Urban GHG inventories, target setting and mitigation achievements: How German cities fail to outperform their country

Abstract

Cities across the globe, and mainly in developed countries, have conducted GHG emission inventories and set emission targets as part of their climate protection activities. Based on official information material and questionnaire data from 40 cities this study analyses local GHG inventorying and urban emission trends in Germany.

All cities do inventories or are preparing inventories. Comparability of reporting data between cities is limited due to varying methodologies and frequency. Many cities have also adopted ambitious emission targets. However, most cities in Germany do not use their GHG reporting and emission targets as meaningful GHG management tools: The majority of targets are not city-specific and almost half of cities do not report base year emissions. Urban mitigation performance is limited. It is correlated to the overall German mitigation performance, which differs significantly between Eastern and Western German 'Laender': Eastern German cities clearly outperform Western German cities because of 'wall-fall profits' in the 1990s. No single Western German city is on course to reach its emission target.

Regular emission reporting based on city-specific data and a uniform reporting format would enable cities to set realistic targets and control for target achievement. Other policy levels could provide funding, make reporting obligatory, and collect cities' inventories in a common and comparable database. City networks could accompany and inform this process.

Keywords: Cities; climate policy; mitigation; GHG inventories; emission reporting; GHG management; emission targets; Germany

1. Introduction

Cities play an important role for the implementation of many greenhouse gas (GHG) mitigation activities. Urban processes like energy use, transport, industrial production or waste management are major drivers for global carbon emissions (Angel et al. 1998, Satterthwaite 2008). The city-specific structure of such processes may be revealed but by local emission inventories (as opposed to national level inventories) (Easterling et al. 1998). Understanding local emission patterns, including urban form, is a precondition for the development of low carbon communities (e.g. Kates et al. 1998; VandeWeghe, Kennedy 2007). Many cities of the world have carried out emission inventories, and recent literature compares the carbon footprint of large cities or metropolitan areas (e.g. Sovacool, Brown 2010; Kennedy et al. 2010). UNEP, World Bank and UN Habitat have recently presented a standard for urban GHG emission reporting at the World Urban Forum (UNEP et al. 2010). The city network ICLEI has presented its proposal for such a standard, too (ICLEI 2009).

Over the last two decades, many cities have become engaged in climate protection activities (e.g. Kousky, Schneider 2003; Qi et al. 2008; Sugiyama, Takeuchi, 2008; Wheeler 2008). However, cities' GHG reductions may also rather be a side effect of local air quality management (D'Avignon et al. 2010). The adoption of GHG emission targets seems to have become common among cities, with more than two thousand cities worldwide having adopted targets (ICLEI, City of Copenhagen 2010). This article analyses the practice of urban GHG emission reporting and target setting in Germany. It focuses on the following research questions:

- Do cities conduct GHG emissions inventories, and how?

- Have cities adopted targets, and what type of targets?
- What are cities' emission trends and how do they perform in terms of target achievement?

2. Research Design

The study focuses on 80 cities in Germany with more than 100,000 inhabitants. In a first step, information was collected in a web-based research. In a second step, a questionnaire was sent out to all 80 cities via e-mail in October/November 2009. The following major elements were included in the questionnaire (in this order): questions on (1) GHG mitigation activities by the city, on (2) GHG reporting activities, on (3) emission targets, and on (4) motivation and barriers for mitigation activities. This article focuses on elements (2) and (3). The questionnaire was addressed to the official contact person for climate or environmental activities in the city administration. 50% or 40 of the cities answered to the questionnaire. They build the basis for the analysis underlying this article. These 40 cities represent 13 million citizens or 16% of the German population. Their size ranges from 103,392 (City of Jena) to 1,770,381 (City of Hamburg) inhabitants, and they are located in 13 of Germany's 16 federal states ('Laender').

3. Results

3.1 GHG Inventories: Popular, but hardly comparable

Urban emission inventories can provide an overview of relevant local carbon emissions and their sources. Based on this knowledge, mitigation potentials can be calculated, mitigation action plans developed and emission targets set (Bennet, Newborough 2001). Furthermore, regular emission reporting reveals a city's emission trends, which is a precondition for the evaluation of local mitigation policies (Fleming, Webber 2004). Consequently, reporting of greenhouse gas emissions is recommended and facilitated by city networks like ICLEI (2009) or Climate Alliance (2009), research networks like the Urban and Regional Carbon Management Initiative (Dhakal, Betsill 2007) as well as by subnational, national or international supporting policies (BMU 2010). However, German national legislation does not require cities to take action on climate change and GHG reporting is a voluntary task for German cities (Bulkeley, Kern 2006). Climate change policy development is probably but one reason for GHG reporting. Other reasons may include reputation or internal and external pressure (Sippel, Jenssen 2010).

All cities in the survey have either conducted emission inventories (75%) or are currently preparing an inventory (25%). Figure 1 shows that earliest urban emission reporting data is available for 1987. A vast majority of cities present their 1990 emissions as earliest emission data. It is not always clear, whether cities actually reported emissions in that year, or calculated back emissions for 1990 from later reporting data. A smaller group of cities is currently about to start emission reporting, probably encouraged by federal funding under 'Germany's Climate Initiative'. There is a cluster of emission data for 1990, 1995, 2000, and 2005. The most recent emission inventory is usually not older than 5 years.

→ *Insert Figure 1 around here*

77% of cities that have been conducting emission inventories have reported emissions in three or more years, which indicates there is some regularity to their habit. Over an average reporting period of almost 12 years, the average frequency of emission reporting has been 3.4 years. However, frequency of emission reporting is highly city-specific and often reporting activities do not follow a stringent pattern. A group of cities are reporting emissions in intervals of about 5-6 years. Another group of cities have been reporting emissions annually. The latter partly rely on readily available but less city-specific aggregated emission data.

Previous research suggests that comparability of cities' emission data may be limited. Dodman (2009) explains that some cities report emissions from urban production and thus include emissions that are generated within a city's boundaries ('territorial' approach). This excludes emissions linked to imported electricity, while it includes emissions from the production of export electricity. To a differing degree, other cities in the international context were found to report emissions from urban consumption and attribute emissions to end users. These cities may have included emissions from imported electricity or district heating, exported waste, or in some cases also from the production processes of fuels, building materials or food (Kennedy et al. 2009). Though embodied or indirect energy consumption may be significant (Schulz 2010; Troy et al. 2003), modelling the urban carbon metabolism is highly complex, and up to now limited to a few case studies worldwide (Sahely et al. 2003; Wackernagel et al. 2006).

In the survey, about a quarter of reporting cities specified they report emissions from urban production, while the remaining 76% report emissions from urban consumption. However, definitions offered by cities for production or consumption based inventories varied significantly and are sometimes overlapping. Methodologies applied have also differed for source categories and gases. While energy emissions are often calculated on a consumption basis, a territorial approach is frequently used for transport. Usually, emissions from energy and transport include carbon emissions only, while emissions from waste also include methane. Some cities have at some point in time changed the methodology of their emission reporting, which renders the evaluation of their emission trends difficult.

The lack of comparability in urban emission reporting also relates to the different sectors which are included under GHG reporting. By including emissions from energy (97%) and transport (91%), a vast majority of cities cover the two most important source categories of GHG emissions in Germany: Energy and transport are responsible for more than 80% of German GHG emissions (Umweltbundesamt 2009). As there is often little agricultural activity in cities, the 85% of cities which do not report emissions from land use may not be leaking too many emissions. Depending on the prevalence of certain types of industries in a city, emissions from industrial processes can be significant (Carney et al. 2009) and their exclusion from urban inventories by 97% of cities may be misleading. GHG emissions from waste are clearly linked to cities and their inhabitants, but currently included in only 38% of urban emission inventories. As a subcategory of emissions from energy, 88% of cities include emissions from municipal buildings in their inventories. This is probably due to the fact that firstly, city administrations can access this data easily, and secondly, municipal energy use is often controlled for, as it is linked to direct costs for the municipal budget.

The annex provides an overview of cities, methodologies they use for emission reporting, sectors included, and reporting periods covered.

3.2 GHG Reduction Targets: Often not verifiable

Theoretically, targets for urban GHG emission pathways are the basis for quality control of mitigation activities. In addition, the adoption of concrete reduction targets may demonstrate a city's commitment to the climate issue.

According to the survey, 80% of cities have adopted emission targets, and further 10% are currently preparing a target. This leaves 10% of cities without target. 1990 is the common base year for 25 out of 32 cities that have adopted emission targets. By referring to 1990, cities follow international and national practice in climate target setting (EU 2008, Michaelowa 2003, UNFCCC 1998).

Cities' targets are often externally influenced: The most popular among cities' targets is the one promoted by the international city network Climate Alliance. It requires cities to reduce emissions by 50% by 2030 as compared to 1990 levels (Climate Alliance 2006) and cities adopt the target quasi automatically by joining the network. About a quarter of cities' emission targets equal the current German target of 40% emission reductions by 2020 as compared to 1990 levels. A reason for this may be that some recent federal funds for municipal climate protection programs were conditional on cities adopting the German emission target (Wuppertal Institute 2009). Three cities have adopted the European target of 20% emission reduction from 1990 to 2020. In sum, almost 3 out of 4 cities with targets have adopted targets which are not city-specific, and probably not derived from an analysis of mitigation options.

On average, cities' reduction target is -1.44% per year. Cities' average target is more ambitious than the German target (-1.33%). Furthermore, it is in line with what the IPCC summarizes to be targets for Annex I countries in order to achieve a stabilization level of 450ppm of CO_2eq (25-40% reduction from 1990 to 2020 =

0.83% to -1.33%; 80-95% reduction from 1990 to 2050 = -1.33% to -1.58%) (IPCC 2007, box 13.7).

Cities that report emissions seem to be more likely to adopt emission targets: 83.3% of reporting cities also do have targets as compared to 60% of cities without emission reporting. Strangely, the adoption of emission targets seems not to be conditional on a city measuring its GHG emissions on a regular base. 20% of cities with emission targets do not even perform basic emission reporting (defined as at least two emission inventories conducted). Almost half of cities that do have targets and report emissions did not present base year emission data – neither on their website nor in the questionnaire. The lack of baseline year emission data seems not to be limited to cities in the survey: The overwhelming majority of 386 German cities in the ‘Cities Climate Catalogue’ that are listed with emission targets, seem to refrain from GHG emission reporting (ICLEI, City of Copenhagen 2010). The question arises, whether and how these cities want to evaluate target achievement.

3.3. Emission Trends: Following national patterns

Emission pathways may be highly city-specific and depend on a variety of factors, such as changing political support for climate policies or investment cycles of energy infrastructures. In this study, for simplification and for evaluation of the overall emission reductions a city has achieved, a linear emission pathway between the earliest and the latest emission data available in a city was assumed: Average annual emission development for the time period covered by emission reporting was calculated as a percentage of emission levels in the first reporting year.

Annual emission development in the cities analysed varies between an annual increase of +1.09% and a decrease of -6.81%. On average, the 25 cities where emission reporting covered a period of at least 5 years have reduced emissions at -1.31% each year. This is slightly less than the average annual German reduction, which was -1.35% from 1990 to 2005 (UBA 2009). In general, the mitigation performance of Eastern German cities (-3.01%) is far better than that of Western German cities (-0.65%). This correlates to the better mitigation performance of Eastern German 'Laender' (-2.77%) as compared to Western German 'Laender' (-0.26%) (UBA 2009). Figure 2 shows a tendency that yearly emission reductions have been higher in the early phase of emission reporting.

→ *Insert Figure 2 around here*

Other factors have been analysed for their potential correlation with mitigation performance. Cities that hold control over local energy utilities perform better (-1.66%), than cities that do not (-0.75%). One reason for this may be that these municipalities can influence a city's energy infrastructure in a 'climate-friendly' way via the local energy utility. Furthermore, municipalities with control over local energy utilities have taken the decision not to fully privatise them. They may thus have had more ownership for the energy issue from the beginning – which then translated into emission reductions. Neither existence of mitigation action plans, nor institutionalization of climate protection in the city administration, or membership to city networks were clearly linked to the mitigation performance of a city.

3.4 Target Achievement: Mostly at risk

To analyse whether cities are on course to reach their GHG targets, it was controlled whether a city's current emission levels are above or beyond a linear reduction pathway from base year emissions to target year emissions. Figure 3 illustrates this approach for the Cities of Fürth and Dresden. The diagram shows that the actual 2005 emissions of Fürth lie above the required emission pathway. As a conclusion, Fürth is considered to be not on course to reach its emission target.

→ *Insert Figure 3 around here*

For cities that do not present emissions for their base year, emissions from later years were calculated back to the base year (based on average emission trends in the according 'Land' over the interpolating period). For some cities, available emission data was not sufficient to analyse emission performance in terms of target achievement. Evaluation was possible for 23 out of 31 cities that do have emission targets.

→ *Insert Figure 4 around here*

Out of these 23 cities, seven are on course to reach their target. Interestingly, all seven cities are located in the new 'Laender' in Eastern Germany. In Western Germany, not a single city is on course to reach its emission target (see Figure 4), though Hamburg is just on course if measured in per-capita emissions. No clear link could be found between the ambitiousness of a target (in terms of required annual emission reductions) and target achievement.

The seemingly good performance of Eastern German cities is similar to emission trends of Eastern Germany as a whole: German Reunification caused a breakdown and restructuring of the Eastern German economy, which resulted in remarkable emission reductions in the 1990s (Schleich et al. 2001). These ‘wall-fall profits’ were mainly a result of the special circumstances, and not of climate policies.

Figure 3 also presents a reduction curve typical for the Eastern German cities analysed. Due to significant emission reductions in the 1990s, current emission levels in Dresden are well below its target pathway towards 2030, and Dresden is thus considered to be on course to reach its emission target. However, emission levels have been stagnating since the late 1990s. If this trend continues, Dresden will still fail to meet its reduction target.

4. Conclusion

It can be concluded that GHG inventorying in large cities in Germany is popular. Three quarters of cities in the survey have reported emissions, at average intervals of 3-4 years. However, emission data from different cities is hardly comparable, because frequency of and methodologies used for emission inventories vary significantly and sometimes data quality may be poor.

A large part of cities has also adopted emission targets, and cities’ ambitions are high (according to IPCC categories). However, the combination of GHG reporting and target setting has not been broadly understood as a tool for GHG management: The majority of targets are not city-specific, and almost half of cities with targets do not publish base year emission data. For example, many cities adopted the German target (-40% from 1990 to 2020), neglecting the fact that a lot of German emission reductions happen(ed) in the industry sector which is small in some of these cities. Furthermore, many of these cities do not include emissions from waste management and industrial processes in their reporting – ignoring that they exclude two source categories, where Germany has achieved significant emission reductions towards its target (Umweltbundesamt 2009).

Some randomness of cities' target setting is also illustrated by the example of Stuttgart in Table 1. The city adopted differing targets in subsequent years – depending on its membership in a city network, realization of insufficient mitigation performance, and funding opportunities. The city's reaction to not being on course to reach its target seems more likely to be the revision of its target, than the revision of its mitigation policies.

→ *Insert Table 1 here*

Overall mitigation performance of German cities is limited, and correlated to national mitigation performance. On average urban emission trends show a -0.65% annual reduction in Western German cities and are thus not suitable to contribute to achieving low global CO_2 stabilization levels. Mitigation performance of Western/Eastern German cities does not differ much from that of Western/Eastern German 'Laender'.

Yearly emission reductions are higher in the early phase of emission reporting. There may be different reasons for this: Emission reporting may mark the beginning of a city’s mitigation activities, and in the early years of mitigation, cities may be able to realize so-called ‘low hanging fruits’ rather quickly. It is probably often later on, that climate activities start to touch controversial policy issues. Human reluctance to change and path dependency (e.g. of energy infrastructures) may slow down political enthusiasm. Furthermore, political support for mitigation activities may decline, with electoral cycles or with a new mayor setting other priorities.

It can be concluded that target achievement is at serious risk in all Western German cities, and also in Eastern German cities that rely solely on their ‘wall fall’ profits for target achievement. Certain barriers may prevent cities from more meaningful achievements (Sippel, Jenssen 2010), however these are not subject to this article.

The findings are based on a careful analysis of data provided by cities. Nevertheless, this is a cross-sectional survey, and it cannot be ruled out that a detailed look on some individual city may reveal a difference to results presented.

5. Recommendations

The results of the survey may provide guidance for urban GHG management and lead to some preliminary policy recommendations:

Firstly, there is significant room for cities to improve their practice of GHG inventorying. If cities would report emissions regularly and based on a common reporting format and city-specific data, emission data would be comparable and illustrate city-specific emission trends.

Secondly, cities should probably revise their targets. In order to make GHG targets a component of urban GHG management, targets need to be realistic and derived from city-specific mitigation potentials.

Thirdly, cities should use the results of GHG reporting to correct their mitigation policies – and not their emission targets.

Last but not least, city networks and other policy levels play an important role. They can support and establish a common GHG emission reporting format, such as the ones proposed by UNEP, UN-HABITAT and the World Bank or by ICLEI. The German federal government could make urban emission reporting obligatory, starting with cities of more than 100,000 inhabitants (which would cover about 30% of the German population). A national collection of cities' inventories would make emission performance comparable.

If cities start to use GHG targets and reporting as management tools for their mitigation activities, they may benefit at least twofold: Policy evaluation may not only lead to improved mitigation policies, but also increase credibility. This seems essential for municipalities whose climate performance depends largely on meaningful interaction, be it with local stakeholders or other policy levels.

This study did not analyse underlying reasons for cities' mitigation performance systematically. Knowledge about such reasons may further improve the understanding of local climate protection and thus inform policy-making. Therefore, future research may want to analyse, e.g. whether specific sectors (such as industry or commercial) have an influence, what role municipal buildings play (the sector where municipalities have most control), or whether and how cities have operationalized climate strategies and integrated them into their urban development plans.

Acknowledgement:

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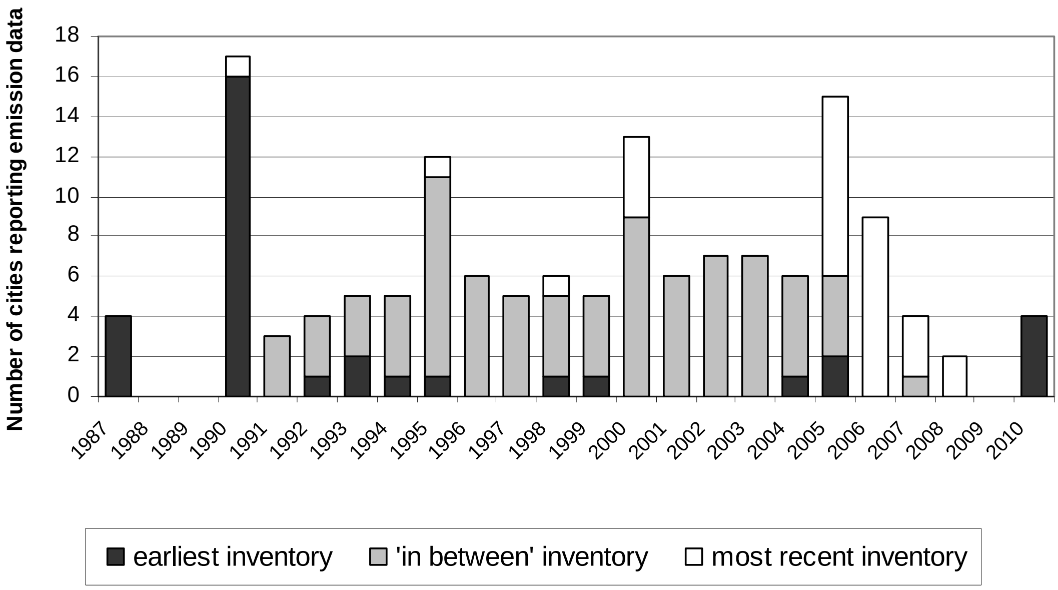
Annex

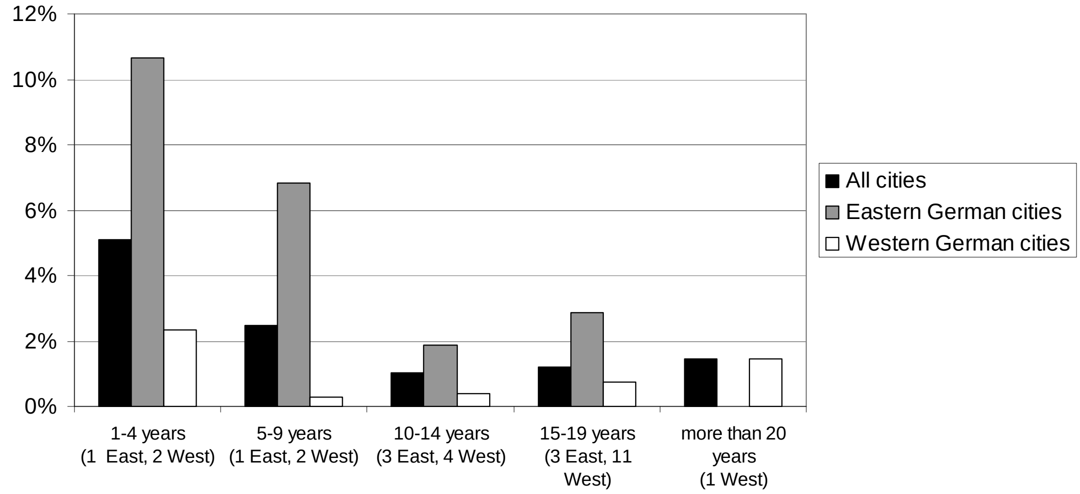
	Reduction target	Base year	Target year	on course to reach target?	Target achievement (with current emission trends)	Emission reporting?	earliest inventory	most recent inventory	Frequency of reporting (every x years)	consumption based	Production based	Energy	Transport	Public buildings	Waste	Land use	Industrial processes	per capita CO2-Emissions (tCO2/a)
Augsburg	50%	1990	2030	no	2376	yes	1990	2006	2,1	x		x	x	x				7.6 (2005)
Bielefeld	40%	1987	2020			yes	2004	2006	1,0		x	x	x	x	x	x		5.6 (2005)
Bochum	not spec.	1990	2020			yes	1999	2005	2,3		x	x	x	x	x	x		10.5 (2005)
Bonn	50%	1990	2030	no	2144	yes	1987	2000	4,7	x		x	x	x	x			
Bottrop						in preparation												
Bremen	40%	1990	2020	no	2062	yes	1990	2005	5,3		x	x	x					21.3 (2005)
Chemnitz	50%	1990	2030	no	2039	yes	1990	2005	4,0	x		x	x	x				7.5 (2005)
Dresden	50%	1990	2030	yes	2022	yes	1993	2006	1,3	x		x	x	x				9.9 (2005)
Duisburg	40%	1990	2020			in preparation	2010											
Düsseldorf	10%	2007	2012			yes	1987	2007	3,5		x	x	x	x				10.7 (2005)
Erfurt	50%	1993	2010	yes	2000	in preparation	1993	2000	2,7		x	x	x	x				
Frankfurt am Main	50%	1990	2030	no	2132	yes	1995	2005	5,5	x		x	x	x	x			12.6 (2005)
Fürth	20%	1990	2020	no	never	yes	1990	2005	4,0	x		x	x	x	x			7.7 (2005)
Hagen	50%	1990	2030			yes	1990	1990	1,0	x		x	x	x				
Halle (Saale)	50%	1990	2030	yes	2003	yes	1994	2006	4,3	x		x	x	x				4.5 (2006)
Hamburg	80%	1990	2050	no	2061	yes	1990	2006	3,4	x		x	x		x	x	x	10.3 (2005)
Hannover	40%	1990	2020	no	2058	yes	1990	2005	8,0		x	x	x	x	x			9.8 (2005)
Herne						yes	1987	1995	4,5	x		x	x	x				
Jena	20%	2005	2012	yes	2007		2005	2008	2,0			x	x	x				7.1 (2005)
Karlsruhe						yes	1990	2007	3,6	x		x	x	x				11.2 (2007)
Kiel	40%	1990	2020	no	2157	yes	1990	2000	3,7	x		x		x				
Koblenz						yes	1998	1998		x		x		x				
Köln	20%	1990	2020			in preparation	2010					x	x	x				
Leverkusen	50%	1990	2030			in preparation	2010											
Lübeck						yes	2010					x	x	x				
Magdeburg	50%	1990	2030	yes	2152	yes	1992	2005	4,7		x	x	x	x	x			7.2 (2005)
Mannheim	40%	1990	2020	no	2045	yes	1990	2005	5,3	x		x	x					10.7 (2005)
Münster	40%	1990	2020	no	2084	yes	1990	2005	4,0	x		x	x	x	x			7.7 (2005)
Offenbach am Main	50%	1990	2030			yes	2005	2006	1,0	x		x	x	x				10.5 (2005)
Oldenburg						in preparation												
Pforzheim						in preparation												
Potsdam	20%	2005	2020	yes	2010	yes	1990	2006	1,0	x		x	x	x		x		3.3 (2005)
Remscheid	50%	1990	2030	no	2038	yes	1990	2007	6,0	x		x	x	x	x	x		10.5 (2006)
Rostock	52%	1990	2010	yes	2006	yes	1990	2008	6,3	x		x	x	x	x			4.2 (2005)
Salzgitter						in preparation								x				
Siegen	40%	1990	2020			in preparation												
Stuttgart	40%	1990	2020	no	2058	yes	1990	2000	3,7	x		x	x	x	x			
Wiesbaden	20%	1990	2020	no	2084	yes	1987	2006	1,2	x		x	x	x				11.4 (2005)
Wuppertal	38%	1992	2010	no	never	yes	1990	2006	1,0	x		x	x	x	x			8.9 (2005)
Würzburg	40%	1990	2012			yes						x	x					

Figure 1: Year of emission inventories



Source: Own analysis based on survey and internet data

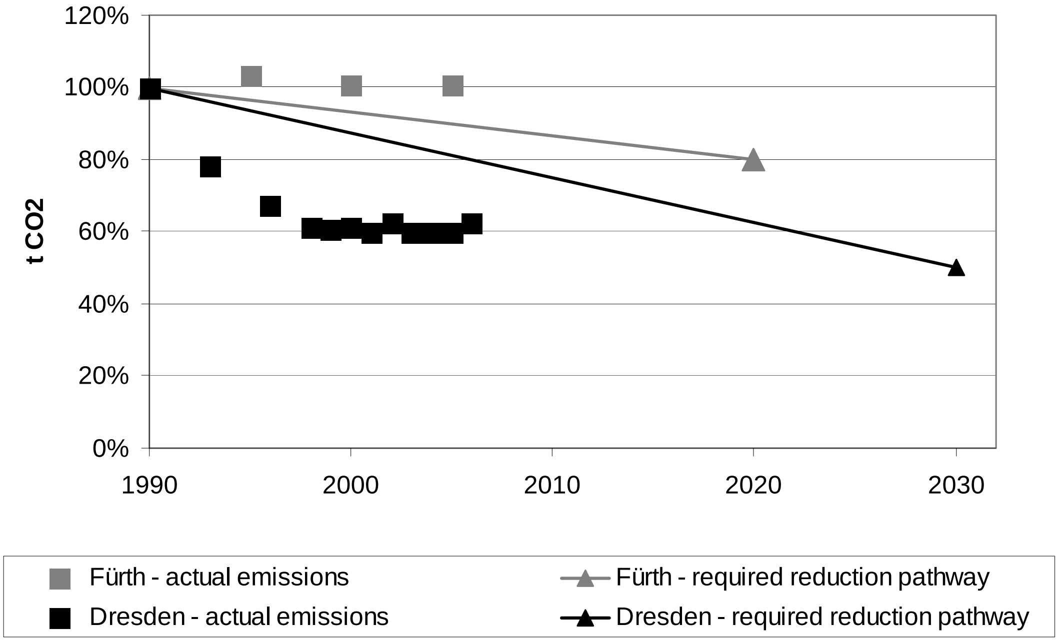
Figure 2: Average annual emission reductions in correlation to reporting period



Including all cities of the survey, and cities from both Eastern and Western Germany (East/West)

Source: Own analysis based on survey and internet data

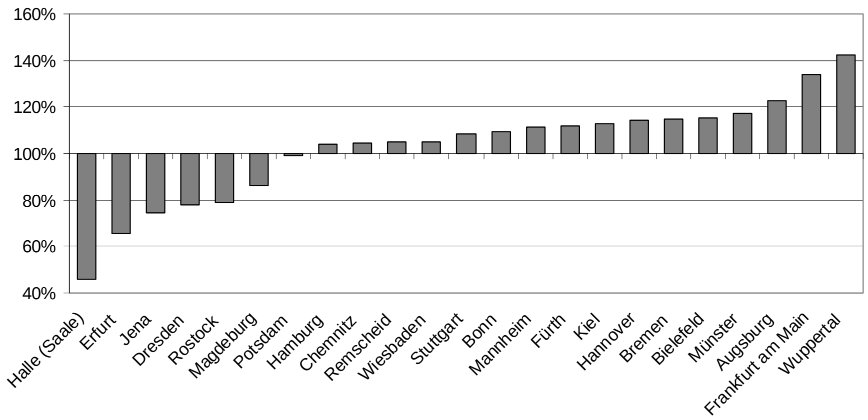
Figure 3: Target achievement – City of Fürth and City of Dresden



Source: Own analysis based on survey and internet data

Fürth starting from absolute emissions of 829 ktCO2 (1990). Dresden starting from absolute emissions of 8,000 ktCO2 (1987).

Figure 4: Current emission levels in relation to target reduction pathway



Source: Own analysis based on survey and internet data

A city exactly on line to meet its reduction target is on the 100% line. A city on the 80% line performs 20% better than required to meet its reduction target. A city on the 120% line performs 20% worse than required to meet its reduction target and is not on course to reach its target.

Table 1: Reduction targets in Stuttgart

Target	**Base Year**	**Target year**	**Required yearly reduction** (% of base year)	**Date of target setting**	**Process of target setting**
-30%	1994	2005	2.73%	1994	Adoption by city council
-50%	1987	2010	2.17%	1995	By joining Climate Alliance
-10%	2000	2010	1.00%	2004	Correction of former target by city council (because original target not realistic)
-40%	1990	2020	1.33%	2008	By fulfilling funding requirement under the 'Energieeffiziente Stadt Programm' of the German Ministry of Education and Research

Source: Wuppertal Institute 2009