boston	73.9
Vajxo	66.6
Brussels	62.8
Manchester	62.0
Portland	56.0
Belo Horizonte	46.9
Kaohsiung	43.4
Copenhagen	42.3
Östersund	36.9
Västerås	34.3
City Vancouver	32.8
New York	32.0
Sydney	30.9
Hamburg	30.4
Panaji	27.4
North Vancouver	24.0
Uppsala	21.6
Bristol	19.1
London	17.8
Thane Municipality	17.6
Seoul	15.0
Taipei	14.0
Melbourne	11.4
Umeå	8.7
Boudler	6.5
Tuscon	0
Hong Kong	-3.3
Hiroshima	-3.5
Durban	-6.7
Flagstaff	-11.1
Edmonton	-12.9
Tainan	-15.8
Oslo	-22.3
Tokyo	-43.1
Yokohama	-77.1
Amsterdam	-77.1
Atlanta	-130.2
Wonju	-142.2

Buenos Aires	102.9
Umeå	108.7
Wonju	113.3
Hamburg	114.2
Uppsala	115.9
Tokyo	119.1
Edmonton	123.4
Atlanta	125.3
Pimpri Chinchwad	128.3
Vajxo	128.7
Tainan	129.3
Durban	130.5
New York	133.1
Manchester	133.7
Yokohama	135.1
City Vancouver	136.6
Shimla	139.7
Portland	140.7
Taipei	140.8
Seoul	151.5
North Vancouver	157.5
Panaji	160.8
Brussels	164.2
Västerås	165.7
Kaohsiung	169.6
Belo Horizonte	185.1
Boston	191.3
Philadelphia	194.6
Nagoya	198.6
Des Moines	203.3
Madrid	203.5
Evanson	218.1
Tuscon	222.3
Minneapolis	223.3
Toronto	223.3
Denver	224.3
Turku	243.8
Wellington	261.3
Stockholm	266.6
Bogota	325

Pimpri Chinchwad	-66.2	Shimla	-174.9	Kadiovacik	377.2
Buenos Aires	-78.8	Rajkot	-191.1	Lisbon	474.1
eThekwini	-80.4	eThekwini	-309.3		
Rajkot	-93.2	Buenos Aires	-787.8		
Gwalior	-101.9	Gwalior	-1019.1		

Source: Author

As 3 cities have “0” emissions target policy thereby those cities excluded from last table Copenhagen, Östersund, Melbourne.

These results were very close to the results of trend analysis has been described in subchapter 4.3. The cities that already met their targets generally were European and North American cities.

22% of cities instead of decreasing have been increased the GHG emissions, which can serve as a basis for claiming that there is very high possibility that those cities could not reach the GHG emissions reduction target. In general, the results indicated that the Asian cities including in thesis sample belong to the group of cities that could not meet the GHG emissions reduction target.

4.5 The results of correlation analysis

In order to answer the second and third sub-questions of this research, namely to realize which factors mainly correlate with achievement of GHG emissions reduction and to conceive the nature of interrelations, whether they are positive or negative, by the help of SPSS software has been conducted Pearson’s test.

Based on the conditions for running Pearson’s test (Field, 2009) and determining the Pearson’s correlation coefficient from the list of independent variables has been chosen the variables which have continuous value. Those variables are “Density”, “City size (area km^2)”, “Population”, “Cities geographical location”, “GDP per capita”, “Number of mitigation actions” “Age Composition” (“Age 0-14”, “Age 15-64”, “Age 65+”). A Pearson’s correlation coefficient has been conducted for evaluating the “null hypothesis” that there is no relationship between the level of achievement of GHG emissions reduction and above mentioned eight independent variables. As in sub-chapter 4.4 is mentioned for calculating the level of GHG emissions reduction has been used the following indicators:

1) GHG emissions reduction based on trend (compare to baseline)
2) Percent of the target has been achieved
3) Emissions reduction target achievement based on trend
4) Target achievement based on last year emissions.

Pearson’s correlation coefficient has been determined for all indicators and independent variables separately.

The results indicated that there is no correlation between GHG emissions reduction target achievement (based on last year emissions) and following factors; “Density”, “City size (area km^2)”, “Population”, “GDP per capita”, “Number of mitigation actions”, “Age Composition” (“Age 0-14”, “Age 15-64”, “Age 65+”). For all of this independent variables, the p-value was not significant, which is significant evidence to accept the null hypothesis and conclude that there was no correlation between last year GHG emissions reduction and above mentioned independent variables.

Correlation analysis has been specified only the one moderate correlation between "GHG emissions reduction based on last year emissions" and ***"Cities' geographical location"***, which also specified with the same indicators based on trend analysis (Tables 16, 17).

Table 16: Correlation between GHG emissions reduction based on Last Year Emissions (LYE) and City location

Correlations

		Reduction based on LYE (% comparing to baseline)	Location
Reduction based on LYE (% comparing to baseline)	Pearson Correlation	1	.340**
	Sig. (2-tailed)		.008
	N	59	59
Location	Pearson Correlation	.340**	1
	Sig. (2-tailed)	.008	
	N	59	59

**. Correlation is significant at the 0.01 level (2-tailed).

P-value is .008 < .05 which means that there is the significant difference between variables (Field, 2009p. 178), Pearson's Correlation .340, which is close to .5 and can be considered that emissions reduction target achievement could slightly change positively when the location of cities is changed.
Below is presented the results of correlation analysis between a dependent variable that has been calculated based on trend analysis and continues independent variables.

Based on literature where has been specified the classification of the correlation coefficient (Field, 2009, Ratner, 2009), the analysis indicates three moderate positive, one moderate negative and one weak positive correlation, which is presented below accordingly.

Table 17: Correlation between GHG emissions reduction based on trend and City location

Correlations

		Reduction based on trend (% comparing to baseline)	Location
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	.286*
	Sig. (2-tailed)		.028
	N	59	59
Location	Pearson Correlation	.286*	1
	Sig. (2-tailed)	.028	
	N	59	59

*. Correlation is significant at the 0.05 level (2-tailed).

P-value is .028 < .05 which means that it is significant difference between variables (Field, 2009p. 178), Pearson's Correlation .286.
As Pearson's Correlation coefficient is close to .5, and meanwhile having significant p-value allow to assume that there is a ***weak positive*** correlation between cities location and GHG emissions reduction based on the trend. It is also worth to underline that with the bigger sample size of investigated cities the probability that the intensity of correlation will be changed from weak to strong is high.
The results of Table 16 and Table 17 supported the results from trend analysis (sub-chapter 4.2), where specified that in general those cities which already achieved committed GHG emissions reduction target are from Northern Hemisphere of the globe (North America, Europe).

Correlation with socio-economic factor GDP per capita

The correlation analysis has recorded a weak correlation between GDP per capita and three indicators of the dependent variable, that are *"GHG emissions reduction based on trend"*, *"Percent of target achieved"* and *"Level of emissions that achieved"* (Tables 18, 19, 20).

Table 18: Correlation between GHG emissions reduction and GDP per capita

Correlations

		Reduction based on trend (% comparing to baseline)	GDP Per capita (USD)
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	.372*
	Sig. (2-tailed)		.014
	N	59	43
GDP Per capita (USD)	Pearson Correlation	.372*	1
	Sig. (2-tailed)	.014	
	N	43	43

*. Correlation is significant at the 0.05 level (2-tailed).

P-value .014 < .05, which means that there is a significant difference between variables, Pearson's Correlation coefficient is .372, and as it is higher than 0.3, that gives evidence to reject null hypothesis ("there is no difference between those two variables"), which means that it is possible to assume the existence of ***moderate positive*** correlation between GDP per capita and GHG emissions reduction based on trend analysis. If GDP per capita is growing then GHG emissions reduction based on trend is also growing, but not strongly.

Table 19 illustrates the results of Pearson's correlation between GDP per capita and "Percent of target achieved" indicator. P-value is .025 < .05, which can be interpreted as a significant value, in particular, there is a significant difference between variables. Pearson's Correlation coefficient .342 is higher than 0.3, which means that there is a moderate relation between those variables. The change of GDP per capita slightly changed the performance of GHG emissions target achievement, therefore it is justified to assume that there is a moderate correlation between GDP per capita and percent of target achievement. The results lead to arguing that the correlation can be stronger in case of running the correlation analysis with a bigger sample size.

Table 19: Correlation between Percent GHG emissions reduction target achieved and GDP per capita

Correlations

		Percent of the Target achieved	GDP Per capita (USD)
Percent of the Target achieved	Pearson Correlation	1	.342*
	Sig. (2-tailed)		.025
	N	59	43
GDP Per capita (USD)	Pearson Correlation	.342*	1
	Sig. (2-tailed)	.025	
	N	43	43

*. Correlation is significant at the 0.05 level (2-tailed).

Table 20: Correlation between Percent GHG emissions reduction target achieved and GDP per capita

Correlations

		Level of GHG emissions target achievement (%)	GDP Per capita (USD)
Level of GHG emissions target achievement (%)	Pearson Correlation	1	-.348*
	Sig. (2-tailed)		.022
	N	59	43
GDP Per capita (USD)	Pearson Correlation	-.348*	1
	Sig. (2-tailed)	.022	
	N	43	43

*. Correlation is significant at the 0.05 level (2-tailed).

P-value 0.022<0.05 not significant, Pearson's Correlation -0.348 is close to "-0.5", which means that there can be weak negative correlation.

The Pearson's correlation coefficient showed a moderate negative correlation between variables, more specifically if GDP per capita is growing the ratio of GHG trend emissions to GHG target emissions changed negatively. As this ratio had a negative meaning, in terms of GHG emissions reduction, that means if the ratio is high then the level of emissions reduction is low, therefore this result also coincided and confirmed the interrelation between GDP per capita and 3 indicators.

Correlation with "Density"

The next correlation has been conducted between "Density" and "Level of emissions reduction target achievement" (3^{rd} indicator). Density has been calculated by dividing the number of inhabitants in cities size per km^2 (Table 21).

Table 21: **Correlation between Percent GHG emissions reduction target achieved and GDP per capita**

Correlations between "Level of emissions reduction target achievement" and "Density"

Correlations

		Level of GHG emissions target achievement (%)	Density
Level of GHG emissions target achievement (%)	Pearson Correlation	1	.312*
	Sig. (2-tailed)		.016
	N	59	59
Density	Pearson Correlation	.312*	1
	Sig. (2-tailed)	.016	
	N	59	59

*. Correlation is significant at the 0.05 level (2-tailed).

The analysis shows that P-value .016< .05 was significant, Pearson's Correlation .312 is close to 0.5. With this results, it can be assumed that there is a moderate correlation between variables, namely "Density" and "Level of GHG emissions target achievement". These results give an evidence to assume that compact cities with high density have moderately more potential to achieve GHG emissions reduction target than cities with low density.
The complete results can be seen in Annex 4.

4.6 The results of T–Test analysis

For understanding the relationship between indicators mentioned in 4.4 subchapter and independent variables that have nominal value has been conducted independent T-Test in SPSS. Independent variables with nominal value are four: "C40 membership", "CoM members", "ICLEI members", "Member of more than one climate network". T-Test allows to compare nominal and continues variables and find the possible association between them. To test the hypothesis that being a member of C40, CoM, ICLEI and more than one climate network were associated with the statistically significantly different means of the GHG emissions reduction target (3 indicators based on trend and based on last year emissions) an independent sample T-Test has been performed. The complete results can be seen on Annex 5.

Table 22: Results of the T-Test between "Reduction based on trend" and "member of Covenant of Mayors"

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Reduction based on trend (% comparing to baseline)	Equal variances assumed	1.926	.171	2.189	57	.033	.47304	.21609	.04033	.90574
	Equal variances not assumed			2.935	52.622	.005	.47304	.16116	.14974	.79633

By the help of descriptive statistic compared means for two groups. The standard deviation between groups is not big. From Table 22 the Levine's test shows P-value = 0.171> 0.05, looking top results for t, the Sig. (2-tailed) is 0.033, which is smaller than 0.05, thus null hypothesis is rejected and there is enough evidence to claim that membership of Covenant of Mayors has a significant effect on achievement GHG emissions reduction target. Thus, being a member of Covenant of Mayors associated with a statistically significantly larger mean of achievement of GHG emissions reduction target than non-members.

This results ideally coincided the results of trend analysis, more specifically, the results indicate that majority of cities with the high level of achievement of GHG emissions reduction target are European cities, 16 cities out of 19 European cities in the thesis sample are a member of Covenant of Mayors.

As a conclusion, out of four independent variables which are external factors, only the membership with the Covenant of Mayors was significantly interrelated to cities level of achievement of climate mitigation targets based on trend analysis taking into account total emissions.

4.7 The results of the GHG emissions reduction target achievement per capita

This section presents the results of analyzing the achievement of GHG emissions reduction per capita. As it is mentioned in 3rd Chapter, has been calculated baseline emissions per capita, committed emissions per capita, trend emissions and last year emissions per capita. By comparing those three values has been made comparison the level of achievement GHG emissions reduction target per capita among 59 cities.

4.7.1 Comparison of cities GHG emissions per capita

The classification of 59 cities by increasing order for trend emissions per capita gave different results compared to the cities emissions calculated in absolute level. From Table 23 it is clear that based on trend analysis, not all Asian cities had a high level of GHG emissions per capita. Compared to the trend analysis in the absolute level of GHG emissions North American cities were in a better position while calculating emissions per capita it is obvious that North American cities emitted more GHG than other cities included in this thesis sample.

Table 23: Baseline, Target year, Trend and Last year GHG emissions per capita

City	Baseline emissions per capita (metric tonnes CO_2 e)	Target year emissions per capita (metric tonnes CO_2 e)	Trend emissions per capita (metric tonnes CO_2 e)	Last year emissions per capita (metric tonnes CO_2 e)	Reduction based on trend per capita (% comparing to baseline)	Percent of the emission reduction target achieved (per capita)
Copenhagen	4.7	0.0	-1.0	2.5	120.2	120.2
Östersund	7.3	0.0	0.0	5.4	99.6	99.6
Panaji	0.9	0.4	0.5	1.3	48.5	87.3
Sydney	1.2	0.2	0.6	0.8	52.1	66.0
Gwalior	0.3	0.2	0.6	1.1	-85.7	-206.6
Belo Horizonte	1.3	0.9	1.0	1.1	26.2	93.6
Thane Municipality	2.9	0.2	1.2	1.1	60.1	65.6
Melbourne	1.3	0.0	1.2	1.0	10.9	10.9
Oslo	1.7	0.5	1.3	2.0	22.5	33.3
Rajkot	1.1	0.2	1.5	1.3	-40.3	-50.5
Shimla	1.1	0.8	1.6	1.3	-35.6	-128.4
Bogota	2.1	1.8	1.6	1.6	22.2	169.7
Brussels	4.2	2.3	1.7	2.8	60.1	131.6
Stockholm	5.5	2.7	1.9	2.9	65.4	127.5
Madrid	4.2	3.3	2.0	3.2	51.6	243.5
North Vancouver	2.7	1.9	2.2	2.3	18.1	57.9
Vajxo	4.6	2.1	2.5	2.3	46.6	85.7
Denver	24.2	12.4	2.6	13.5	89.1	183.6
Wellington	3.7	2.8	2.7	2.7	26.8	105.3
Lisbon	6.9	5.8	2.9	3.6	58.6	365.6
London	6.7	2.0	3.2	4.8	52.4	74.2
Toronto	11.8	6.5	3.2	6.7	72.8	162.9
Pimpri Chinchwad	1.1	0.8	3.2	1.8	-192.6	-713.3
Bristol	6.1	2.1	3.4	4.8	45.0	67.8
Amsterdam	4.9	2.2	3.5	5.4	28.3	52.0
City Vancouver	4.8	3.1	3.8	3.8	19.9	58.3
Portland	18.5	7.1	4.0	11.3	78.5	127.0
New York	6.9	4.0	4.0	5.8	42.0	100.2
Umeå	6.0	2.2	4.1	4.3	30.8	48.5
Taipei	5.9	4.3	4.2	5.6	29.3	105.4
Västerås	7.8	3.0	4.2	5.5	45.3	73.4
Seoul	5.0	3.7	4.7	4.8	7.2	27.6
Nagoya	8.1	5.7	4.8	4.1	40.9	139.8
Buenos Aires	3.9	3.1	4.8	6.6	-24.3	-128.6
Manchester	9.3	4.0	4.9	5.4	47.6	83.6

Tokyo	4.9	3.0	5.0	5.2	-2.1	-5.4
Turku	9.2	6.2	5.2	6.1	43.8	130.9
Uppsala	8.4	3.2	5.5	5.9	34.1	54.8
Hong Kong	6.2	2.8	5.7	6.0	7.5	13.7
Durban	6.6	4.0	6.0	6.4	8.9	22.6
Yokohama	5.5	4.4	6.3	5.9	-15.0	-80.8
Boston	12.2	7.9	7.5	9.2	38.8	109.0
Flagstaff	24.2	6.0	7.7	17.0	68.2	90.7
Wonju	5.2	3.1	8.2	6.2	-59.3	-148.8
Des Moines	12.1	9.3	8.5	10.5	30.0	130.4
Hiroshima	7.8	3.8	8.7	7.3	-11.0	-21.2
Philadelphia	15.2	11.7	9.3	12.4	38.6	165.1
Minneapolis	15.2	11.3	10.3	11.8	32.3	127.0
Saffle	35.5	12.5	10.6	12.2	70.0	107.9
eThekwini	4.8	3.0	10.7	8.1	-123.8	-338.2
Boudler	20.1	2.5	10.9	17.5	45.7	52.2
Hamburg	12.8	5.7	11.1	10.1	13.5	24.3
Evanson	13.2	10.7	11.1	10.7	16.0	84.6
Edmonton	18.3	7.7	13.2	17.9	27.8	47.8
Tainan	13.7	10.0	13.3	14.1	2.9	10.8
Tuscon	14.1	14.1	15.4	14.3	-9.0	0.0
Kaohsiung	23.4	18.5	17.3	21.1	26.0	125.0
Atlanta	14.2	12.1	22.9	21.2	-61.9	-433.1
Kadiovacik				2.1		

Table 24 shows the cities that could reduce GHG emissions per capita more than the target was. 35% of cities that achieved emissions reduction target (per capita) are from Europe, 40% from North America, 15% from Asia. The calculation of emissions reduction per capita raised the Asian cities comparable higher level. The same picture is also for cities that were close to achieving the target per capita. Analysing the last year GHG emissions per capita (Annex 6) also could be concluded that even if taken into account that the majority of Asian cities in thesis sample were behind, however, the results of the analysis for emissions per capita gave more details of climate mitigation policy of cities and disclosed the real characteristics of cities climate mitigation.

Table 24: Cities that achieved GHG emissions reduction target

City	Baseline year emissions per capita (metric tonnes CO_2e)	Target year emissions per capita (metric tonnes CO_2e)	Trend emissions per capita (metric tonnes CO_2e)	Last year emissions per capita (metric tonnes CO_2e)	Percent of the emission reduction target achieved (per capita) %
Lisbon	6.9	5.8	2.9	3.6	365.6
Madrid	4.2	3.3	2.0	3.2	243.5
Denver	24.2	12.4	2.6	13.5	183.6
Bogota	2.1	1.8	1.6	1.6	169.7
Philadelphia	15.2	11.7	9.3	12.4	165.1
Toronto	11.8	6.5	3.2	6.7	162.9

Nagoya	8.1	5.7	4.8	4.1	139.8
Brussels	4.2	2.3	1.7	2.8	131.6
Turku	9.2	6.2	5.2	6.1	130.9
Des Moines	12.1	9.3	8.5	10.5	130.4
Stockholm	5.5	2.7	1.9	2.9	127.5
Portland	18.5	7.1	4.0	11.3	127.0
Minneapolis	15.2	11.3	10.3	11.8	127.0
Kaohsiung	23.4	18.5	17.3	21.1	125.0
Copenhagen	4.7	0.0	-1.0	2.5	120.2
Boston	12.2	7.9	7.5	9.2	109.0
Saffle	35.5	12.5	10.6	12.2	107.9
Taipei	5.9	4.3	4.2	5.6	105.4
Wellington	3.7	2.8	2.7	2.7	105.3
New York	6.9	4.0	4.0	5.8	100.2

Source: Author

4.7.2 The results of correlation analysis, achievement of the GHG emissions reduction per capita

In order to understand the interrelation between GHG emissions reduction per capita and external and internal factors used in this thesis has been conducted correlation analysis by using SPSS software. As it is mentioned in Chapter 3 has been separated several indicators for external and internal factors, namely of socioeconomic, demographic and climate factors.

The independent variables are “Density”, “City size (area km^2)”, “Population”, “Cities geographical location”, “GDP per capita”, “Number of mitigation actions” “Age Composition” (“Age 0-14”, “Age 15-64”, “Age 65+”). The Pearson’s test has been conducted with above-mentioned factors and following dependent variables *trend emissions per capita*, *last year emissions per capita*, *emissions reduction target achievement based on trend(per capita)* and *percent of the target has been achieved (per capita)* separately. The Pearson’s test gave the evidence to assess the nature of correlation (negative, positive, strong, moderate or weak) in the case of the existence of any type of correlation.

According to Pearson’s correlation test the results manifested that there was a negative moderate correlation between cities’ density and trend emissions per capita and also the same results were recorded with the indicator that has been calculated based on the last year emissions per capita, which means that if density increased then GHG emissions per capita decreased, that is not the same when has been calculated the absolute emissions reduction. This results could support the assumption that compact cities performed climate mitigation well than cities with low density. The results also were harmonic with the results of analysis of Joint Research Centre of the European Commission (Kona, Melica, et al., 2016, p.17) “dense urban settlements through the concentration of services may lead to a reduction of per-capita emissions”.

The correlation analysis specified the absence of correlation between trend emissions reduction per capita and following factors; “City size (area km^2)”, “Population”, “Cities geographical location”, “GDP per capita”, “Number of mitigation actions”, “Age Composition” (“Age 0-14”, “Age 15-64”, “Age 65+”). For all of the independent variable, the p-value is not significant, which is significant evidence to accept the null hypothesis and conclude that there was no correlation between trend emissions per capita and above mentioned independent variables. The same results were with those independent variables and last year emissions reduction per capita.

The correlation analysis with indicator reduction per capita based on trend (compared to baseline) indicates the existence of the moderate correlation with cities geographical location and GDP per capita. P-value is significant and Pearson's correlation coefficient shows positive moderate correlation. This means that the emissions reduction per capita was higher in Northern cities than cities from South, which correspondent with the results of correlation analysis conducted based on the absolute level of GHG emissions.

Studying the results of correlation with GDP per capita, it is obvious that cities with developed economies could decrease the emissions per capita more effectively than those with a weak economy. As in this thesis sample, the vast majority of cities that were able to reduce the GHG emissions per capita mainly were European and North American cities, therefore it can be underline the results reflected the reality.

The next result which worth to mention is the weak correlation between cities' location and percent of a target (per capita) that has been achieved. This comes to supplement the results of correlation between Northern cities and cities location. It can be concluded that geographical location played an important role in achieving GHG emissions reduction per capita, however, the existence of weak correlation gives an evidence to assume that location has certain importunateness but it is not enough significant factor for achieving GHG emissions reduction target.

The complete results can be seen on Annex 7.

4.7.3 The results of T-Test, GHG emissions reduction per capita

For testing the existence of possible interrelations between GHG emissions per capita, last year emissions per capita and external factors, that are *"C40 membership"*, *"CoM members"*, *"ICLEI members"*, *"Member of more than one climate network"* has been performed an independent T-Test in SPSS by comparing mean values of those variables.

The T-Test analysis showed a significant level of p-value with three independent variables, which are *"C40 membership"*, *"CoM members" and "Member of more than one climate network"*. In both cases trend emissions per capita and last year emissions per capita, the results were significant. The T-tests indicate statistically significant results, more specifically being a member of C40, CoM initiatives or being a member of more than climate network highly resulted to the level of GHG emissions per capita. Unlike the analysis of the GHG emissions in absolute level, where a relation between indicators and networks highlighted significance only with a membership of Covenant of Mayors, the same analysis with GHG emissions trend per capita show relation with 2 networks and being a member more than one network. The significance level of independent sample T-Test gives enough evidence to emphasize that international climate networks are closely related to GHG emissions reduction per capita than emissions reduction in absolute value.

The results of T-Test analysis can be seen on Annex 8 and the results of the normal distribution of a dependent variable, histograms can be seen in Annex 9.

Chapter 5: Conclusions and recommendations

All findings based on the results of data analysis in chapter 4 are summarised and concluded in this chapter. After concluding the main breakthroughs of research, recommendations for climate mitigation policy makers are ordered based on apparent patterns found and also the gaps that can be the object for further research are highlighted.

This thesis has assessed the level of climate mitigation target achievement of 59 cities from different continents and has illustrated the factors that correlate with the achievement of GHG emissions reduction target. The results of the assessment show the consistencies or inconsistencies of local authorities' climate mitigation pledges and estimated results, more specifically, how effective the local climate mitigation actions are, therefore also the achievability of the GHG emissions reduction targets in BAU scenario has been assessed.

The majority of cities as a significant player of producing GHGs has been coped against climate mitigation under the umbrella of national pledges, however, under a new mechanisms of the Paris Agreement (United Nations, 2014c, Höhne, Kuramochi, et al., 2017) the role of cities re-assessed and has been evaluated "**combined potential impact of mitigation initiatives** by non-state actors could make a significant contribution to achieving the 2^0 C or 1.5^0 C goal" (Höhne, Kuramochi, et al., 2017, p.25) (as non-state actors authors mean cities, regions, organizations etc.). In regard to this, it becomes more important the assessment of the level of achievement of GHG emissions reduction targets of cities, which is one of the main objectives of this thesis.

As it is indicated in the Chapter 1 and 2, with the aim to reduce GHG emissions in atmosphere by countries and achieve GHG emissions reduction targets by the help of Kyoto's Protocol (United Nations, 2014b), special mechanisms have been created, by which the developing countries have been involved in the process. The majority of cities as a significant player of producing GHGs have coped against climate mitigation under the umbrella of national pledges. However, under new mechanisms of the Paris Agreement (United Nations, 2014c, Höhne, Kuramochi, et al., 2017) the role of cities has been re-assessed and it has been evaluated that "**combined potential impact of mitigation initiatives** by non-state actors could make a significant contribution to achieving the 2^0 C or 1.5^0 C goal" (Höhne, Kuramochi, et al., 2017, p.25) (by non-state actors, authors mean cities, regions, organizations etc.). In regard to this, it becomes more important to assess the level of achievement of GHG emissions reduction targets of cities, which is one of the main objectives of this thesis.

Based on the literature review, the cities' potential for mitigation has been assessed, namely the level of cities' achievement of the committed GHG emissions reduction target. The results of correlation analysis, namely the interrelation between the external and internal factors mentioned in 2.6.1 and 2.6.2 sub-chapters and the achievement of the local climate mitigation target underlined the possibilities for increasing GHG emissions reduction, consequently the cities' potential for climate mitigation.

The results of this research can contribute to the efforts of cities' government to choose the right climate mitigation policy, hence to have a significant investment in the process of struggling against global warming.

5.1 Conclusion and discussion

In order to answer the main research question, namely, w*hich factors correlate with achievement of local climate mitigation targets of 59 cities from different continents,* firstly answers for research sub-questions have been found. Based on the literature state of art of the thesis (Sippel, 2011) the trend analysis have been conducted for 59 cities, therefore it has been assessed if the level of achievement of GHG emissions reduction target for 59 cities follows actual trends of cities' emissions reduction. This analysis gave the following results: 36% of cities will achieve the GHG emissions reduction target, 15% of cities are close to achieving and 49 % of cities will not achieve the committed target.

The conclusion has been drawn on the assessment of the achievement of cities' reduction of the GHG emissions. Different indicators have been measured to realize the level of achievement of GHG emissions reduction. The indicators have been chosen by taking into account the results of the last report of the Joint Research Centre (Kona, Melica, et al., 2016). One of the sufficient indicators that explained the level of the GHG emissions reduction target achievement is a determination of percent of the target that cities can achieve in the targeted year. The analysis indicates that mainly European and North American cities tend to achieve the climate goals.

In order to respond to the second and third research sub-questions, the correlation between internal (socio-economic, demographic, climate) and external factors and the indicators that measured the level of achievement of the GHG emissions reduction target which is indicated in chapter 4 have been explored. The results highlighted the main factors that are related to achievement of the climate mitigation goals. The correlation analysis indicated a moderate correlation between cities achievement level of the GHG emissions reduction target and GDP per capita. Results gave significant evidence that increasing the value of GDP per capita leads to the increase of achievement of GHG emissions reduction target. As the GDP per capita comparable is higher in European and North American continents, the possibility that cities from those continents will achieve their climate mitigation target is higher. The results of correlation analysis allow to conclude that **GDP per capita** is one of the main internal factors that can have great influence on cities' climate mitigation policies.

Correlation analysis between **cities' geographical locations** and achievement of GHG emissions reduction target also supports above-mentioned results, namely cities from Northern Hemisphere of the globe are closer to achieve carbon reduction than cities from Southern part of the globe. Based on literature review has been mentioned in chapter 2, the results of the correlation analysis comes to prove the assumption that the geographical location as a climate factor is interrelated to climate mitigation.

As the analysis indicates also a weak correlation with cities' **density,** mainly cities with high density tend to increase the level of achievement of GHG emissions reduction target. Therefore, it is justified to conclude that compact cities are closer to achieve emissions reduction target than cities with low density. As it is mentioned in the literature review, one of the main factors that can have noteworthy influence on GHG emissions is density (Dodman, 2009). Therefore, the explored interrelation once again emphasizes the importance of density for emissions reduction. In sample size, one third of cities are small, medium or large size and the highest share of inhabitants comes from extra-extra-large and global cities (two-third of thesis sample). Comparing the correlation results with cities' level of density, it can be summarized that target achievability with the high density is slightly higher than cities with low density. The correlation is weak as cities with the highest and the lowest density in the sample are not close to achieve the emissions reduction target, but cities with high density, in the classification of the Covenant of Mayors (JRC, 2013), mainly more than 1500 inhabitants per 1km^2 tend to achieve the target.

The correlation analysis with other internal factors, that are cities' size (area km^2), number of population, number of climate mitigation actions did not give significant evidence about negative or positive interrelations. Therefore, it can be summarized that there is no correlation between above-mentioned factors and the achievement of GHG emissions reduction target.

The analysis allows to explore two external sufficient factors that are related to achievement of climate mitigation targets: *member of Covenant of Mayors* and being a *member more than one climate network.*

Based on the results of T-test analysis there is enough evidence to claim that being a **member of Covenant of Mayors** is significant for achieving GHG emissions reduction target. As the trend analysis shows, the majority of European cities can achieve GHG emissions reduction target, and, even more, they can also exceed the target, more specifically the emissions reduction can be more than cities are committed to achieving. These results ideally coincide with the results of the last research of the Joint Research Centre (Kona, Melica, et al., 2016) according to which 315 European cities achieved 23% of the GHG emissions reduction target with the results of 2014, namely they already achieved 2020 target (20%) in 2014. These results also match with Kern and Bulkeley analysis (2009) according to which transnational municipal networks have an influence on local climate change policy.

Thus, it can be argued that Covenant of Mayors is one of the productive climate networks which guide the local governments and give sufficient support to achieve climate mitigation targets. They have successful guidelines and methodology which have helped cities to decrease GHG emissions.

Being a **member of more than one climate network** also gives a sufficient support to the urban governors, by steering them to enhance positive results of climate mitigation policy.

The correlation analysis between "the number of climate mitigation actions" and climate mitigation target achievement shows that there is no any kind of relation between the level of the GHG emissions reduction target achievement. The same results have been recorded with "age composition" factor. It can be concluded that depending on the changes of the demographic picture of 59 cities' populations, including in this thesis, the level of the climate mitigation target achievement cannot be changed.

The findings of this research confirm that one of the significant factors for assessing the level of achievement of GHG emissions reduction target is determining the level of GHG emissions reduction per capita. Based on the Guidebook of JRC mentioned in chapter 3, if there is a sharp change of population, it is recommended to use "per capita" reduction for setting target. This approach gives more opportunity to assess the effectiveness of local climate mitigation plans and make meaningful robust comparison between different cities' performances, as the main goal of GHG emissions reduction plans is not only to reduce the absolute amount of CO_2 and CO_2e in atmosphere, thereby to restrain the global temperature increase but also through climate mitigation policy to achieve public welfare for each person.

The results of correlation analysis and independent sample T-Test based on per capita emissions indicate the interrelation of cities' density, geographical location, GDP per capita and membership of international climate networks (*"C40 membership"*, *"CoM members"* *and "Member of more than one climate network").* Unlike the analysis of the GHG emissions in absolute level, where the relationship between indicators and networks highlighted significance only with a membership of Covenant of Mayors, the same analysis with GHG emissions trend per capita shows relation with 2 international networks, and also being a member more than one network is a crucial factor for achieving emissions reduction target. The significance level of independent sample T-Test gave enough evidence to emphasize that international climate networks are more closely related to GHG emissions reduction per capita than emissions reduction in absolute value.

Based on the moderate positive relationship between membership of CoM and the achievement of the GHG emissions reduction target, it can be claimed that being a member of Covenant of Mayor initiative can change the performance of climate mitigation plans, enhance GHG emissions reduction not only in absolute level but also per capita. There is enough evidence to emphasize that CoM is the effective initiative among others in this thesis sample used, its guidelines, coordination with local governments are more effective compared with other climate networks.

It can be summarised that in thesis sample size, the correlation analysis indicates that there is no relation between age composition, a number of climate mitigation actions, cities' size (area km^2) and population size. However, in thesis sample, the majority of cities have more than a 500,000 population, sample size is homogeneous. That can be the reason for not having significant results compared with the achievement level of the GHG emissions reduction.

It can justify that irrespective of the existence of climate mitigation actions, the emissions reduction cannot be changed unless there is enough technology or also maybe political will to implement certain climate mitigation policy. For instance, Asian cities from India Rajkot, Shimla, Gwalior, Latin American city Buenos Aires have more mitigation actions than some European cities, but climate mitigation target achievement is incomparably lower (Table 25).

Analysing last year's GHG emissions per capita (Annex 6), we can also conclude that even if we take into account that the majority of Asian cities in thesis sample are behind, however, the results of the analysis for emissions per capita gives more details of climate mitigation policy of cities. It is worth mentioning that emissions reduction per capita depends also on the level of ambition of cities' commitments, more specifically GHG emissions reduction target. In those cities that have ambitious target, the trend level of emission per capita is lower.

It is also worth mentioning that with ambitious target the possibility to decrease GHG emissions and even target achievability is not as high compared to cities with less ambitious target. However, the main goal for climate mitigation is not to have achievable target, which with non-ambitious target is easy to achieve, but to reach the drop of global temperature and meet Paris Agreements' goals, which can be possible with ambitious target (based on the results of this research).

Table 25: GHG emissions target ambitious & emissions reduction per capita

City	Baseline emissions per capita (metric tonnes CO_2e)	Target year emissions per capita(metric tonnes CO_2e)	Trend emissions per capita (metric tonnes CO_2e)	Last year emissions per capita (metric tonnes CO_2e)	Reduction based on trend per capita (% comparing to baseline)	Percent of the emission reduction target achieved	Number of climate mitigation Actions	GHG emissions reduction target %
Copenhagen	4.74	0.00	-0.96	2.49	120.2	120.2	11	100
Östersund	7.34	0.00	0.03	5.42	99.6	99.6		100
Melbourne	1.35	0.00	1.20	1.04	10.9	10.9	5	100
Boudler	20.05	2.51	10.89	17.51	45.7	52.2	19	80
Thane Municipality	2.90	0.24	1.16	1.07	60.1	65.6	33	73
Saffle	35.49	12.46	10.64	12.22	70.0	107.9	12	70
Sydney	1.19	0.25	0.57	0.81	52.1	66.0	8	70
London	6.66	1.96	3.17	4.81	52.4	74.2		60
Bristol	6.09	2.05	3.35	4.81	45.0	67.8	5	60
Flagstaff	24.23	5.99	7.69	16.99	68.2	90.7	8	60
Vajxo	4.60	2.10	2.46	2.31	46.6	85.7		55
Hamburg	12.79	5.65	11.05	10.06	13.5	24.3		50
Oslo	1.69	0.55	1.31	2.00	22.5	33.3	28	50
Västerås	7.76	2.97	4.25	5.49	45.3	73.4		50
Umeå	5.97	2.18	4.14	4.34	30.8	48.5	86	50
Hiroshima	7.79	3.75	8.65	7.30	-11.0	-21.2	5	50
Hong Kong	6.16	2.77	5.70	5.97	7.5	13.7		50
Rajkot	1.05	0.21	1.48	1.32	-40.3	-50.5	33	49
Manchester	9.29	4.00	4.87	5.45	47.6	83.6		48
Uppsala	8.37	3.16	5.51	5.89	34.1	54.8	54	45
Amsterdam	4.92	2.24	3.52	5.44	28.3	52.0		40
Portland	18.45	7.05	3.97	11.26	78.5	127.0	9	40
Edmonton	18.31	7.67	13.22	17.86	27.8	47.8	47	35
New York	6.91	4.02	4.01	5.83	42.0	100.2		35
Pimpri Chinchwad	1.11	0.81	3.24	1.84	-192.6	-713.3	0	34
City Vancouver	4.79	3.15	3.83	3.78	19.9	58.3	116	33
Brussels	4.21	2.29	1.68	2.80	60.1	131.6	58	30
Toronto	11.81	6.53	3.21	6.68	72.8	162.9		30
Tokyo	4.93	2.99	5.03	5.19	-2.1	-5.4	4	30
eThekwini	4.80	3.04	10.75	8.13	-123.8	-338.2	71	26
Wonju	5.17	3.11	8.24	6.18	-59.3	-148.8	29	26
Tainan	13.67	10.04	13.27	14.15	2.9	10.8	26	26
North Vancouver	2.70	1.86	2.21	2.34	18.1	57.9	79	25
Boston	12.20	7.85	7.46	9.20	38.8	109.0	7	25
Taipei	5.90	4.26	4.17	5.57	29.3	105.4	27	25
Seoul	5.04	3.71	4.67	4.80	7.2	27.6	41	25

Nagoya	8.07	5.71	4.77	4.09	40.9	139.8	9	25
Durban	6.59	4.00	6.01	6.37	8.9	22.6		25
Stockholm	5.46	2.66	1.89	2.91	65.4	127.5	85	24
Turku	9.25	6.15	5.20	6.15	43.8	130.9		20
Madrid	4.18	3.29	2.02	3.22	51.6	243.5	5	20
Lisbon	6.92	5.81	2.86	3.55	58.6	365.6	6	20
Belo Horizonte	1.30	0.93	0.96	1.15	26.2	93.6	40	20
Philadelphia	15.21	11.65	9.34	12.45	38.6	165.1	2	20
Denver	24.19	12.44	2.63	13.47	89.1	183.6		20
Atlanta	14.15	12.13	22.91	21.19	-61.9	-433.1	4	20
Kaohsiung	23.40	18.53	17.32	21.14	26.0	125.0	30	20
Evanson	13.22	10.72	11.11	10.73	16.0	84.6	36	20
Panaji	0.91	0.41	0.47	1.26	48.5	87.3	28	19
Yokohama	5.46	4.45	6.28	5.92	-15.0	-80.8	0	16
Minneapolis	15.18	11.32	10.28	11.79	32.3	127.0	3	15
Des Moines	12.14	9.35	8.50	10.47	30.0	130.4	4	11
Bogota	2.09	1.81	1.62	1.57	22.2	169.7	30	10
Buenos Aires	3.86	3.13	4.81	6.57	-24.3	-128.6	38	10
Wellington	3.70	2.76	2.71	2.72	26.8	105.3	5	10
Shimla	1.14	0.83	1.55	1.29	-35.6	-128.4	15	10
Gwalior	0.33	0.19	0.61	1.12	-85.7	-206.6	17	10
Tuscon	14.09	14.08	15.36	14.34	-9.0	0.0	5	8
Kadiovacik				2.06				4

By summarizing the results based on correlation analysis, T- Test and trend analysis the GHG emissions reduction in the absolute level and per capita, we can draw the conclusion that the combination of socioeconomic, climate, the degree of urbanization factors with effective international cooperation for urban governments are essential elements to achieve climate mitigation goals.

In conclusion, to answer the main research question “Which factors correlate with achievement of local climate mitigation targets of global cities”, we can conclude that socioeconomic (GDP per capita), climate (geographical location), degree of urbanization (density) and membership of climate networks (CoM, C40) are the main factors that correlate with achievement of climate mitigation targets.

By comparing these results with the research mentioned in Chapter 2, it can be summarized that this outcome is in line with existing studies, where also underlined that the socio-economic, climate, urbanization degree and external factors are mainly interrelated to the achievement climate mitigation goals.

5.2 Recommendations

The scientific search through the cities carbon reduction report, especially during data collection period, gave some evidence to claim that cities should improve the level of carbon registry reports.

The accuracy of reporting was not proper especially for developing countries and very often previous year GHG emissions reduction inventories were repeated, which practically is not possible.

As has been found, there is moderate correlation between GDP per capita and the level of achievement of GHG emissions reduction target. Therefore, it would be important to conduct further analysis of the correlation between the level of cities' foreign direct investments (FDI) and achievement of GHG emissions reduction. As an external factor, the possibility that FDI can have great influence on emissions reduction is high, as it has influence not only the cities' economy bat also on the level of technological advancement.

It worth to underline that during data collection, an immense number of inconsistencies in the Asian cities report have been found, which gives an idea that it will be important to analyze the correlation between achievement of emissions reduction with cities' corruption index.

The results of this research allow us to do the following observation: the permanent monitoring of cities abatement potential can help to achieve GHG emissions reduction target. Therefore, for having a realistic and achievable GHG emissions reduction target it is very important to assess climate mitigation potential by taking into account the interrelation between the main driver factors and GHG emissions target achievement.

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Annex 1: Research Instruments and Time schedule

Research instruments

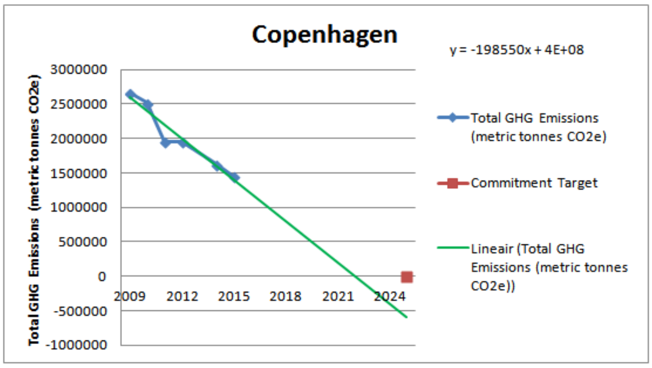
The research used secondary data from cities carbon reports, international climate projects online databases, municipalities policy documents.

Time Schedule of Field Work

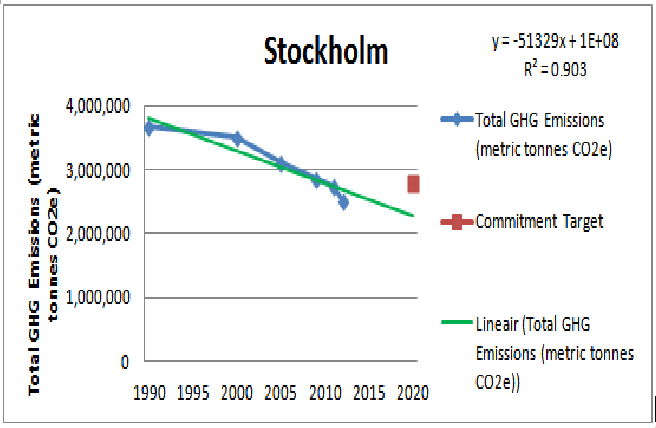
Actions (28 June-30 July)	JUNE			JULY																													
	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Collecting data from CoM database																																	
Collecting data from carbonn.org database																																	
Collecting data from cities policy document																																	
Collecting data from Erasmus University libraray database																																	
Collecting data from Carbon Disclosure Project database																																	
Evaluating and monitoring previous week data																																	

Annex 2: Trend Analysis, Graphs

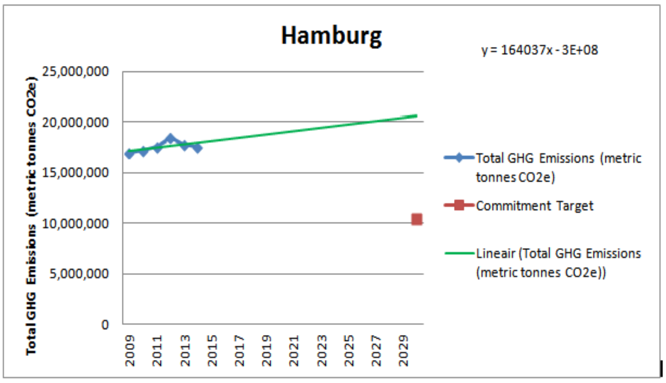
European cities



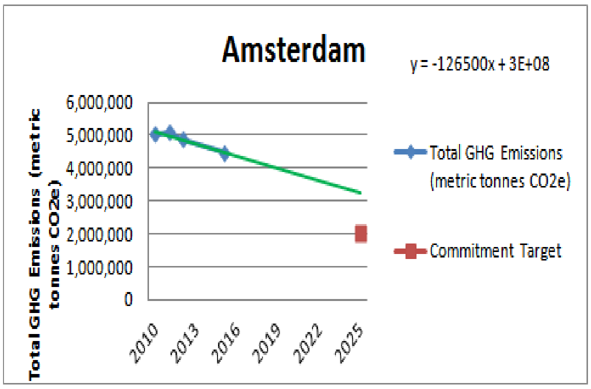
Copenhagen		
Year	Total GHG Emissions (metric tonnes CO2e)	Commitment Target and Baseline year
2009	2,656,796	
2010	2,515,250	Baseline
2012	1,958,886	
2014	1,626,573	
2015	1,450,358	
2025	0	Target



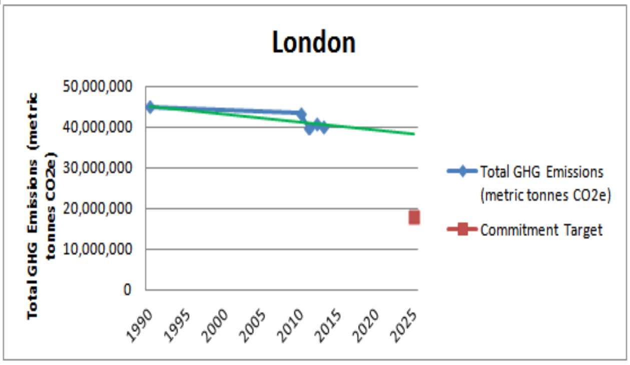
Stockholm		
	Total GHG Emissions (metric tonnes CO2e)	Commitment Target, Baseline Year
1990	3,668,000	Baseline Year
2000	3,510,000	
2005	3,104,000	
2009	2,852,000	
2011	2,742,000	
2012	2,511,000	
2020	2,787,680	Target



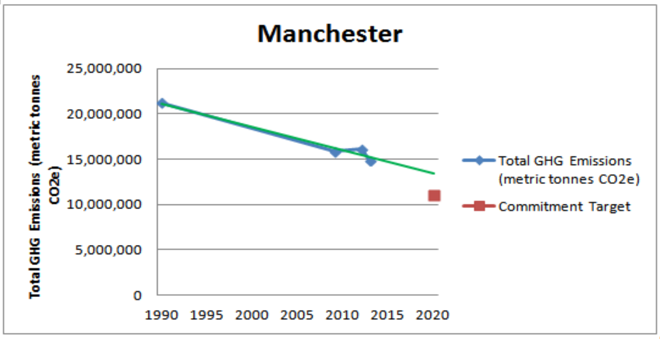
Hamburg		
	Total GHG Emissions (metric tonnes CO2e)	Commitment Target, Baseline Year
1990	20,727,000	Baseline
2009	16,951,242	
2010	17,159,161	
2011	17,572,000	
2012	18,422,000	
2013	17,755,000	
2014	17,572,000	
2030	10,363,500	Target



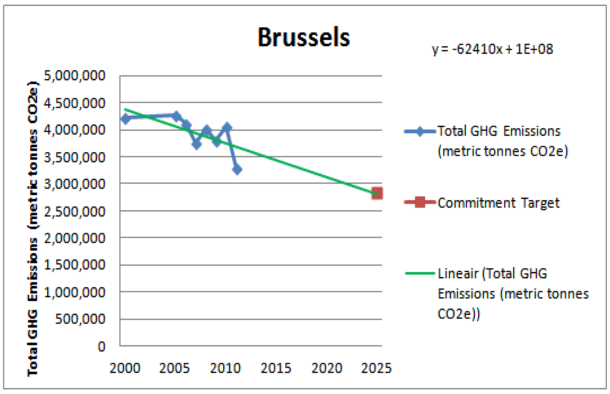
Amsterdam		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	3,417,000	Baseline
2010	5,045,000	
2011	5,094,000	
2012	4,886,300	
2015	4,471,000	
2025	2,050,200	Target



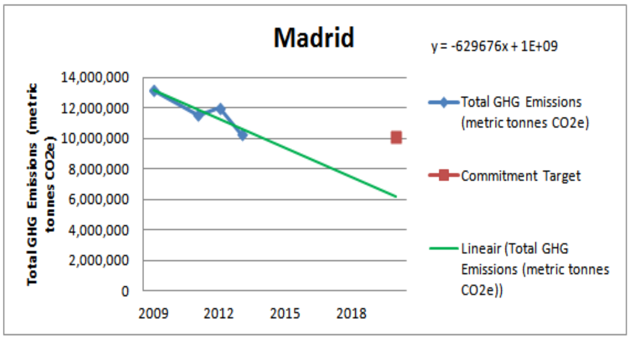
London		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	45,000,000	Baseline
2010	43,400,000	
2011	39,920,355	
2012	40,750,490	
2013	40,190,000	
2025	18,000,000	Target



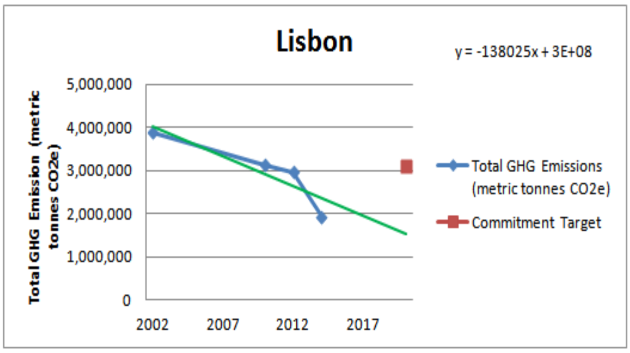
Manchester		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	21,200,000	Baseline
2009	15,902,000	
2012	16,145,000	
2013	14,889,318	
2020	11,024,000	Target



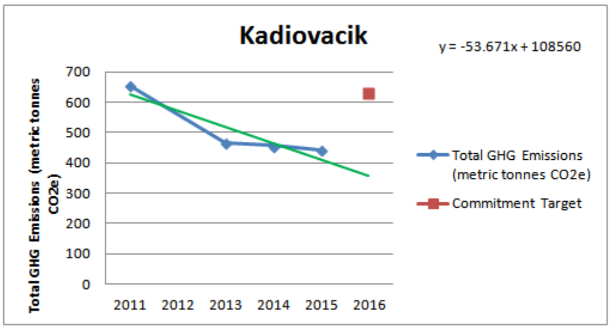
Brussels		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	4,057,300	Baseline
2000	4,222,500	
2005	4,260,500	
2006	4,119,100	
2007	3,763,400	
2008	4,008,000	
2009	3,803,900	
2010	4,055,800	
2011	3,293,000	
2025	2,840,110	Target



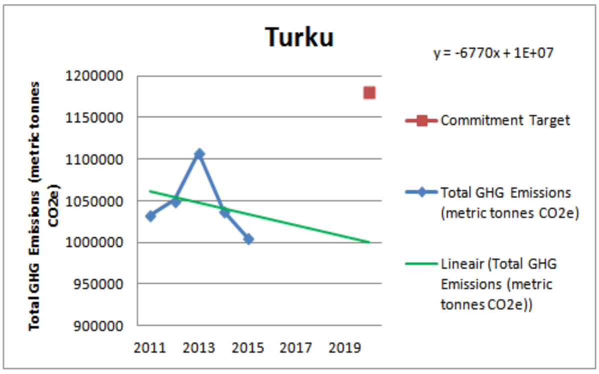
Madrid		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	12,653,000	Baseline
2009	13,139,000	
2011	11,527,000	
2012	11,980,000	
2013	10,257,048	
2020	10,122,400	Target



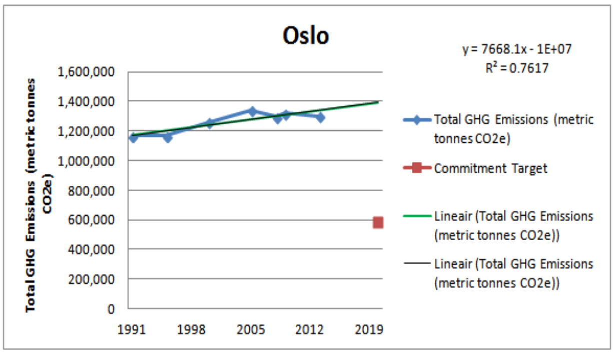
Lisbon		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2002	3,887,013	Baseline
2010	3,133,805	
2012	2,969,996	
2014	1,934,361	
2020	3,109,610	Target



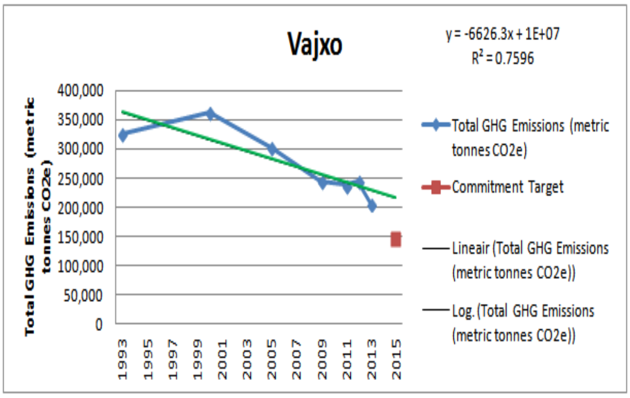
Kadiovacik		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2011	655	Baselie
2013	467	
2014	457	
2015	444	
2016	628	Target



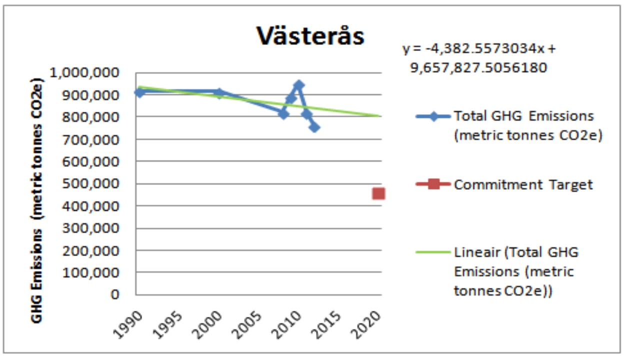
Turku		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	1,475,000	Baseline
2011	1,033,000	
2012	1,051,000	
2013	1,107,500	
2014	1,038,300	
2015	1,005,500	
2020	1,180,000	Target



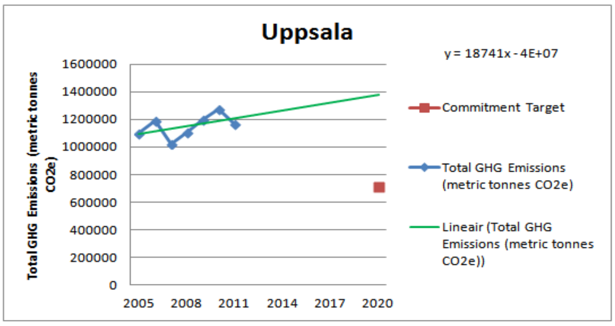
Oslo		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1991	1,168,000	Baseline
1995	1,166,800	
2000	1,260,100	
2005	1,337,400	
2008	1,295,700	
2009	1,321,100	
2013	1,298,000	
2020	584,000	Target



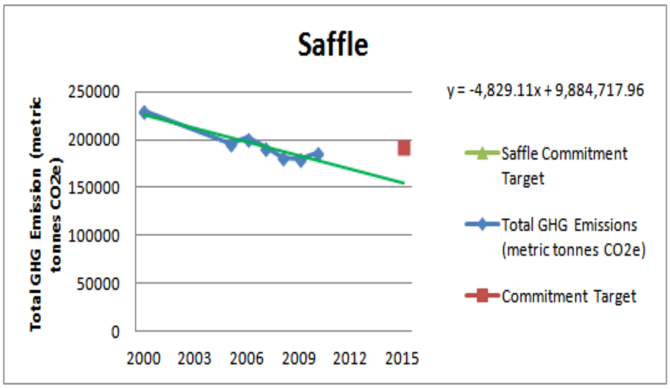
Vajxo		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1993	326,738	Baseline
2000	362,318	
2005	302,291	
2009	245,816	
2011	238,382	
2012	244,642	
2013	207,042	
2015	147,032	Target



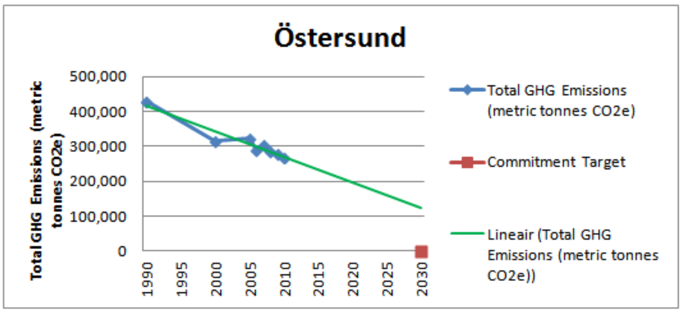
Västerås		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	918,500	Baseline
2000	913,900	
2008	822,100	
2009	890,300	
2010	948,100	
2011	819,800	
2012	760,988	
2020	459,250	Target



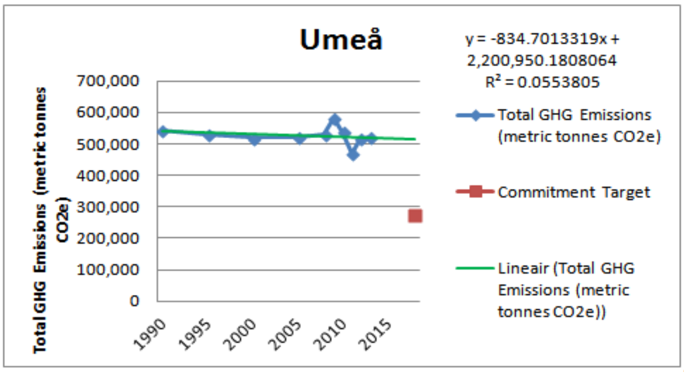
Uppsala		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	1,289,300	Baseline
2000	1,147,300	
2005	1,099,700	
2006	1,191,800	
2007	1,025,000	
2008	1,109,580	
2009	1,198,234	
2010	1,271,008	
2011	1,164,069	
2020	709,115	Target



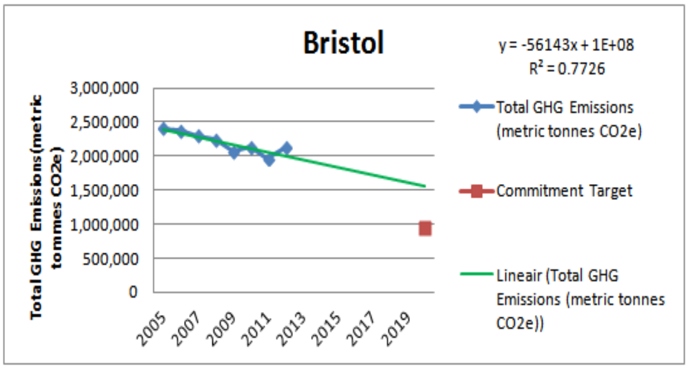
Saffle		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	638,100	Baseline
2000	229,607	
2005	196,060	
2006	201,859	
2007	192,080	
2008	181,974	
2009	179,537	
2010	187,016	
2015	191,430	Target



Östersund		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	428,000	Baseline
2000	315,301	
2005	324,587	
2006	291,316	
2007	305,832	
2008	285,561	
2009	279,666	
2010	270,143	
2030	0	Target

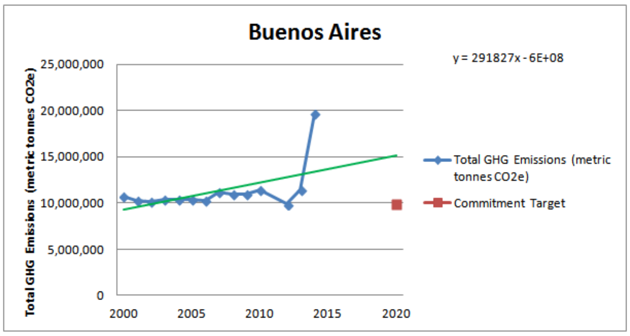


Umeå		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	545,003	Baseline
1995	530,623	
2000	519,427	
2005	521,009	
2008	529,385	
2009	580,138	
2010	539,025	
2011	469,200	
2012	516,159	
2013	521,267	
2018	272,502	Target

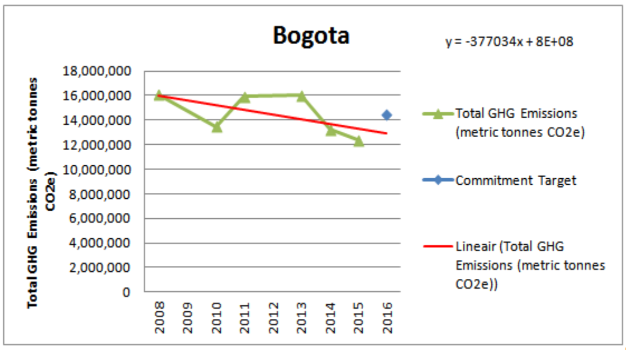


Bristol		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	2,405,000	Baseline
2006	2,380,000	
2007	2,302,000	
2008	2,244,000	
2009	2,063,000	
2010	2,134,000	
2011	1,963,000	
2012	2,127,000	
2020	952,476	Target

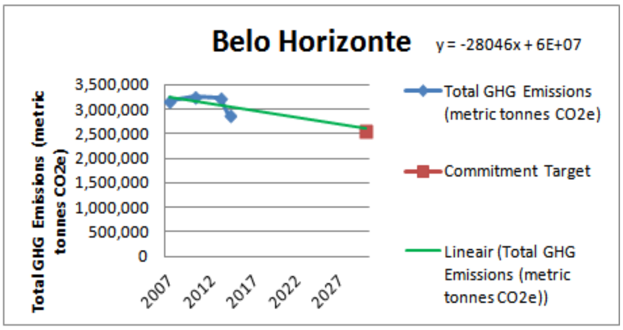
Latin American Cities



Buenos Aires		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2000	10,735,938	
2001	10,272,220	
2002	10,153,936	
2003	10,406,559	
2004	10,405,917	
2005	10,404,748	
2006	10,277,153	
2007	11,213,617	
2008	11,000,720	Baseline
2009	11,000,720	
2010	11,411,200	
2012	9,886,932	
2013	11,438,694	
2014	19,667,128	
2020	9,900,648	Target

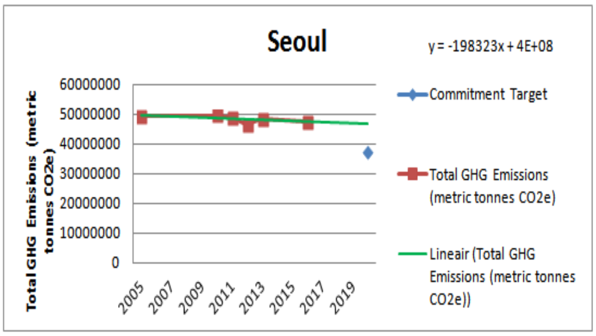


Bogotá		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2008	16,083,753	Baseline
2010	13,496,667	
2011	15,921,690	
2013	16,077,576	
2014	13,217,521	
2015	12,359,325	
2016	14,469,819	Target

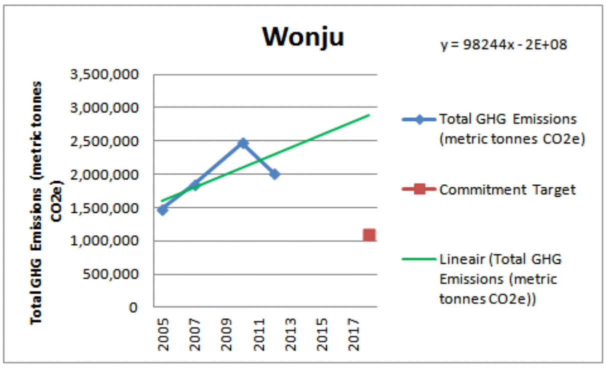


Belo Horizonte		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2007	3,176,966	Baseline
2010	3,253,559	
2013	3,241,713	
2014	2,878,873	
2030	2,541,573	Target

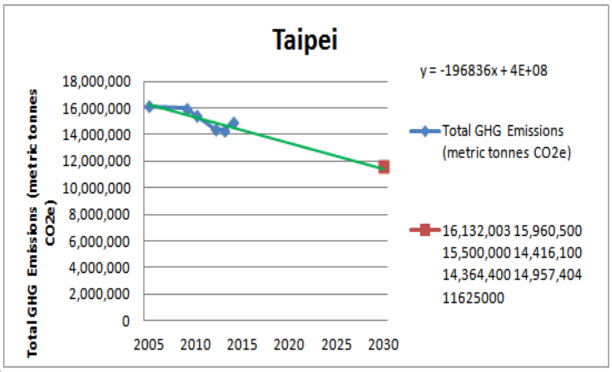
Asian cities



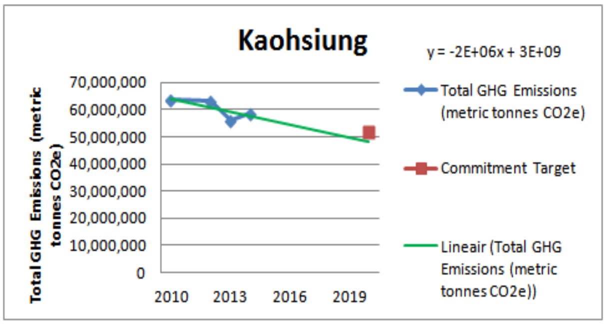
Seoul		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	49,467,000	Baseline
2010	49,581,584	
2011	49,008,230	
2012	46,400,612	
2013	48,550,952	
2016	47,612,664	
2020	37,100,250	Target



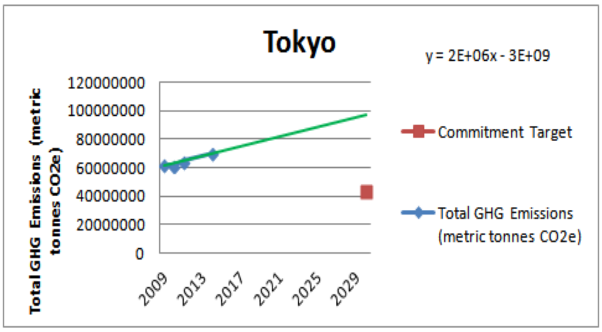
Wonju city		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	1,471,393	Baseline
2007	1,843,648	
2010	2,473,362	
2012	2,015,540	
2018	1,088,831	Target



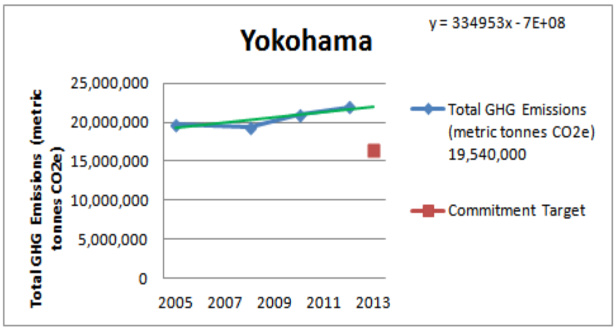
Taipei		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	14,622,800	Baseline
2005	16,132,003	
2009	15,960,500	
2010	15,500,000	
2012	14,416,100	
2013	14,364,400	
2014	14,957,404	
2030	11,625,000	Target



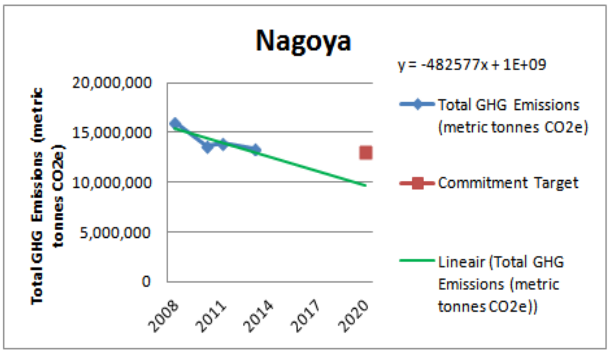
Kaohsiung		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	64,339,200	Baseline
2010	63,624,500	
2012	63,251,100	
2013	56,234,284	
2014	58,755,764	
2020	51,471,360	Target



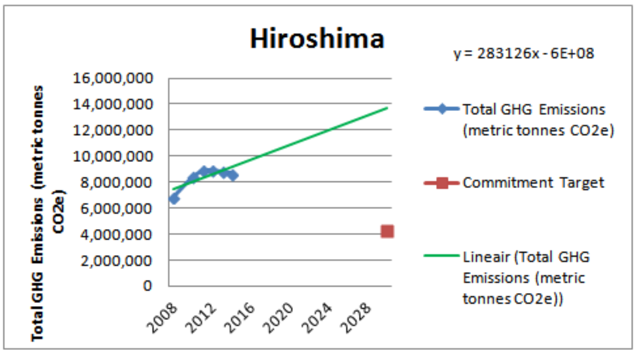
Tokyo		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2000	62,100,000	Baseline
2009	62,178,462	
2010	61,905,000	
2011	64,770,000	
2014	70,125,000	
2030	43,470,000	Target



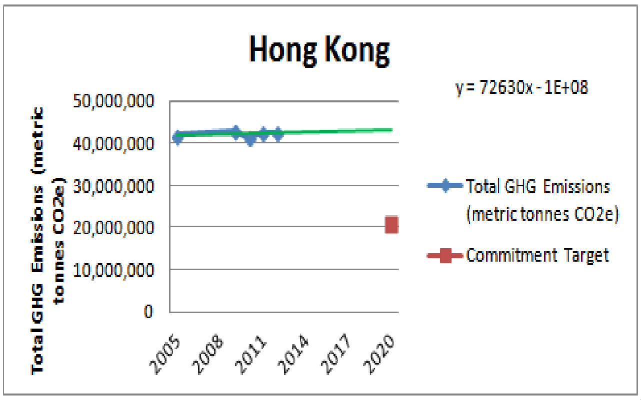
Yokohama		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	19,540,000	Baseline
2008	19,787,000	
2010	19,300,000	
2012	21,039,000	
2013	21,950,000	
2020	16,413,600	Target



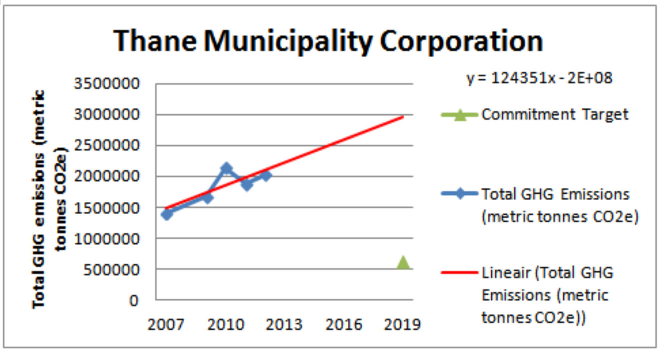
Nagoya		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	17,390,000	Baseline
2008	15,989,000	
2010	13,650,000	
2011	13,948,000	
2013	13,420,000	
2020	13,042,500	Target



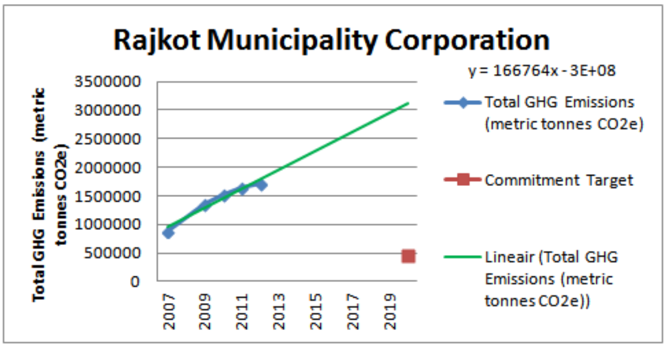
Hiroshima		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	8,525,221	Baseline
2008	6,899,000	
2010	8,423,204	
2011	8,916,709	
2012	8,916,709	
2013	8,836,285	
2014	8,675,437	
2030	4,262,611	Target



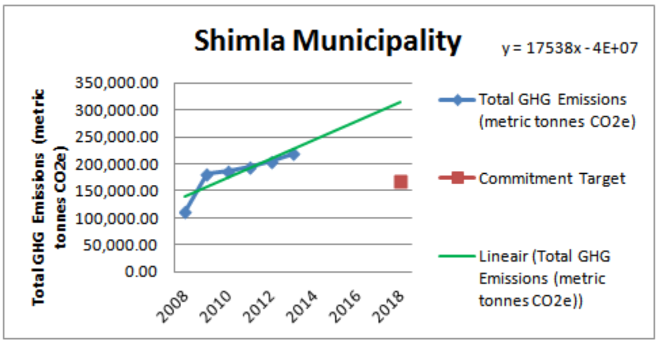
Hong Kong		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	42,000,000	Baseline
2009	42,900,000	
2010	41,500,000	
2011	42,600,500	
2012	42,700,000	
2020	21,000,000	Target



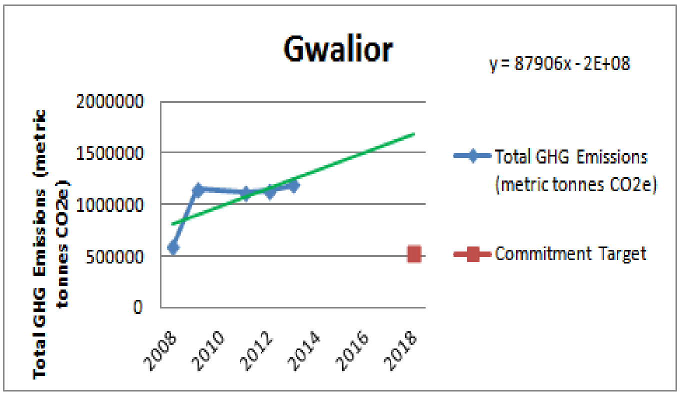
Thane Municipality Corporation		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	2,327,233.00	
2007	1,411,454.00	Baseline
2009	1,676,722.00	
2010	2,138,165.00	
2011	1,872,014.00	
2012	2,027,179.00	
2019	623,763.00	Target



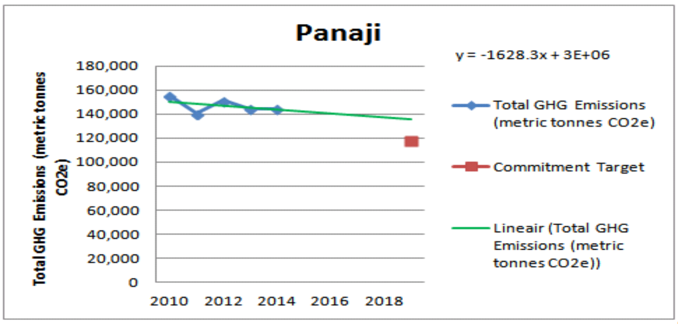
Rajkot Municipality Corporation		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2007	882,103.00	Baseline
2009	1,344,676.00	
2010	1,514,267.00	
2011	1,634,367.00	
2012	1,704,380.00	
2020	451,825.00	Target



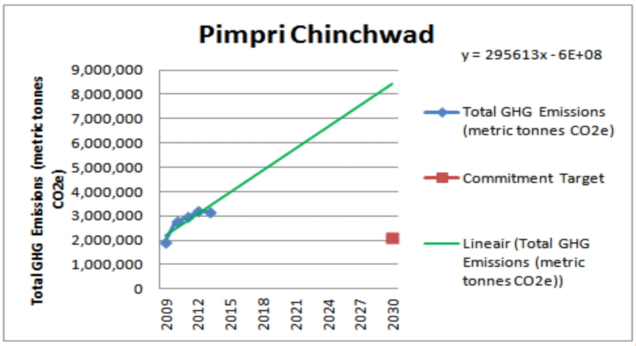
Shimla Municipality Corporation		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2008	111,294	Baseline
2009	182,667	
2010	186,316	
2011	195,201	
2012	204,982	
2013	218,896	
2018	167,684	Target



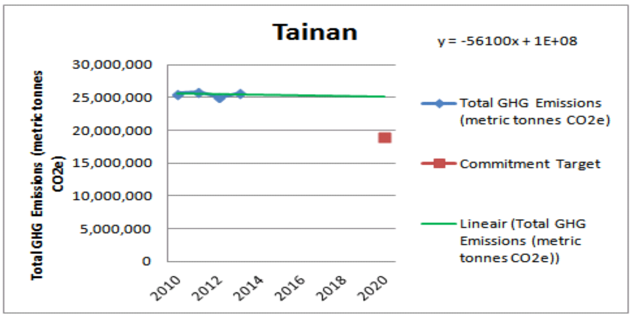
Gwalior Municipality Corporation		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2008	591,963	Baseline
2009	1,161,078	
2011	1,115,381	
2012	1,138,632	
2013	1,195,239	
2018	532,767	Target



Corporation of the city Panaji		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2010	154,912	
2011	140,363	
2012	151,228	
2013	144,706	Baseline
2014	144,599	
2019	117,212	Target

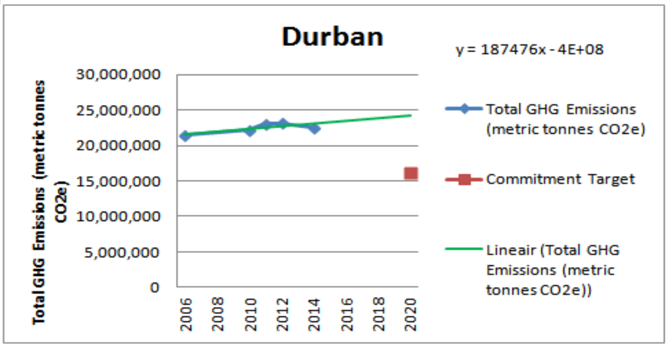


Pimpri Chinchwad Municipal Corporation		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2009	1,913,797	
2010	2,761,775	
2011	2,947,580	
2012	3,185,500	
2013	3,180,000	Baseline
2030	2,098,800	Target

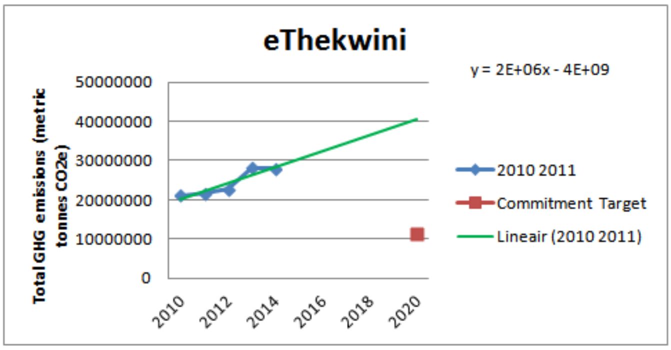


Tainan City Government		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2010	25,620,952	Baseline
2011	25,791,831	
2012	25,081,617	
2013	25,670,690	
2020	18,959,504	Target

African cities

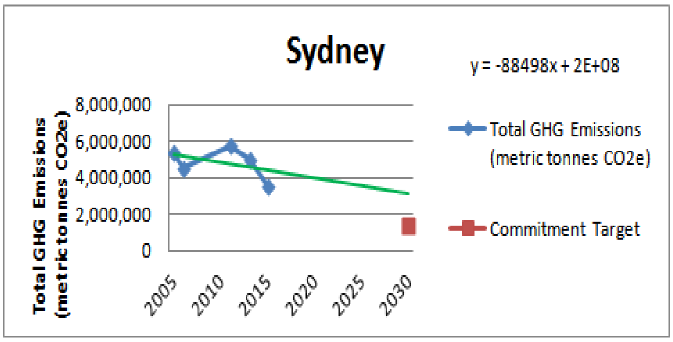


Durban		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2006	21,413,906	Baseline
2010	22,235,084	
2011	23,080,651	
2012	23,154,180	
2014	22,587,081	
2020	26,167,499	Target

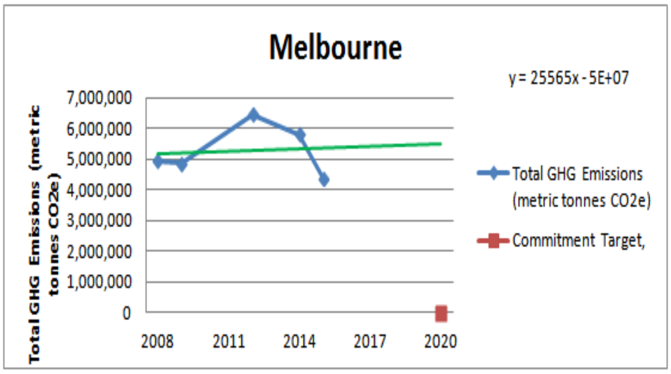


eThekwini Metropolitan Municipality		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Yaer**
2005	15,514,200.00	Baseline
2010	21,160,200.00	
2011	21,563,446.00	
2012	22,778,331.00	
2013	28,164,034.00	
2014	27,991,829.00	
2020	11,480,508.00	Target

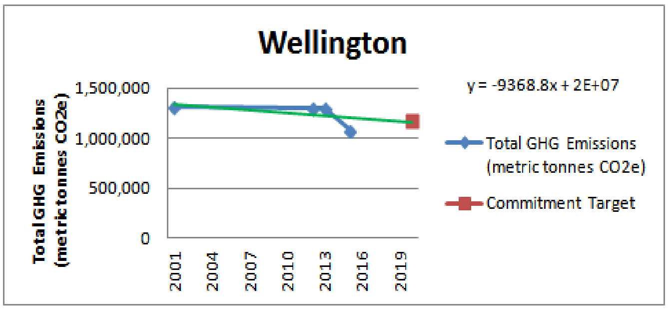
Australasia (Australia, New Zealand)



Sydney		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Target Year**
2005	5,457,064	Baseline
2006	4,536,712	
2011	5,766,936	
2013	5,052,256	
2015	3,556,529	
2030	1,361,014	Target

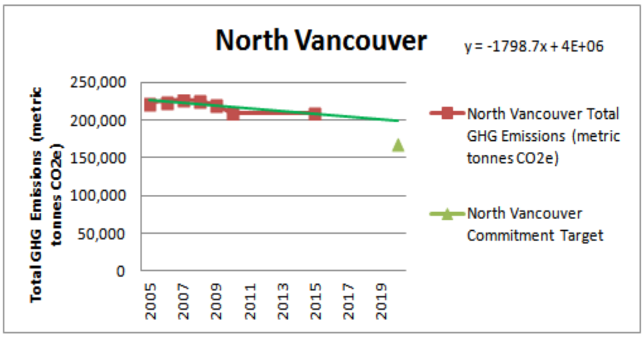


Melbourne		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2008	4,934,000	Baseline
2009	4,870,289	
2012	6,442,240	
2014	5,805,437	
2015	4,372,420	
2020	0	Target

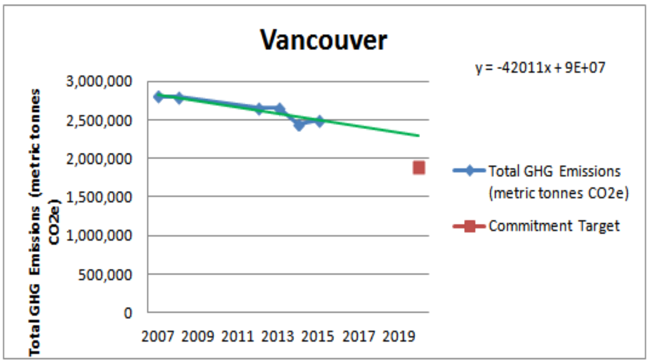


Wellington		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2001	1,310,705	Baseline
2012	1,301,739	
2013	1,301,739	
2015	1,084,979	
2020	1,179,635	Target

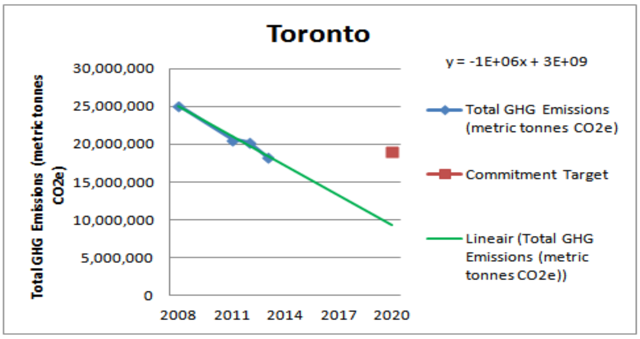
North American cities



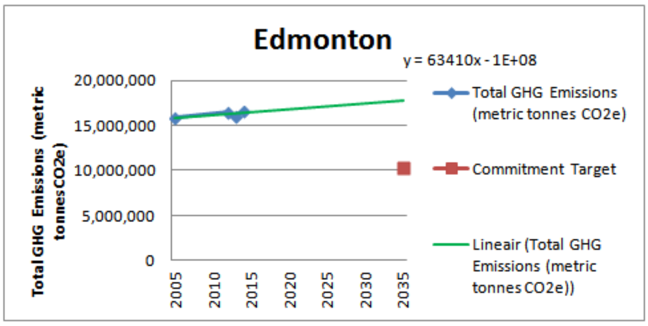
North Vancouver		
	Total GHG Emissions (metric tonnes CO_2e)	**Commitment Target, Baseline Year**
2005	223,127	Baseline
2006	224,708	
2007	226,821	
2008	226,153	
2009	220,072	
2010	209,751	
2015	209,721	
2020	167,345	Target



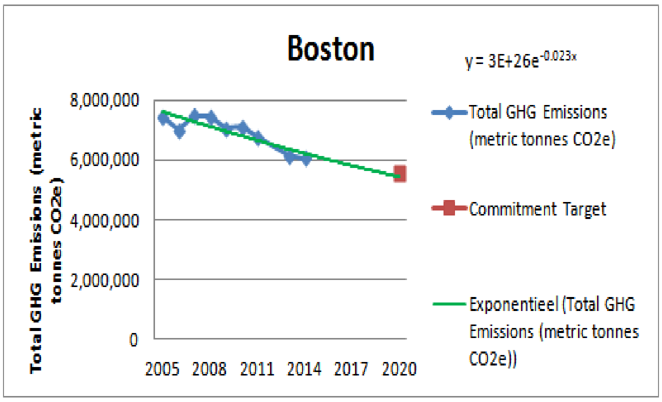
Vancouver		
	Total GHG Emissions (metric tonnes CO_2e)	**Commitment Target, Baseline Year**
2007	2,805,000	Baseline
2008	2,800,000	
2012	2,657,000	
2013	2,657,105	
2014	2,442,602	
2015	2,501,218	
2020	1,879,350	Target



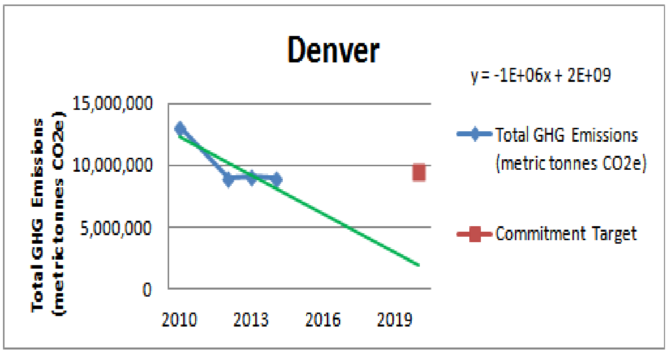
Toronto		
	Total GHG Emissions (metric tonnes CO_2e)	**Commitment Target, Baseline Year**
1990	27,051,617	Baseline
2008	25,100,000	
2011	20,662,821	
2012	20,313,061	
2013	18,320,966	
2020	18.936,132	Target



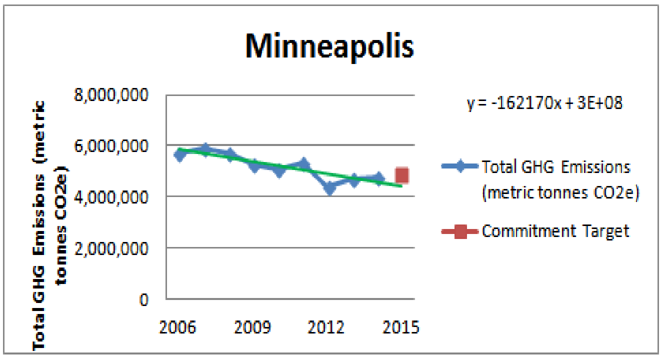
Edmonton		
	Total GHG Emissions (metric tonnes CO_2e)	**Commitment Target, Baseline Year**
2005	15,862,000	Baseline
2012	16,510,297	
2013	16,051,047	
2014	16,576,702	
2035	10,310,300	Target



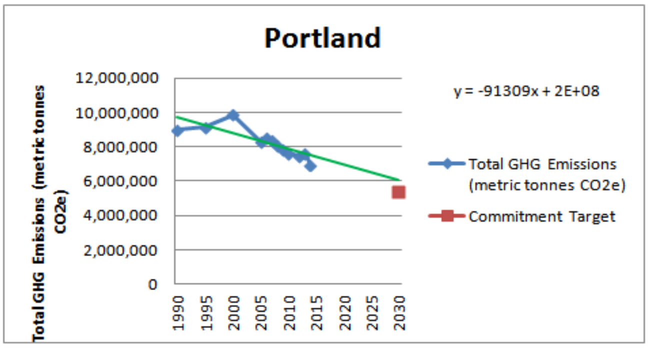
Boston		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Target Year**
2005	7,440,000	Baseline
2006	6,983,427	
2007	7,481,846	
2008	7,441,878	
2009	7,063,009	
2010	7,104,890	
2011	6,766,714	
2013	6,135,026	
2014	6,066,182	
2020	5,580,000	Target



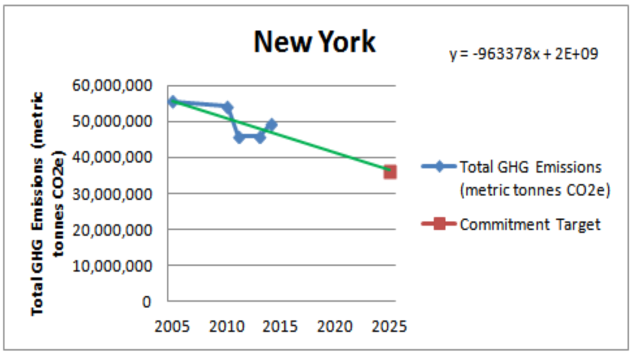
Denver		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	11,800,000	Baseline
2010	13,028,000	
2012	8,934,000	
2013	9,132,000	
2014	8,942,000	
2020	9,440,000	Target



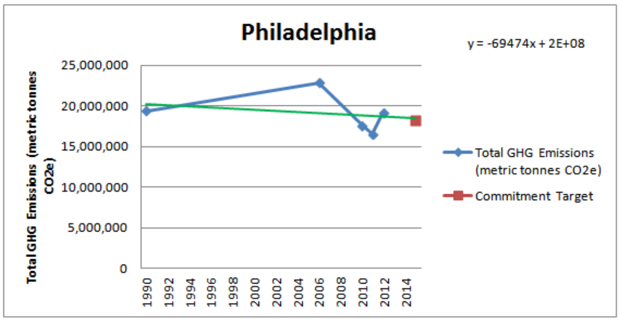
Minneapolis		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2006	5,700,000	Baseline
2007	5,879,301	
2008	5,704,355	
2009	5,275,337	
2010	5,095,765	
2011	5,353,548	
2012	4,396,116	
2013	4,689,049	
2014	4,794,708	
2015	4,845,000	Target



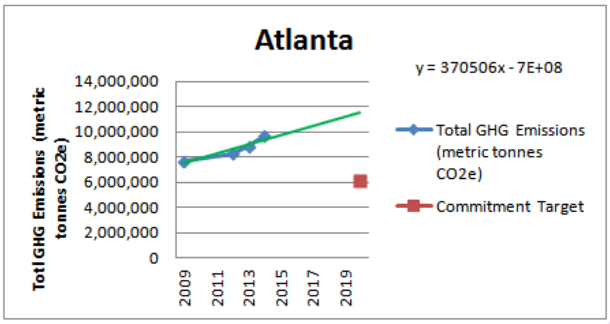
Portland		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	8,989,460	Baseline
1995	9,135,411	
2000	9,872,228	
2005	8,318,465	
2006	8,558,015	
2007	8,386,247	
2008	8,121,788	
2009	7,890,029	
2010	7,664,696	
2012	7,511,675	
2013	7,601,940	
2014	6,974,544	
2030	5,393,676	Target



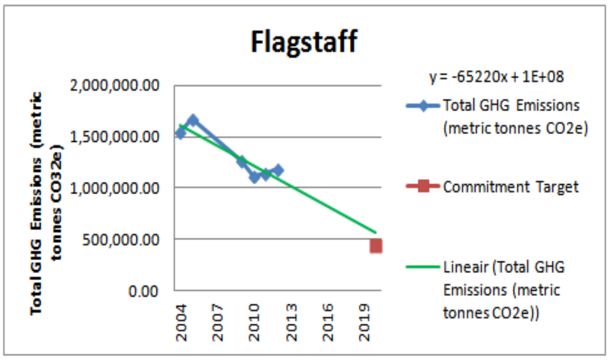
New York		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	55,616,668	Baseline
2010	54,348,841	
2011	45,923,778	
2013	45,993,429	
2014	49,385,508	
2025	36,150,834	Target



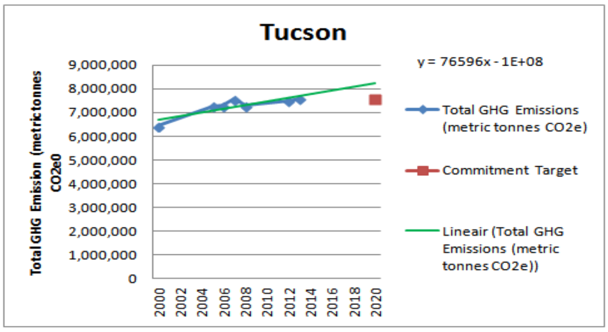
Philadelphia		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	19,403,213	**Baseline**
2006	22,837,228	
2010	17,584,791	
2011	16,520,450	
2012	19,212,870	
2015	18,269,782	Target



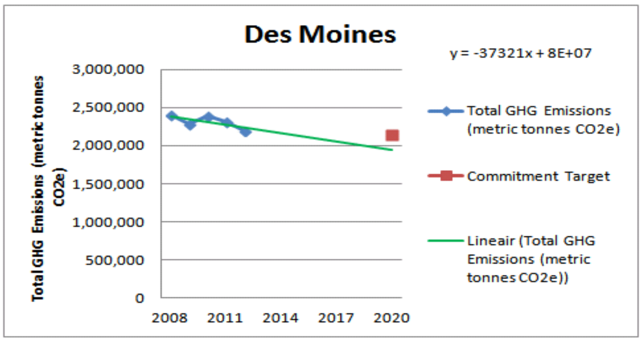
Atlanta		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2009	7,656,727	Baseline
2012	8,252,914	
2013	8,857,265	
2014	9,650,000	
2020	6,125,382	Target



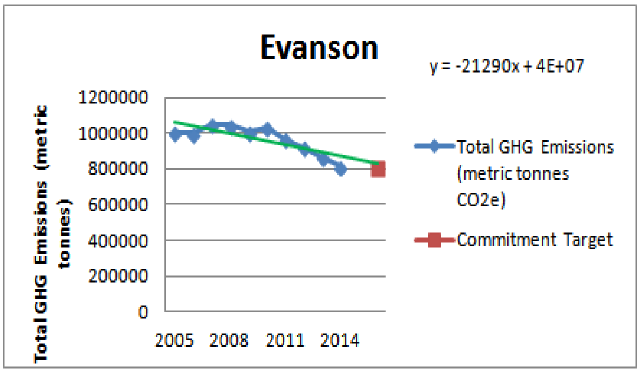
Flagstaff		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	1,116,738	Baseline
2004	1,553,518	
2005	1,667,566	
2009	1,268,261	
2010	1,119,076	
2011	1,142,987	
2012	1,190,809	
2020	446,695	Target



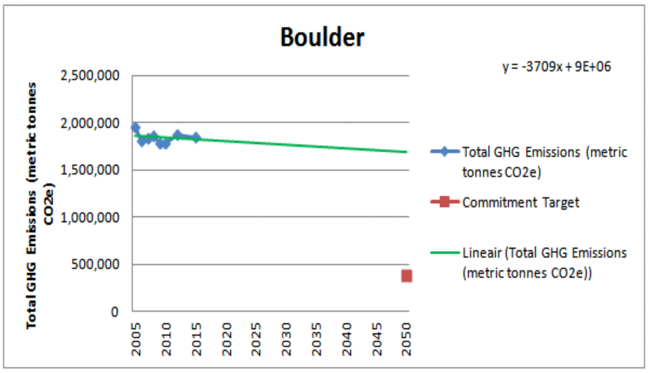
Tucson		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
1990	5,461,020	
2000	6,432,766	
2005	7,252,776	
2006	7,286,349	
2007	7,560,728	Baseline
2008	7,289,722	
2012	7,501,135	
2013	7,567,930	
2020	7,560,728	Target



City of Des Moines		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2008	2,398,445	Baseline
2009	2,280,469	
2010	2,383,621	
2011	2,314,404	
2012	2,194,871	
2020	2,134,616	Target



Evanston		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Baseline Year**
2005	1,003,807	Baseline
2006	1,000,682	
2007	1,047,714	
2008	1,045,590	
2009	1,006,381	
2010	1,031,257	
2011	967,656	
2012	922,582	
2013	863,837	
2014	812,660	
2016	803,046	Target



City of Boulder		
	Total GHG Emissions (metric tonnes CO2e)	**Commitment Target, Bseline Year**
2005	1,949,796	Baseline
2006	1,814,978	
2007	1,835,517	
2008	1,858,034	
2009	1,785,525	
2010	1,787,820	
2012	1,870,346	
2015	1,848,741	
2050	389,959	Target

Annex 3: Tables: GHG emissions reduction target achievement

Indicator 1- GHG emissions reduction Based on trend

City	Baseline Year	Target Year	Baseline emissions (metric tonnes CO2e)	Target emissions(metric tonnes CO2e)	Trend emissions (metric tonnes CO2e)	Actual emissions reduction based on trend (metric tonnes CO2e)	Reduction based on trend (% comparing to baseline)
Copenhagen	2010	2025	2,515,250	0	-656,761	3,172,011	1.26
Östersund	1990	2030	428,000	0	2,045	425,955	1.00
Denver	1990	2020	11,800,000	9,440,000	1,994,171	9,805,829	0.83
Portland	1990	2030	8,989,460	5,393,676	3,037,792	5,951,668	0.66
Toronto	1990	2020	27,051,617	18,936,132	9,305,993	17,745,624	0.66
Lisbon	2002	2020	3,887,013	3,109,610	1,532,031	2,354,982	0.61
Saffle	1990	2015	11,186,419	3,355,926	4,447,255	6,739,164	0.60
Madrid	1990	2020	12,653,000	10,122,400	6,216,096	6,436,904	0.51
Flagstaff	1990	2020	1,116,738	446,695	573,673	543,065	0.49
Brussels	1990	2025	4,057,300	2,840,110	2,086,021	1,971,279	0.49
Stockholm	1990	2020	3,668,000	2,787,680	1,979,537	1,688,463	0.46
Kadiovacik	2011	2016	655	628	358	297	0.45
Nagoya	1990	2020	17,390,000	13,042,500	10,898,038	6,491,962	0.37
Manchester	1990	2020	21,200,000	11,024,000	13,418,129	7,781,871	0.37
Philadelphia	2006	2015	22,837,228	18,269,782	14,645,562	8,191,666	0.36
Bristol	2005	2020	2,405,000	952,476	1,556,607	848,393	0.35
London	1990	2025	45,000,000	18,000,000	29,185,354	15,814,646	0.35
New York	2005	2025	55,616,668	36,150,834	36,098,770	19,517,898	0.35
Vajxo	1993	2015	326,738	147,032	216,628	110,110	0.34
Turku	1990	2020	1,475,000	1,180,000	996,670	478,330	0.32
Sydney	2006	2030	4,536,712	1,361,014	3,103,947	1,432,765	0.32
Boston	2005	2020	7,440,000	5,580,000	5,303,306	2,136,694	0.29
Västerås	1990	2020	918,500	459,200	655,534	262,966	0.29
Taipei	2005	2030	15,500,000	11,625,000	11,383,441	4,116,559	0.27
Kaohsiung	2005	2020	64,339,200	51,471,360	48,093,338	16,245,862	0.25
Minneapolis	2006	2015	5,700,000	4,845,000	4,398,949	1,301,051	0.23
Bogota	2013	2016	16,077,576	14,469,819	12,955,113	3,122,463	0.19
Des Moines	2008	2020	2,398,445	2,134,616	1,941,149	457,296	0.19
City Vancouver	2007	2020	2,805,000	1,879,350	2,286,730	518,270	0.18
Belo Horizonte	2007	2030	3,176,966	2,541,573	2,604,905	572,061	0.18
Evanson	2005	2016	1,003,807	803,046	831,833	171,974	0.17
Boudler	2005	2050	1,949,796	389,959	1,691,777	258,019	0.13
Panaji	2013	2019	154,912	117,212	135,764	19,148	0.12

Wellington	2001	2020	1,310,705	1,179,635	1,158,445	152,260	0.12
North Vancouver	2005	2020	223,127	167,345	199,494	23,633	0.11
Seoul	2005	2020	49,467,000	37,100,250	46,684,987	2,782,013	0.06
Amsterdam	1990	2025	3,417,000	2,050,200	3,225,500	191,500.00	0.06
Umeå	1990	2018	545,003	272,502	516,523	28,480	0.05
Uppsala	1990	2020	1,289,300	709,115	1,236,427	52,873	0.04
Hamburg	1990	2020	20,727,000	10,363,500	20,270,972	456,028	0.02
Tainan	2010	2020	25,620,952	18,959,504	25,064,423	556,529	0.02
Hong Kong	2005	2020	42,000,000	21,000,000	43,187,671	-1,187,671	-0.03
Tuscon	2007	2020	7,560,728	7,560,728	8,244,058	-683,330	-0.09
Durban	2007	2040	22,186,187	16,167,499	24,256,459	-2,070,272	-0.09
Melbourne	2008	2020	4,934,000	0	5,499,624	-565,624	-0.11
Edmonton	2005	2035	15,862,000	10,310,300	17,771,850	-1,909,850	-0.12
Hiroshima	1990	2030	8,525,221	4,262,611	9,821,916	-1,296,695	-0.15
Tokyo	2000	2030	62,100,000	43,470,000	73,282,269	-11,182,269	-0.18
Yokohama	2005	2020	19,540,000	16,413,600	23,175,728	-3,635,728	-0.19
Oslo	1991	2020	1,168,000	584,000	1,394,228	-226,228	-0.19
Thane Municipality	1990	2019	2,327,233	623,723	2,969,136	-641,903	-0.28
Buenos Aires	2008	2020	11,000,720	9,900,648	15,182,523	-4,181,803	-0.38
Atlanta	2009	2020	7,656,727	6,125,382	11,568,275	-3,911,548	-0.51
Shimla	2010	2018	186,316	167,684	314,763	-128,447	-0.69
Wonju	2005	2018	1,471,393	1,088,831	2,884,307	-1,412,914	-0.96
eThekwini	2005	2020	15514200	11,480,508	40,542,645	-25,028,445	-1.61
Gwalior	2008	2018	591,963	532,767	1,690,963	-1,099,000	-1.86
Rajkot	2007	2020	882,103	451,825	3,116,947	-2,234,844	-2.53
Pimpri Chinchwad	2013	2030	1,913,797	2,098,800	8,414,379	-6,500,582	-3.40

Percents of the target has been achieved (Indicator 2)

City	Baseline year Emissions (1)	Target (emissions target to be achieved): (2)	Trend (3)	Emissions to be reduced: (1)-(2)	Baseline - Trend (actual emissions reduction based on trend):(1)-(3)	Percent of target has been achieved
Kadiovacik	655	628	358	27	297	1100%
Denver	11,800,000	9,440,000	1,994,171	2,360,000	9,805,829	415.5%
Lisbon	3,887,013	3,109,610	1,532,031	777,403	2,354,982	302.9%
Madrid	12,653,000	10,122,400	6,216,096	2,530,600	6,436,904	254.4%
Toronto	27,051,617	18,936,132	9,305,993	8,115,485	17,745,624	218.7%
Bogota	16,077,576	14,469,819	12,955,113	1,607,757	3,122,463	194.2%
Stockholm	3,668,000	2,787,680	1,979,537	880,320	1,688,463	191.8%
Philadelphia	22,837,228	18,269,782	14,645,562	4,567,446	8,191,666	179.3%
Des Moines	2,398,445	2,134,616	1,941,149	263,829	457,296	173.3%
Portland	8,989,460	5,393,676	3,037,792	3,595,784	5,951,668	165.5%

Turku	1,475,000	1,180,000	996,670	295,000	478,330	162.1%
Brussels	4,057,300	2,840,110	2,086,021	1,217,190	1,971,279	162.0%
Minneapolis	5,700,000	4,845,000	4,398,949	855,000	1,301,051	152.2%
Nagoya	17,390,000	13,042,500	10,898,038	4,347,500	6,491,962	149.3%
Kaohsiung	64,339,200	51,471,360	48,093,338	12,867,840	16,245,862	126.3%
Copenhagen	2,515,250	0	-656,761	2,515,250	3,172,011	126.1%
Wellington	1,310,705	1,179,635	1,158,445	131,070	152,260	116.2%
Boston	7,440,000	5,580,000	5,303,306	1,860,000	2,136,694	114.9%
Taipei	15,500,000	11,625,000	11,383,441	3,875,000	4,116,559	106.2%
New York	55,616,668	36,150,834	36,098,770	19,465,834	19,517,898	100.3%
Östersund	428,000	0	2,045	428,000	425,955	99.5%
Belo Horizonte	3,176,966	2,541,573	2,604,905	635,393	572,061	90.0%
Saffle	11,186,419	3,355,926	4,447,255	7,830,493	6,739,164	86.1%
Evanston	1,003,807	803,046	831,833	200,761	171,974	85.7%
Flagstaff	1,116,738	446,695	573,673	670,043	543,065	81.0%
Manchester	21,200,000	11,024,000	13,418,129	10,176,000	7,781,871	76.5%
Vajxo	326,738	147,032	216,628	179,706	110,110	61.3%
London	45,000,000	18,000,000	29,185,354	27,000,000	15,814,646	58.6%
Bristol	2,405,000	952,476	1,556,607	1,452,524	848,393	58.4%
Västerås	918,500	459,200	655,534	459,300	262,966	57.3%
City Vancouver	2,805,000	1,879,350	2,286,730	925,650	518,270	56.0%
Panaji	154,912	117,212	135,764	37,700	19,148	50.8%
Sydney	4,536,712	1,361,014	3,103,947	3,175,698	1,432,765	45.1%
North Vancouver	223,127	167,345	199,494	55,782	23,633	42.4%
Seoul	49,467,000	37,100,250	46,684,987	12,366,750	2,782,013	22.5%
Boulder	1,949,796	389,959	1,691,777	1,559,837	258,019	16.5%
Amsterdam	3,417,000	2,050,200	3,225,500	1,366,800	191,500.00	14.0%
Umeå	545,003	272,502	516,523	272,501	28,480	10.5%
Uppsala	1,289,300	709,115	1,236,427	580,185	52,873	9.1%
Tainan	25,620,952	18,959,504	25,064,423	6,661,448	556,529	8.4%
Hamburg	20,727,000	10,363,500	20,270,972	10,363,500	456,028	4.4%
Tuscon	7,560,728	7,560,728	8,244,058	0	-683,330	0.0%
Hong Kong	42,000,000	21,000,000	43,187,671	21,000,000	-1,187,671	-5.7%
Melbourne	4,934,000	0	5,499,624	4,934,000	-565,624	-11.5%
Hiroshima	8,525,221	4,262,611	9,821,916	4,262,610	-1,296,695	-30.4%
Durban	22,186,187	16,167,499	24,256,459	6,018,688	-2,070,272	-34.4%
Edmonton	15,862,000	10,310,300	17,771,850	5,551,700	-1,909,850	-34.4%
Thane Municipality	2,327,233	623,723	2,969,136	1,703,510	-641,903	-37.7%
Oslo	1,168,000	584,000	1,394,228	584,000	-226,228	-38.7%
Tokyo	62,100,000	43,470,000	73,282,269	18,630,000	-11,182,269	-60.0%
Yokohama	19,540,000	16,413,600	23,175,728	3,126,400	-3,635,728	-116.3%
Atlanta	7,656,727	6,125,382	11,568,275	1,531,345	-3,911,548	-255.4%
Wonju	1,471,393	1,088,831	2,884,307	382,562	-1,412,914	-369.3%
Buenos Aires	11,000,720	9,900,648	15,182,523	1,100,072	-4,181,803	-380.1%
Rajkot	882,103	451,825	3,116,947	430,278	-2,234,844	-519.4%
eThekwini	15514200	11,480,508	40,542,645	4,033,692	-25,028,445	-620.5%

Shimla	186,316	167,684	314,763	18,632	-128,447	-689.4%
Gwalior	591,963	532,767	1,690,963	59,196	-1,099,000	-1856.5%

3rd indicator- Emissions reduction target achievement based on trend

City	Baseline Year	Target Year	Baseline Emissions (metric tonnes)	Target emissions (metric tonnes)	Trend emissions (metric tonnes)	Level of achievement (%)
Saffle	1990	2015	638,100	191,430	163,549	85.4
Denver	1990	2020	11,800,000	9,440,000	1,994,171	78.9
Toronto	1990	2020	27,051,617	18,936,132	9,305,993	50.9
Lisbon	2002	2020	3,887,013	3,109,610	1,532,031	50.7
Portland	1990	2030	8,989,460	5,393,676	3,037,792	43.7
Kadiovacik	2011	2016	655	628	358	43
Madrid	1990	2020	12,653,000	10,122,400	6,216,096	38.6
Stockholm	1990	2020	3,668,000	2,787,680	1,979,537	29
Brussels	1990	2025	4,057,300	2,840,110	2,086,021	26.6
Philadelphia	2006	2015	22,837,228	18,269,782	14,645,562	19.8
Nagoya	1990	2020	17,390,000	13,042,500	10,898,038	16.4
Turku	1990	2020	1,475,000	1,180,000	996,670	15.5
Bogota	2013	2016	16,077,576	14,469,819	12,955,113	10.5
Minneapolis	2006	2015	5,700,000	4,845,000	4,398,949	9.2
Des Moines	2008	2020	2,398,445	2,134,616	1,941,149	9.1
Kaohsiung	2005	2020	64,339,200	51,471,360	48,093,338	6.6
Boston	2005	2020	7,440,000	5,580,000	5,303,306	5
Taipei	2005	2030	15,500,000	11,625,000	11,383,441	2.1
Wellington	2001	2020	1,310,705	1,179,635	1,158,445	1.8
New York	2005	2025	55,616,668	36,150,834	36,098,770	0.1
Belo Horizonte	2007	2030	3,176,966	2,541,573	2,604,905	-2.5
Evanston	2005	2016	1,003,807	803,046	831,833	-3.6
Tuscon	2007	2020	7,560,728	7,560,728	8,244,058	-9
Panaji	2013	2019	154,912	117,212	135,764	-15.8
North Vancouver	2005	2020	223,127	167,345	199,494	-19.2
City Vancouver	2007	2020	2,805,000	1,879,350	2,286,730	-21.7
Manchester	1990	2020	21,200,000	11,024,000	13,418,129	-21.7
Seoul	2005	2020	49,467,000	37,100,250	46,684,987	-25.8
Flagstaff	1990	2020	1,116,738	446,695	573,673	-28.4
Tainan	2010	2020	25,620,952	18,959,504	25,064,423	-32.2
Yokohama	2005	2020	19,540,000	16,413,600	23,175,728	-41.2
Västerås	1990	2020	918500	459,200	655,534	-42.7
Vajxo	1993	2015	326,738	147,032	216,628	-47.3
Durban	2007	2040	22,186,187	16,167,499	24,256,459	-50
Buenos Aires	2008	2020	11,000,720	9,900,648	15,182,523	-53.3
Amsterdam	1990	2025	3,417,000	2,050,200	3,225,500	-57.3
London	1990	2025	45,000,000	18,000,000	29,185,354	-62.1
Bristol	2005	2020	2,405,000	952,476	1,556,607	-63.4
Tokyo	2000	2030	62,100,000	43,470,000	73,282,269	-68.6
Edmonton	2005	2035	15,862,000	10,310,300	17,771,850	-72.4
Uppsala	1990	2020	1,289,300	709,115	1,236,427	-74.4
Shimla	2010	2018	186,316	167,684	314,763	-87.7
Atlanta	2009	2020	7,656,727	6,125,382	11,568,275	-88.9
Umeå	1990	2018	545,003	272,502	516,523	-89.5

Hamburg	1990	2020	20,727,000	10,363,500	20,270,972	-95.6
Hong Kong	2005	2020	42,000,000	21,000,000	43,187,671	-105.7
Sydney	2006	2030	4,536,712	1,361,014	3,103,947	-128.1
Hiroshima	1990	2030	8,525,221	4,262,611	9,821,916	-130.7
Oslo	1991	2020	1,168,000	584,000	1,394,228	-138.7
Västerås	1990	2020	919	459	1,189	-159
Wonju	2005	2018	1,471,393	1,088,831	2,884,307	-164.9
Gwalior	2008	2018	591,963	532,767	1,690,963	-217.4
eThekwini	2005	2020	15514200	11,480,508	40,542,645	-253.1
Pimpri Chinchwad	2013	2030	1,913,797	2,098,800	8,414,379	-300.9
Boulder	2005	2050	1,949,796	389,959	1,691,777	-333.8
Thane Municipality	1990	2019	2,327,233	623,723	2,969,136	-376
Rajkot	2007	2020	882,103	451,825	3,116,947	-589.9
Copenhagen	2010	2025	2,515,250	0	-656,761	
Östersund	1990	2030	428,000	0	2,045	
Melbourne	2008	2020	4,934,000	0	5,499,624	

GHG emissions reduction target achievement based on last year emissions

City	Last Measured Year	Last Year Emission	Target Year	Target (emissions target to be achieved)	Last Year emissions reduction target achievement
Lisbon	2014	1,934,361	2020	3,109,610	138
Kadiovacik	2015	444	2016	628	129
Bogota	2015	12,359,325	2016	14,469,819	115
Stockholm	2012	2,511,000	2020	2,787,680	110
Wellington	2015	1,084,979	2020	1,179,635	108
Turku	2013	1,107,500	2020	1,180,000	106
Denver	2014	8,942,000	2020	9,440,000	105
Toronto	2013	18,320,966	2020	18,936,132	103
Saffle	2010	187,016	2015	191,430	102
Minneapolis	2014	4,794,708	2015	4,845,000	101
Tuscon	2013	7567930	2020	7,560,728	100
Evanston	2014	812,660	2016	803,046	99
Madrid	2013	10,257,048	2020	10,122,400	99
Nagoya	2013	13,420,000	2020	13,042,500	97
Des Moines	2012	2,194,871	2020	2,134,616	97
Philadelphia	2012	19,212,870	2015	18,269,782	95
Boston	2014	6,066,182	2020	5,580,000	91
Belo Horizonte	2014	2,878,873	2030	2,541,573	87
Kaohsiung	2014	58,755,764	2020	51,471,360	86
Brussels	2011	3,293,000	2025	2,840,110	84
Panaji	2014	144599	2019	117212	77
North Vancouver	2015	209,721	2020	167,345	75
Seoul	2016	47,612,664	2020	37,100,250	72
Taipei	2014	14,957,404	2030	11,625,000	71
Portland	2014	6,974,544	2030	5,393,676	71
Shimla	2013	218,896	2018	167,684	69

City Vancouver	2015	2,501,218	2020	1,879,350	67
Yokohama	2013	21,950,000	2020	16,413,600	66
Manchester	2013	14,889,318	2020	11,024,000	65
New York	2014	49,385,508	2025	36,150,834	63
Durban	2014	22,587,081	2040	16,167,499	60
Vajxo	2013	207,042	2015	147,032	59
Tainan	2013	26,670,690	2020	18,959,504	59
Pimpri Chinchwad	2013	3,180,000	2030	2,098,800	48
Atlanta	2014	9,650,000	2020	6,125,382	42
Edmonton	2014	16,576,702	2035	10,310,300	39
Tokyo	2014	70,125,000	2030	43,470,000	39
Uppsala	2011	1,164,069	2020	709,115	36
Västerås	2011	760,988	2020	459,250	34
Hamburg	2014	17,572,000	2020	10,363,500	30
Wonju	2012	2,015,540	2018	1,088,831	15
Umeå	2013	521,267	2018	272,502	9
Buenos Aires	2014	19,667,128	2020	9,900,648	1
Hong Kong	2012	42,700,000	2020	21,000,000	-3
Hiroshima	2014	8,675,437	2030	4,262,611	-4
Amsterdam	2015	4,471,000	2025	2,050,200	-18
Oslo	2013	1,298,000	2020	584,000	-22
London	2013	40,190,000	2025	18,000,000	-23
Bristol	2012	2,127,000	2020	952,476	-23
Gwalior	2013	1,195,239	2018	532,767	-24
eThekwini	2014	27,991,829	2020	11,480,508	-44
Sydney	2015	3,556,529	2030	1,361,014	-61
Flagstaff	2012	1,190,809	2020	446,695	-67
Thane Municipality	2012	2,027,179	2019	623,723	-125
Rajkot	2012	1,704,380	2020	451,825	-177
Boulder	2015	1,848,741	2050	389,959	-274

*Copenhagen, Ostersund, Melburne target emissions is 0.

Annex 4: Correlation analysis

"Level of achievement GHG emissions reduction" and "Density", "City size (area km^2)", "Location", "Population", "GDP per capita", "Age composition" ("Age 0-14", "Age 15-64", "Age 65 +")

1. Correlations between "GHG emissions reduction based on trend" and "Density"

Correlations

		Reduction based on trend (% comparing to baseline)	Density
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	-.140
	Sig. (2-tailed)		.291
	N	59	59
Density	Pearson Correlation	-.140	1
	Sig. (2-tailed)	.291	
	N	59	59

P-value is .291 > .05 not significant, Pearson's Correlation -.14 is between -0.5 to 0.5 interval, No Correlation

Correlations between "GHG emissions reduction based on trend" and "City size (Area-km^2)"

Correlations

		Reduction based on trend (% comparing to baseline)	City size - Area (km2)
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	-.002
	Sig. (2-tailed)		.985
	N	59	59
City size - Area (km2)	Pearson Correlation	-.002	1
	Sig. (2-tailed)	.985	
	N	59	59

P-value .958 > .05, not significant, Pearson's Correlation -.002 is between -0.5 to 0.5 interval, No correlation

Correlations between "GHG emissions reduction based on trend" and "Population"

Correlations

		Reduction based on trend (% comparing to baseline)	Population
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	-.043
	Sig. (2-tailed)		.744
	N	59	59
Population	Pearson Correlation	-.043	1
	Sig. (2-tailed)	.744	
	N	59	59

P-value .744 > .05 not significant, Pearson's Correlation - .043 is between -0.5 to 0.5" interval, No Correlation

Correlations between "GHG emissions reduction based on trend" and "Location"

Correlations

		Reduction based on trend (% comparing to baseline)	Location
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	.286*
	Sig. (2-tailed)		.028
	N	59	59
Location	Pearson Correlation	.286*	1
	Sig. (2-tailed)	.028	
	N	59	59

*. Correlation is significant at the 0.05 level (2-tailed).
P-value .028 < .05 is significant, Pearson's Correlation is .286 , weak correlation

Correlations between "GHG emissions reduction based on trend" and "GDP per capita"

Correlations

		Reduction based on trend (% comparing to baseline)	GDP Per capita (USD)
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	.372*
	Sig. (2-tailed)		.014
	N	59	43
GDP Per capita (USD)	Pearson Correlation	.372*	1
	Sig. (2-tailed)	.014	
	N	43	43

*. Correlation is significant at the 0.05 level (2-tailed).
P-value .014 < .05 , which means that it is significant, Pearson's Correlation 0.372 is close to 0.5, which means that it is possible to assume that there is ***slight positive*** correlation between GDP per capita and emissions reduction based on trend.

Correlations between "GHG emissions reduction based on trend" and "Number of Mitigation Actions"

Correlations

		Reduction based on trend (% comparing to baseline)	Number of mitigation Actions
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	-.002
	Sig. (2-tailed)		.991
	N	59	45
Number of mitigation Actions	Pearson Correlation	-.002	1
	Sig. (2-tailed)	.991	
	N	45	45

P-value .991 > .05 not significant, Pearson's Correlation -.002 is between "-0.5 to 0.5" interval, which means that there is No correlation

Correlations between "GHG emissions reduction based on trend" and "Age 0-14"

Correlations

		Reduction based on trend (% comparing to baseline)	Age 0-14 (%)
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	-.082
	Sig. (2-tailed)		.595
	N	59	44
Age 0-14 (%)	Pearson Correlation	-.082	1
	Sig. (2-tailed)	.595	
	N	44	44

P-value .595 > .05 not significant, Pearson's Correlation -.082 is between "-0.5 to 0.5" interval, No Correlation

Correlations between "GHG emissions reduction based on trend" and "Age 15-64"

Correlations

		Reduction based on trend (% comparing to baseline)	Age 15-64 (%)
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	.032
	Sig. (2-tailed)		.837

	N	59	44
Age 15-64 (%)	Pearson Correlation	.032	1
	Sig. (2-tailed)	.837	
	N	44	44

P-value .837 > .05 not significant, Pearson's Correlation .032 is between "-0.5 to 0.5" interval, No Correlation.

Correlations between "GHG emissions reduction based on trend" and "Age 65+"

Correlations

		Reduction based on trend (% comparing to baseline)	AGE 65+ (%)
Reduction based on trend (% comparing to baseline)	Pearson Correlation	1	.047
	Sig. (2-tailed)		.764
	N	59	43
AGE 65+ (%)	Pearson Correlation	.047	1
	Sig. (2-tailed)	.764	
	N	43	43

P-value .764 > .05 not significant, Pearson's Correlation .047 is between "-0.5 to 0.5" interval, No correlation.

2. Correlations between "Percent of Target achieved" and "Density"

Correlations

		Percent of the Target achieved	Density
Percent of the Target achieved	Pearson Correlation	1	.083
	Sig. (2-tailed)		.533
	N	59	59
Density	Pearson Correlation	.083	1
	Sig. (2-tailed)	.533	
	N	59	59

P-value .533 > .05 is not significant, Pearson's Correlation .083 is between -0.5 to 0.5 interval, No Correlation

Correlations between "Percent of Target achieved" and "City size (Area-km^2)"

Correlations

		Percent of the Target achieved	City size - Area (km2)
Percent of the Target achieved	Pearson Correlation	1	-.055
	Sig. (2-tailed)		.682
	N	59	59
City size - Area (km2)	Pearson Correlation	-.055	1
	Sig. (2-tailed)	.682	
	N	59	59

P-value .682 > .05 is not significant, Pearson's Correlation -.055 is between -0.5 to 0.5 interval, No Correlation

Correlations between "Percent of Target achieved" and "Location"

Correlations

		Percent of the Target achieved	Location
Percent of the Target achieved	Pearson Correlation	1	.065
	Sig. (2-tailed)		.623
	N	59	59
Location	Pearson Correlation	.065	1
	Sig. (2-tailed)	.623	
	N	59	59

P-value .623 > .05 is not significant, Pearson's Correlation .065 is between -0.5 to 0.5 interval, No Correlation

Correlations between “Percent of Target achieved” and “Population”

Correlations

		Percent of the Target achieved	Population
Percent of the Target achieved	Pearson Correlation	1	-.022
	Sig. (2-tailed)		.871
	N	59	59
Population	Pearson Correlation	-.022	1
	Sig. (2-tailed)	.871	
	N	59	59

P-value .871 > .05 not significant, Pearson’s Correlation -.022 is between “-0.5 to 0.5” interval, No Correlation

Correlations between “Percent of Target achieved” and “GDP per capita”

Correlations

		Percent of the Target achieved	GDP Per capita (USD)
Percent of the Target achieved	Pearson Correlation	1	.342*
	Sig. (2-tailed)		.025
	N	59	43
GDP Per capita (USD)	Pearson Correlation	.342*	1
	Sig. (2-tailed)	.025	
	N	43	43

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations between “Percent of Target achieved” and “Number of Mitigation Actions”

Correlations

		Percent of the Target achieved	Number of mitigation Actions
Percent of the Target achieved	Pearson Correlation	1	-.141
	Sig. (2-tailed)		.355
	N	59	45
Number of mitigation Actions	Pearson Correlation	-.141	1
	Sig. (2-tailed)	.355	
	N	45	45

P-value .355 > .05 is not significant, Pearson’s Correlation -.141 is between “-0.5 to 0.5” interval, No Correlation

Correlations between “Percent of Target achieved” and “Age 0-14”

Correlations

		Percent of the Target achieved	Age 0-14 (%)
Percent of the Target achieved	Pearson Correlation	1	-.033
	Sig. (2-tailed)		.833
	N	59	44
Age 0-14 (%)	Pearson Correlation	-.033	1
	Sig. (2-tailed)	.833	
	N	44	44

P-value .833 > .05 not significant, Pearson’s Correlation -.033 is between “-0.5 to 0.5” interval, No Correlation

Correlations between “Percent of Target achieved” and “Age 15-64”

Correlations

		Percent of the Target achieved	Age 15-64 (%)
Percent of the Target achieved	Pearson Correlation	1	.028
	Sig. (2-tailed)		.856
	N	59	44
Age 15-64 (%)	Pearson Correlation	.028	1
	Sig. (2-tailed)	.856	
	N	44	44

P-value .856>0.05 is not significant, Pearson’s Correlation .028 is between “-0.5 to 0.5” interval, No Correlation

Correlations between “Percent of Target achieved” and “Age 65+”

Correlations

		Percent of the Target achieved	AGE 65+ (%)
Percent of the Target achieved	Pearson Correlation	1	.000
	Sig. (2-tailed)		.999
	N	59	43
AGE 65+ (%)	Pearson Correlation	.000	1
	Sig. (2-tailed)	.999	
	N	43	43

P-value .999 > .05 is not significant, Pearson’s Correlation .000 is between -0.5 to 0.5 interval, No Correlation

3. Correlations between “Emissions reduction target achieved based on trend” and “Density”

Correlations

		Level of GHG emissions target achievement (%)	Density
Level of GHG emissions target achievement (%)	Pearson Correlation	1	.312*
	Sig. (2-tailed)		.016
	N	59	59
Density	Pearson Correlation	.312*	1
	Sig. (2-tailed)	.016	
	N	59	59

*. Correlation is significant at the 0.05 level (2-tailed).

P-value .016<0.05 is significant, Pearson’s Correlation .312 is close to 0.5. With this results we can assume that there is weak correlation between variables, namely “Density” and “Level of GHG emissions target achievement”.

Correlations between “Emissions reduction target achieved based on trend” and “City size (Area-km^2)”

Correlations

		Level of GHG emissions target achievement (%)	City size - Area (km2)
Level of GHG emissions target achievement (%)	Pearson Correlation	1	-.032
	Sig. (2-tailed)		.812
	N	59	59
City size - Area (km2)	Pearson Correlation	-.032	1
	Sig. (2-tailed)	.812	
	N	59	59

P-value .291 > .05 not significant, Pearson’s Correlation -.032 is in -0.5 to 0.5 interval, No Correlation

Correlations between "Emissions reduction target achieved based on trend" and "Location"

Correlations

		Level of GHG emissions target achievement (%)	Location
Level of GHG emissions target achievement (%)	Pearson Correlation	1	-.017
	Sig. (2-tailed)		.898
	N	59	59
Location	Pearson Correlation	-.017	1
	Sig. (2-tailed)	.898	
	N	59	59

P-value .898 > .05 not significant, Pearson's Correlation -.017 is between "-0.5 to 0.5" interval, No Correlation

Correlations between "Emissions reduction target achieved based on trend" and "Population"

Correlations

		Level of GHG emissions target achievement (%)	Population
Level of GHG emissions target achievement (%)	Pearson Correlation	1	.058
	Sig. (2-tailed)		.664
	N	59	59
Population	Pearson Correlation	.058	1
	Sig. (2-tailed)	.664	
	N	59	59

P-value .664 > .05 not significant, Pearson's Correlation .058 is in "-0.5 to 0.5" interval, No Correlation

Correlations between "Emissions reduction target achieved based on trend" and "GDP per capita"

Correlations

		Level of GHG emissions target achievement (%)	GDP Per capita (USD)
Level of GHG emissions target achievement (%)	Pearson Correlation	1	-.348*
	Sig. (2-tailed)		.022
	N	59	43
GDP Per capita (USD)	Pearson Correlation	-.348*	1
	Sig. (2-tailed)	.022	
	N	43	43

*. Correlation is significant at the 0.05 level (2-tailed).

P-value .022 < .05 not significant, Pearson's Correlation -.348 is close to "-0.5", which means that there can be weak negative correlation.

Correlations between "Emissions reduction target achieved based on trend" and "Number of Mitigation Actions"

Correlations

		Level of GHG emissions target achievement (%)	Number of mitigation Actions
Level of GHG emissions target achievement (%)	Pearson Correlation	1	.056
	Sig. (2-tailed)		.717
	N	59	45
Number of mitigation Actions	Pearson Correlation	.056	1
	Sig. (2-tailed)	.717	
	N	45	45

P-value .717 > .05 not significant, Pearson's Correlation .056 is between "-0.5 to 0.5" interval, No Correlation

Correlations between “Emissions reduction target achieved based on trend” and “Age 0-14”

Correlations

		Level of GHG emissions target achievement (%)	Age 0-14 (%)
Level of GHG emissions target achievement (%)	Pearson Correlation	1	.071
	Sig. (2-tailed)		.648
	N	59	44
Age 0-14 (%)	Pearson Correlation	.071	1
	Sig. (2-tailed)	.648	
	N	44	44

P-value .648 > .05 is not significant, Pearson’s Correlation 0.071 is between -0.5 to 0.5 interval, No Correlation

Correlations between “Emissions reduction target achieved based on trend” and “Age 15-64”

Correlations

		Level of GHG emissions target achievement (%)	Age 15-64 (%)
Level of GHG emissions target achievement (%)	Pearson Correlation	1	.017
	Sig. (2-tailed)		.914
	N	59	44
Age 15-64 (%)	Pearson Correlation	.017	1
	Sig. (2-tailed)	.914	
	N	44	44

P-value .914 > .05 not significant, Pearson’s Correlation .017 is between “-0.5 to 0.5” interval, No Correlation

Correlations between “Emissions reduction target achieved based on trend” and “Age 65+”

Correlations

		Level of GHG emissions target achievement (%)	AGE 65+ (%)
Level of GHG emissions target achievement (%)	Pearson Correlation	1	-.085
	Sig. (2-tailed)		.588
	N	59	43
AGE 65+ (%)	Pearson Correlation	-.085	1
	Sig. (2-tailed)	.588	
	N	43	43

P-value .588 > .05 not significant, Pearson’s Correlation -.085 is between “-0.5 to 0.5” interval, No Correlation

Annex 5: T-Test results

Group Statistics

	C40 cities	N	Mean	Std. Deviation	Std. Error Mean
Reduction based on trend (% comparing to baseline)	C40	19	.2337	.38584	.08852
	NO	40	-.1152	.86820	.13727

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Reduction based on trend (% comparing to baseline)	Equal variances assumed	2.843	.097	1.669	57	.101	.34893	.20902	-.06961	.76748
	Equal variances not assumed			2.136	56.871	.037	.34893	.16334	.02184	.67603

CoM

Group Statistics

	CoM cities	N	Mean	Std. Deviation	Std. Error Mean
Reduction based on trend (% comparing to baseline)	CoM	16	.3419	.40266	.10067
	NO	43	-.1312	.82525	.12585

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Reduction based on trend (% comparing to baseline)	Equal variances assumed	1.926	.171	2.189	57	.033	.47304	.21609	.04033	.90574
	Equal variances not assumed			2.935	52.622	.005	.47304	.16116	.14974	.79633

Levine's test shows that P-value 0.171>0.05, then we must look to top results for t, as Sig. (2-tailed) is 0.033, which is smaller than 0.05, then the test is significant.

If p<0.05, then variances are significantly different, and must be interpreted the bottom row of results for t.

If p>0.05, then variances are not significantly different, and must be interpreted the top row of results for t.

Group Statistics

	ICLEI cities	N	Mean	Std. Deviation	Std. Error Mean
Reduction based on trend (% comparing to baseline)	ICLEI	44	-.0825	.84949	.12807
	NO	15	.2307	.32925	.08501

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Reduction based on trend (% comparing to baseline)	Equal variances assumed	2.710	.105	-1.386	57	.171	-.31317	.22593	-.76559	.13926
	Equal variances not assumed			-2.037	55.904	.046	-.31317	.15371	-.62110	-.00523

P-value =0.105, 0.105>0.05, => 0.171>0.05 t-test is not significant

Member of more than one network

Group Statistics

	Member of more than one climate network	N	Mean	Std. Deviation	Std. Error Mean
Reduction based on trend (% comparing to baseline)	Yes	25	.2524	.35422	.07084
	NO	34	-.1906	.91795	.15743

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Reduction based on trend (% comparing to baseline)	Equal variances assumed	5.787	.019	2.287	57	.026	.44299	.19372	.05506	.83091
	Equal variances not assumed			2.566	45.172	.014	.44299	.17263	.09532	.79065

Group Statistics

	C40 cities	N	Mean	Std. Deviation	Std. Error Mean
Percent of the Target achieved	C40	19	53.526	147.2094	33.7722
	NO	40	68.008	691.2431	109.2951

As SD is big then T-Test was not conducted.

Annex 6: Last year emissions per capita

City	Baseline emissions per capita (metric tonnes)	Target year emissions per capita (metric tonnes)	Trend emissions per capita (metric tonnes)	Last year emissions per capita (metric tonnes)
Sydney	1.2	0.2	0.6	0.8
Melbourne	1.3	0.0	1.2	1.0
Thane Municipality	2.9	0.2	1.2	1.1
Gwalior	0.3	0.2	0.6	1.1
Belo Horizonte	1.3	0.9	1.0	1.1
Panaji	0.9	0.4	0.5	1.3
Shimla	1.1	0.8	1.6	1.3
Rajkot	1.1	0.2	1.5	1.3
Bogota	2.1	1.8	1.6	1.6
Pimpri Chinchwad	1.1	0.8	3.2	1.8
Oslo	1.7	0.5	1.3	2.0
Vajxo	4.6	2.1	2.5	2.3
North Vancouver	2.7	1.9	2.2	2.3
Copenhagen	4.7	0.0	-1.0	2.5
Wellington	3.7	2.8	2.7	2.7
Brussels	4.2	2.3	1.7	2.8
Stockholm	5.5	2.7	1.9	2.9
Madrid	4.2	3.3	2.0	3.2
Lisbon	6.9	5.8	2.9	3.6
City Vancouver	4.8	3.1	3.8	3.8
Nagoya	8.1	5.7	4.8	4.1
Umeå	6.0	2.2	4.1	4.3
Seoul	5.0	3.7	4.7	4.8
Bristol	6.1	2.1	3.4	4.8
London	6.7	2.0	3.2	4.8
Tokyo	4.9	3.0	5.0	5.2
Östersund	7.3	0.0	0.0	5.4
Amsterdam	4.9	2.2	3.5	5.4
Manchester	9.3	4.0	4.9	5.4
Västerås	7.8	3.0	4.2	5.5
Taipei	5.9	4.3	4.2	5.6
New York	6.9	4.0	4.0	5.8
Uppsala	8.4	3.2	5.5	5.9
Yokohama	5.5	4.4	6.3	5.9
Hong Kong	6.2	2.8	5.7	6.0
Turku	9.2	6.2	5.2	6.1
Wonju	5.2	3.1	8.2	6.2

Durban	6.6	4.0	6.0	6.4
Buenos Aires	3.9	3.1	4.8	6.6
Toronto	11.8	6.5	3.2	6.7
Hiroshima	7.8	3.8	8.7	7.3
eThekwini	4.8	3.0	10.7	8.1
Boston	12.2	7.9	7.5	9.2
Hamburg	12.8	5.7	11.1	10.1
Des Moines	12.1	9.3	8.5	10.5
Evanson	13.2	10.7	11.1	10.7
Portland	18.5	7.1	4.0	11.3
Minneapolis	15.2	11.3	10.3	11.8
Saffle	35.5	12.5	10.6	12.2
Philadelphia	15.2	11.7	9.3	12.4
Denver	24.2	12.4	2.6	13.5
Tainan	13.7	10.0	13.3	14.1
Tuscon	14.1	14.1	15.4	14.3
Flagstaff	24.2	6.0	7.7	17.0
Boudler	20.1	2.5	10.9	17.5
Edmonton	18.3	7.7	13.2	17.9
Kaohsiung	23.4	18.5	17.3	21.1
Atlanta	14.2	12.1	22.9	21.2

Annex 7: The results of correlation and T-Test analysis (emissions reduction per capita)

Density

Correlations

		Trend emissions per capita	Density
Trend emissions per capita	Pearson Correlation	1	-.316*
	Sig. (2-tailed)		.016
	N	58	58
Density	Pearson Correlation	-.316*	1
	Sig. (2-tailed)	.016	
	N	58	59

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

		Last year emissions per capita	Density
Last year emissions per capita	Pearson Correlation	1	-.344**
	Sig. (2-tailed)		.008
	N	59	59
Density	Pearson Correlation	-.344**	1
	Sig. (2-tailed)	.008	
	N	59	59

**. Correlation is significant at the 0.01 level (2-tailed).

Location

Correlations

		Reduction based on trend per capita (% comparing to baseline)	Location
Reduction based on trend per capita (% comparing to baseline)	Pearson Correlation	1	.362**
	Sig. (2-tailed)		.005
	N	58	58
Location	Pearson Correlation	.362**	1
	Sig. (2-tailed)	.005	
	N	58	59

**. Correlation is significant at the 0.01 level (2-tailed).

GDP per capita

Correlations

		Reduction based on trend per capita (% comparing to baseline)	GDP Per capita USD
Reduction based on trend per capita (% comparing to baseline)	Pearson Correlation	1	.382*
	Sig. (2-tailed)		.011
	N	58	44
GDP Per capita USD	Pearson Correlation	.382*	1
	Sig. (2-tailed)	.011	
	N	44	44

*. Correlation is significant at the 0.05 level (2-tailed).

Location

Correlations

		Percent of the emission reduction target achieved! (per capita)	Location
Percent of the emission reduction target achieved! (per capita)	Pearson Correlation	1	.292*
	Sig. (2-tailed)		.026
	N	58	58
Location	Pearson Correlation	.292*	1
	Sig. (2-tailed)	.026	
	N	58	59

*. Correlation is significant at the 0.05 level (2-tailed).

Annex 8: T-Test results, emissions per capita

C40

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Trend emissions per capita	Equal variances assumed	13.009	.001	-2.111	56	.039	-2.7050	1.2816	-5.2723	-.1376
	Equal variances not assumed			-2.679	55.727	.010	-2.7050	1.0096	-4.7277	-.6823

CoM

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Trend emissions per capita	Equal variances assumed	7.296	.009	-2.407	56	.019	-3.2046	1.3311	-5.8711	-.5381
	Equal variances not assumed			-3.123	49.709	.003	-3.2046	1.0263	-5.2662	-1.1430

Member more than one network

Last Year emissions per capita
C40

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Last year emissions per capita	Equal variances assumed	11.457	.001	-1.601	57	.115	-2.3089	1.4421	-5.1967	.5788
	Equal variances not assumed			-1.984	56.587	.052	-2.3089	1.1640	-4.6402	.0223

CoM

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Last year emissions per capita	Equal variances assumed	15.339	.000	-2.039	57	.046	-3.0494	1.4958	-6.0447	-.0541
	Equal variances not assumed			-2.987	56.866	.004	-3.0494	1.0207	-5.0935	-1.0053

Member more than one network

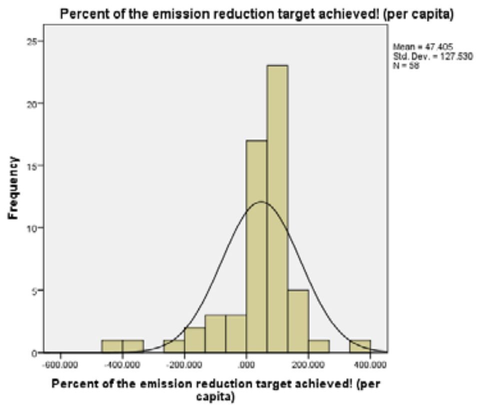
Independent Samples Test

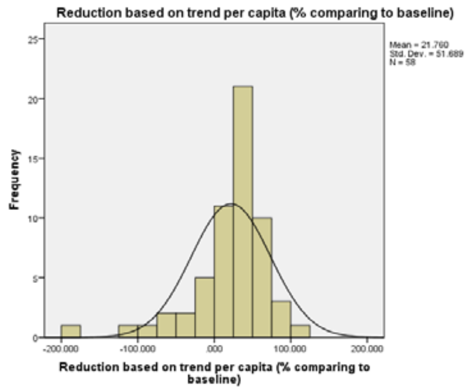
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Last year emissions per capita	Equal variances assumed	15.796	.000	-2.410	57	.019	-3.2004	1.3279	-5.8595	-.5413
	Equal variances not assumed			-2.653	50.426	.011	-3.2004	1.2062	-5.6226	-.7781

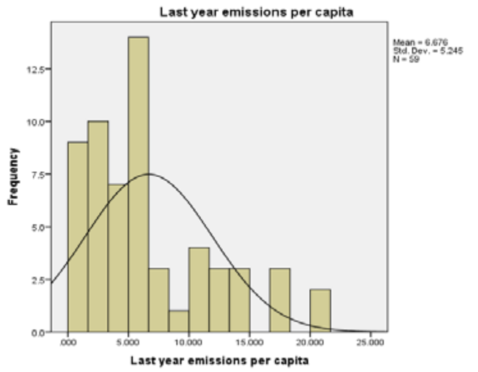
Independent Samples Test

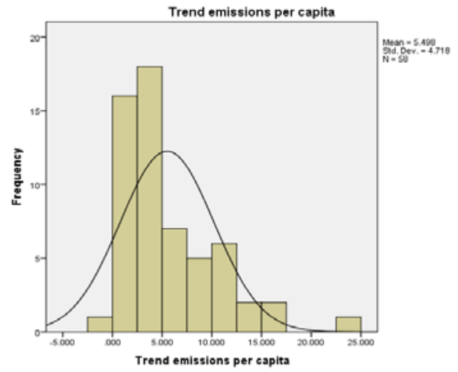
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Trend emissions per capita	Equal variances assumed	13.391	.001	-2.809	56	.007	-3.3188	1.1815	-5.6856	-.9519
	Equal variances not assumed			-3.071	48.103	.004	-3.3188	1.0807	-5.4916	-1.1459

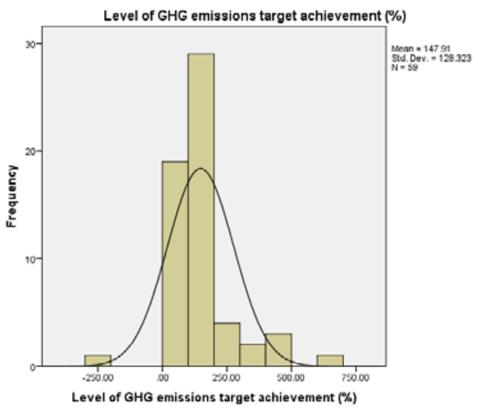
Annex 9: The results of normality test, histograms

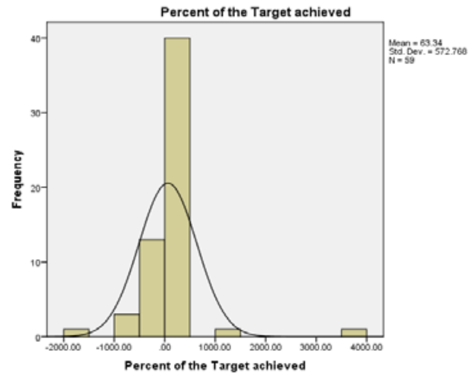


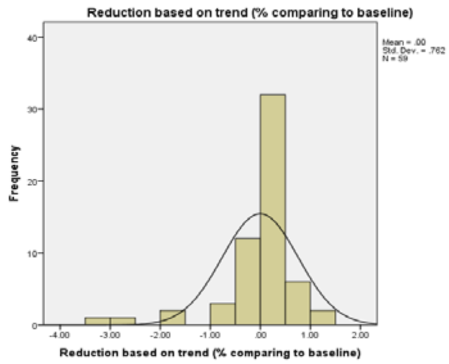










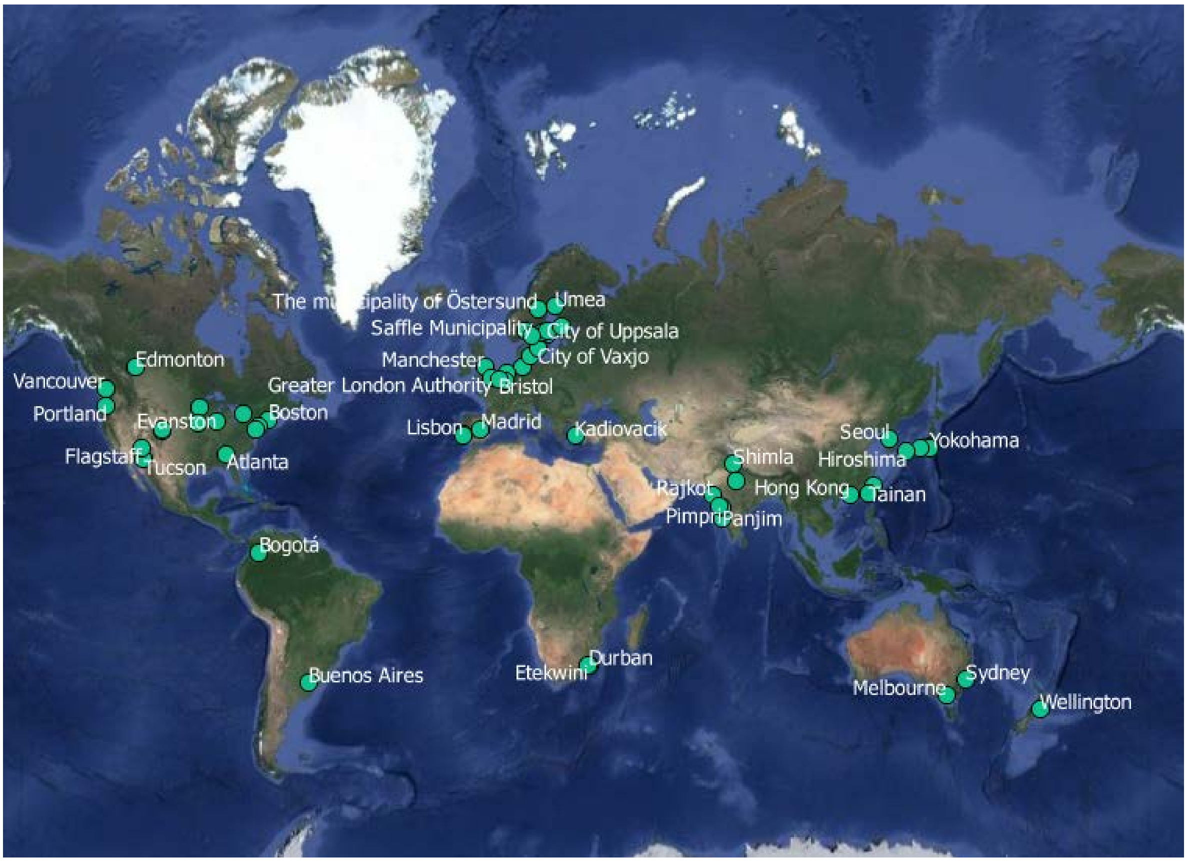


Annex 10: List of cities, World map with 59 cities

Continent	Country	City
Europe		
	Germany	Hamburg
	Denmark	Copenhagen
	Netherlands	Amsterdam
	Norway	Oslo
	Sweden	Stockholm
	Sweden	City of Vaxjo
	Sweden	City of Västerås
	Sweden	City of Uppsala
	Sweden	Saffle Municipality
	Sweden	The municipality of Östersund
	Sweden	Umea
	Finland	Turku
	United Kingdom	Manchester
	United Kingdom	Greater London Authority
	United Kingdom	Bristol
	Portugal	Lisbon
	Turkey	Kadiovacik
	Belgium	Brussels
	Spain	Madrid
Latin America	Brazil	Belo Horizonte
	Colombia	Bogotá
	Argentina	Buenos Aires
North America	Canada	Vancouver
	Canada	North Vancouver
	Canada	Toronto
	Canada	Edmonton
	USA	Boston
	USA	Minneapolis
	USA	Portland
	USA	New York City
	USA	Philadelphia
	USA	Denver
	USA	Atlanta
	USA	Tucson
	USA	Flagstaff
	USA	Evanston
	USA	Boulder
	USA	Des Moines
Asia	Taiwan	Taipei
	Taiwan	Kaohsiung
	Taiwan	Tainan
	South Korea	Seoul

	South Korea	Wonju
	Japan	Tokyo
	Japan	Yokohama
	Japan	Nagoya
	Japan	Hiroshima
	Hong Kong	Hong Kong
	India	Rajkot
	India	Shimla
	India	Gwalior
	India	Panjim
	India	Pimpri
	India	Thane
Africa	South Africa	Durban
	South Africa	Etekwini
Australasia	Australia	Sydney
	Australia	Melbourne
	New Zealand	Wellington

World map with 59 cities including in thesis sample



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