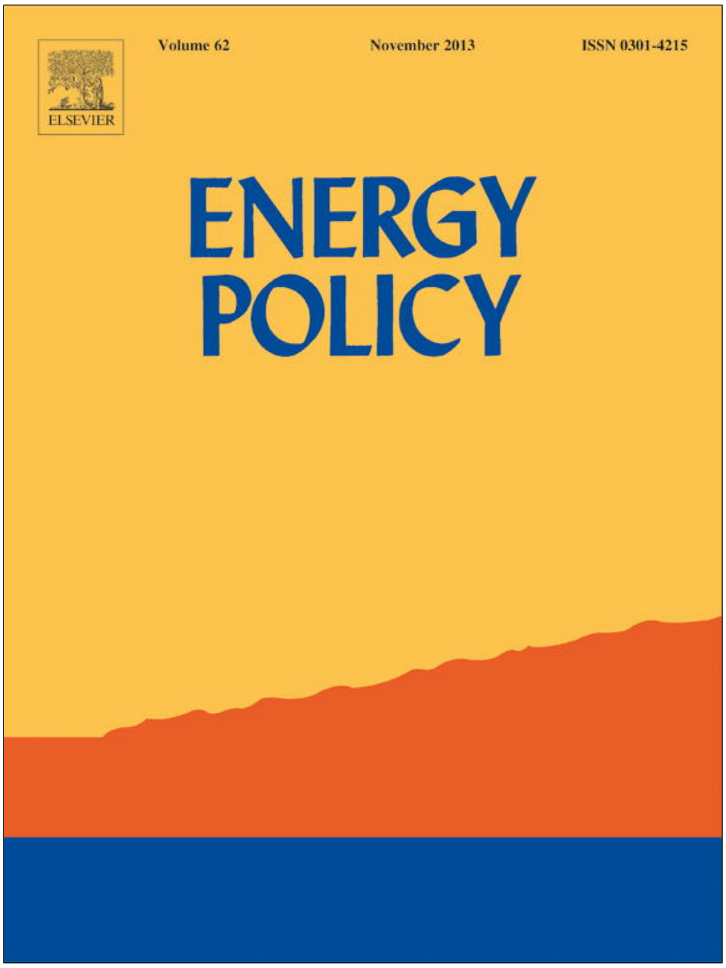
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Towards a comprehensive system of methodological considerations for cities' climate targets

Anna Kramers [a,c,*], Josefin Wangel [a,c], Stefan Johansson [b,c], Mattias Höjer [a,c], Göran Finnveden [a,c], Nils Brandt [b,c]

[a] KTH Royal Institute of Technology, School of Architecture and the Built Environment, Division of Environmental Strategies Research, SE-100 44 Stockholm, Sweden
[b] KTH Royal Institute of Technology, School of Industrial Engineering and Management, Division of Industrial Ecology, SE-100 44 Stockholm, Sweden
[c] KTH Royal Institute of Technology, Centre for Sustainable Communications, SE-100 44 Stockholm, Sweden

HIGHLIGHTS

- Cities' climate targets are almost impossible to compare and benchmark.
- There is a need for consistent protocols and frameworks supporting target setting.
- A framework with key methodological considerations for cities' climate targets is identified.
- The framework is used to explore the climate targets for eight European cities.
- The difference between production- and consumption based accounting is illustrated in a new way.

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ABSTRACT

Climate targets for cities abound. However, what these targets really imply is dependent on a number of decisions regarding system boundaries and methods of calculation. In order to understand and compare cities' climate targets, there is a need for a generic and comprehensive framework of key methodological considerations. This paper identifies eight key methodological considerations for the different choices that can be made when setting targets for GHG emissions in a city and arranges them in four categories: temporal scope of target, object for target setting, unit of target, and range of target. To explore how target setting is carried out in practice, the climate targets of eight European cities were analysed. The results showed that these targets cover only a limited part of what could be included. Moreover, the cities showed quite limited awareness of what is, or could be, include in the targets. This makes comparison and benchmarking between cities difficult.

1. Introduction

During the past decade climate change and urban development have received increasing attention, spurring a large number of low-carbon city initiatives. For instance the city of Stockholm (Sweden) has declared the aim of being fossil fuel-free by 2050, and Copenhagen (Denmark) has set a target to be carbon-neutral by 2025. Other examples are Malmö (Sweden), Freiburg (Germany) and Hamburg (Germany), all of which have adopted the target of reducing CO_2 emissions by 40% by 2020. The focus on cities in relation to climate change is not difficult to understand, as cities are of fundamental importance for mitigating climate change. Estimates indicate that cities contribute 80% of global greenhouse gas (GHG) emissions (Sovacool and Brown, 2010) and in the light of on-going global urbanisation their contribution can only be expected to grow. Fortunately, cities are also reported as having the potential to support more resource-efficient ways of meeting needs and wants than suburbia or the countryside (Mindali et al., 2004; Williams, 1999). While this has been supported by some studies (Dhakal and Shrestha, 2010; Glaeser and Kahn, 2010), others state the opposite and argue that cities only appear more resource-efficient as a result of inferior systems thinking, meaning that many cities actually have a much larger carbon footprint than is typically accounted for (Heinonen and Junnila, 2011a; Heinonen et al., 2011; Hillman and Ramaswami, 2010; Kennedy et al., 2010).

One fundamental difference concerns whether the account only takes into consideration the emissions that occur within the city's geographical boundaries, or whether emissions from goods

* Corresponding author at: KTH Royal Institute of Technology, School of Architecture and the Built Environment, Division of Environmental Strategies Research, Drottning Kristinas väg 30, SE-100 44 Stockholm, Sweden.
E-mail address: kramers@kth.se (A. Kramers).

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and services produced outside but consumed inside the city's boundaries are also included. Given the need and in many countries and cities accepted obligation to decrease such emissions, these differences come with very real implications. For instance, when it comes to setting climate targets, a 40% decrease will mean something completely different if based on a consumption-related accounting approach than if based solely on emissions resulting from production processes within a city's boundaries. However, drawing on methods such as urban metabolism (Baccini and Brunner, 1991), life cycle assessment (Guinée et al., 1993a, 1993b, 2011; Finnveden et al., 2009), input–output analysis (Lave et al., 1995) and other environmental systems analysis tools (e.g. Jeswani et al., 2010; Ness et al., 2006; Finnveden and Moberg, 2005; Wrisberg et al., 2002), there are other types of system boundaries and methods of calculations that also need to be taken into consideration in order to understand what a climate target implies.

This paper aims to facilitate the understanding, comparison and setting of climate targets for cities through identifying, exploring and presenting an overview of these methodological considerations. The particular considerations in themselves are not novel, as each of them has been discussed and used in accounting protocols and methodologies previously. What has been lacking, however, is a comprehensive presentation and this is where this paper makes its contribution. To further concretise the reasoning, the paper also explores how these methodological considerations have been handled in practice.

The paper is structured into five sections. Section 2 describes how the methodological considerations were developed. Section 3 presents and discusses the methodological considerations, describes the literature used and presents the results of the empirical investigation of the eight cities for each methodological consideration. Section 4 discusses some considerations that are important, but for which we did not find the necessary methodological considerations when setting and discussing city targets. In Section 5 the findings of the study are analysed and a new way to illustrate some of the basic considerations is presented, while conclusions are presented in Section 6.

2. Research process

A starting point for this paper was common experience regarding the lack of a comprehensive system for setting targets for cities. However, there was a common understanding within the research group regarding the general topics that need to be addressed. With hindsight, the discussions we needed to have in order to clarify what a target implies can be summarised with four questions: where (the target applies), when (the target should be reached), what (should be included in the target) and how (target fulfilment should be calculated). There are also a number of additional questions that could be addressed to understand e.g. why a certain target has been set in a certain way, or how it could be achieved. However, the aim of the study was not to focus on the processes or power relations in target setting, but on crucial points in the formulation of climate targets. With this as the starting point, our objective was thus to create a detailed system of methodological considerations based on the four key questions mentioned above. This process was guided and supported by literature studies and empirical inquiries, both of which are further described in the following. To test, consolidate and further explore the methodological considerations, a review was made of two main kinds of relevant literature. Publications were selected on the basis of having a record of alleged high environmental standards and in one way or another aiming at a comprehensive approach to GHG accounting. The first was a review of GHG accounting protocols. The accounting protocols included were:

- The pilot version of Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC, 2012).
- The draft ICLEI Community-Scale GHG Emissions Accounting and Reporting Protocol (ICLEI, 2011).
- The 2009 ICLEI International Local Government GHG Emissions Analysis Protocol (IEAP) (ICLEI, 2009).
- The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006, with updates).
- The GHG Protocol Initiative Corporate Accounting and Reporting Standard (WRI-WBCSD, 2004).
- The draft Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI-WBCSD, 2011).

The second source of information was a selection of scientific papers reporting on accounting methodologies for cities (Baynes et al., 2011; Heinonen and Junnila, 2011a, 2011b; Ramaswami et al., 2011; Schulz, 2010; Sovacool and Brown, 2010; Dhakal and Shrestha, 2010; Glaeser and Kahn, 2010; Hillman and Ramaswami, 2010; Kennedy et al., 2010, 2009; Ramaswami et al., 2008; Weber and Matthews, 2008; Lenzen et al., 2004). These articles were identified through searches in the scientific publication database SCOPUS and complemented with additional literature derived from reference lists and previous readings.

To explore how these methodological considerations have been handled in practice when cities set their targets, a questionnaire (see Appendix A) was sent out to eight of the European Green Capital award finalists 2010–2013 (European Green Capital, 2012). These were selected on the basis of having a record of alleged high environmental standards and also being committed to ambitious goals for further environmental improvements and sustainable development. The cities included were Copenhagen (Denmark) (Copenhagen 2009a, 2009b), Freiburg (Germany) (Freiburg, 2011a, 2011b), Hamburg (Germany) (Hamburg 2011a, 2011b), Malmö (Sweden) (Malmö 2011a, 2011b, 2011c, 2011d), Münster (Germany) (Münster, 2011a, 2011b), Nantes (France) (Nantes, 2006, 2011), Oslo (Norway) (Oslo, 2009) and Stockholm (Sweden) (Stockholm, 2010, 2011). These references are used throughout Section 3, particularly in Tables 2–8. The questionnaires were complemented with interviews and analyses of official documents, such as environmental reports, energy plans and the cities' applications to the Green Capital Award.

3. Methodological considerations

The methodological considerations when setting climate targets for cities were developed as outlined in Table 1. The first category "Object for target setting" discusses how to delimit and define the spatial boundaries and the activities covered by the target and thus relates to the question "Where". The second category "Temporal scope of target" comprises the temporal aspects of the target in terms of reference year and time frame and deals with the question "When". The third category "Unit of target" deals with the question "What" – i.e. what GHG are included in the target and whether energy use is also included. In the fourth category "Range of target", questions on life cycle perspectives and consumption-based versus production-based approaches are discussed so as to answer the question "How". In addition, there are a number of other considerations regarding process and implementation, e.g. what actors should be involved in the process of target formulation, what actors are responsible for the achievement of the target, and how radical the target should be.

In the following, for each category the empirical data from the cities are used to illustrate how the relevant issues in this category have been handled in practice. These data are also summarised at the end of each section in the form of a table.

Table 1
Methodological considerations when setting climate targets for cities.

1. Object for target setting – where?
1.1. Defining and delimiting spatial boundaries
What are the geopolitical boundaries of the city or city district?
1.2. Defining and delimiting what activities to include
Should all or a selection of the activities within the boundary be included or not?

2. Temporal scope of target – when?
2.1. Reference year
Is the target absolute or set in relation to some reference year?
2.2. Time frame
For what year is the target set?

3. Unit of target – what?
3.1. Should the target be formulated in terms of GHG and/or energy use?
3.2. Should the target be set for the city or per person living in the city?

4. Range of target – how?
4.1. Consumer or producer perspective?
Should emissions from production or consumption within the geographical boundaries be the focus, or is a combination preferable?
4.2. Life cycle perspective or not?
Should emissions from the whole life cycle of the product/service be included? Single process or production chain?

3.1. Object for target setting

One of the most critical and difficult parts when setting targets for cities' environmental performance is to define the boundaries of the city, i.e. the object to which the target will apply. This includes the spatial boundaries of the city as well as which activities to include.

3.1.1. Defining and delimiting the spatial boundaries

All accounting protocols and methodologies comprise discussions and proposals on how to set the spatial boundaries for the study object. The majority make use of a geopolitical delimitation, understood as the geographical area over which the city has jurisdiction. Such geopolitical boundaries can be set for an entire city, the (usually) larger municipality or region, or for a part of the city, e.g. a city district. However, the smaller the area, the greater the probability that people living in the area will travel and consume services and products outside the area, which causes some methodological challenges (see Section 3.4.1).

The protocols developed by WRI-WBCSD (2011, 2004) build upon an organisational delimitation and thus only include emissions resulting from the specific organisation's activities. The ICLEI IEAP (2009) makes use of an organisational delimitation, but in combination with a geopolitical delimitation.

An alternative way to define a city's spatial boundaries is to use a functional area, e.g. a commuter shed, which is the area from which a workforce commutes or the boundaries of the mass transit system (Kennedy et al., 2010; Sovacool and Brown, 2010). For a major city or metropolitan area this approach might be feasible, but when the object of study is a smaller city or a city district, this way of defining the activity becomes less useful.

All of the eight cities analysed here use the geopolitical boundary of the city to delimit the spatial boundary. However, it is difficult to determine whether and how this delimitation is reflected in the cities' GHG and energy use data. For instance, in Stockholm the geopolitical boundary is used, but the different data sets employed come from local and sometimes regional or even national accounts, which creates problems for the accuracy of the emissions.

3.1.2. Defining and delimiting activities

The next step is to decide what activities to include in the climate target. Even though it might seem self-evident to include all activities taking place within the geopolitical area, in practice this is far from the convention. There are many ways of defining and dividing the activities in a city. As discussed in Section 4.1, depending on each city's purpose with its targets, different approaches are chosen. This can be based on a service approach, in which the focus is on the functions of activities for the user (Höjer et al., 2011; Jonsson et al., 2011; Glaeser and Kahn, 2010; Lebel et al., 2007; Lenzen et al., 2004; Ellegård, 1999; Baccini and Brunner, 1991), from a sectored perspective (Baynes et al., 2011; IPCC, 2006), based on an organisational delimitation, i.e. the scope of influence (Kennedy et al., 2010; Sovacool and Brown, 2010; ICLEI, 2009; WRI-WBCSD, 2004), or on a combination of these.

The possibilities to define and delimit activities differ depending on which activity is being considered, as they all have their specific characteristics concerning the spatial distribution of production and consumption. One especially difficult activity to define and account for is transport because of its mobility over geopolitical limits. Kennedy et al. (2010) compared three different ways of estimating the emissions from road transport; based on fuel sales, vehicle-kilometres travelled, and scaling from a regional level.

There are both similarities and differences between the activities the cities studied here have included or not (see Table 2). All eight cities include emissions from energy, transportation and waste, although these activities are sometimes framed slightly differently. Freiburg, Oslo and Stockholm divide energy emissions into the categories of heating and electricity, while for instance Copenhagen and Malmö do not make any such division at all.

Table 2
The activities included in the GHG emissions inventories in the eight cities included in the study.

Included activities	Copenhagen	Freiburg	Hamburg	Malmö	Münster	Nantes	Oslo	Stockholm
Energy			[a]	X	[a]			
Heating	X	X	X		X	X	X	X
Cooling	X		X		X	X	X	X
Electricity	X	X	X		X	X	X	X
Gas			X		X	X		
Transportation	X	X	X	X	X	X	X	X
Waste							X	[b]
Industry			X	X	X	X		
Work machines				X				
Food		X						

[a] Hamburg and Münster also distinguish between emissions from energy use by households and by small and medium businesses.
[b] In Stockholm, waste is part of the heating system and therefore included in the category of heating rather than as a separate item.

Table 3
The activities excluded from GHG emissions inventories in the eight cities included in the study.

Excluded activities	Copenhagen	Freiburg	Hamburg	Malmö	Münster	Nantes	Oslo	Stockholm
Long distance travel								
Air			X			X		X
Rail						X		X
Harbour emissions			X					
Consumption								X
None explicitly stated	X	X		X	X		X	

Hamburg and Münster categorise energy emissions by sector instead, distinguishing emissions from private households, businesses and industry as separate categories. Waste is another common activity where the emissions are framed in different ways. Stockholm views the collection, transportation and treatment of waste as part of transportation or the energy sector, since household waste is used in that city's district heating network, while Oslo sees it as a separate sector. Freiburg is the only city to include food and Nantes is particular about including emissions from agriculture and industries, which are not included under the European trading scheme (ETS).

Just as important as the included activities are the activities that are not included (Table 3). Not all of the cities studied are specific about excluded activities, but the most common activities to be explicitly excluded are those from consumption of imported goods from outside the geopolitical boundary and long-distance travel, by air or rail. In cases where the city is a transition hub for goods – through hosting a major airport or harbour – activities related to these are also excluded, generally with the motivation that these services (at least in part) benefit a much larger geographical area than the city itself.

3.2. *Temporal scope of target*

By when should the target be reached? In principle, a target can be set without any precise temporal notions, e.g. "zero GHG emissions" or "constantly decreasing energy use per capita". In practice, more or less all the targets set by the cities studied here have a target year. For cities with absolute targets (Copenhagen and Stockholm see Table 5), such as a certain amount of carbon emissions, a reference year is not really needed. However, most targets are set in relation to some deadline, in which case the reference year is of crucial importance.

3.2.1. *The reference year*

A reference year is used when developing targets, which are defined in relation to a point in time. By comparing the target or the current state with the reference year, it is possible to calculate the scope and pace of change. The state needs to be calculated in the same way for both the reference year and the target year to be useful for comparison.

Targets for GHG emissions are often expressed as a reduction in emissions compared with a baseline or reference year. One reason to set the reference to a year in the past rather than the present is that this allows any reductions in emissions resulting from mitigation actions already taken to be accounted for (ICLEI, 2009). Drawing on recommendations by IPCC (2006), WRI-WBCSD (2004) and ICLEI (2009), it is a good practice to establish the reference year according to the first year for which complete and accurate data can be compiled, provided that this year can be seen as representative for the average levels of emissions. The Kyoto protocol negotiators set the reference year to 1990, primarily because there is a lack of data before that year.

Table 4
Reference year used when developing targets by the eight cities included in the study.

City	Reference year /starting year of GHG emission accounting
Hamburg, Malmö, Münster, Nantes, Stockholm	1990
Oslo	1991
Freiburg	1996
Copenhagen	2005

Targets for energy usage in cities are often expressed in two ways, as a reduction and/or as a shift towards renewable energy sources. In the first case, the energy usage may be projected to a future year with the same increase rate as today. The target is then to decrease energy use to a percentage of the energy use in the future target year. In the second case, the target for renewable energy sources is decided to be a certain percentage of the total energy in the target year. There is no need for a reference year in these two cases.

All cities in our study use a reference year for GHG emissions (Table 4). The most common reference year is 1990, although the cities do not specify in detail why it was chosen. A suggestion is that 1990 is a convenient starting year in line with Kyoto protocol reporting at national level. Stockholm and Copenhagen have formulated their goals differently than the other cities and are therefore not using a reference year in the conventional sense (see Section 3.3.2). In their case, the year entered is the earliest year in which they conducted measurements of their GHG emissions, in accordance with their most current reports.

3.2.2. *Time frame*

Deciding upon a time frame is essential when setting targets, at least if these are intended to be fulfilled. The appointed time frame gives an indication of the pace at which changes need to take place and is thus a prerequisite for planning. The time frame chosen also influences the need for interim targets, which function as milestones and points for evaluation of policies and other measures taken.

Shorter and longer time frames each have their respective benefits and drawbacks. A short time period can force the formulation of more specific targets and strategies for achieving these, but at the same time risks becoming subsumed in projections of contemporary trends, causing the target and strategies to be delimited to rather incremental change. If instead targets are developed for more distant futures, the cognitive ability of deviating from prognosis-based thinking can increase and thereby also the possibilities of developing more challenging targets (Dreborg, 1996). However, there is also a risk that the further away in the future the target is set, the less the sense of urgency, responsibility and need for immediate action.

One way of dealing with the pros and cons of longer and shorter time frames is to combine them through using longer time frames when setting the overarching targets and complement these with intermittent targets with shorter time frames, which are compatible with the long-term targets. The short-term targets may include aspects other than emissions of GHG, for example targets related to infrastructure, which may be required for the long-term targets (Persson et al., 2007). This may not solve the difficulties mentioned above, but has the potential to at least increase awareness of the differences of short-term and long-term targets.

Another aspect of the time frame is that city targets are predominantly based on the emissions in the final year of the target period. This is problematic, as emissions released early in the life cycle cause a greater cumulative climate impact than those released later (Säynäjoki et al., 2012; Schwietzke et al., 2011). Current emissions contribute to the greenhouse effect hundreds of years into the future (Schwietzke et al., 2011). There are therefore good arguments for not only having an end-state target for GHG emissions, but also annual targets or the like.

The question of time frame also raises the issue of political commitment and jurisdiction, since all but the shortest of time frames will include one or more elections, implying the possibility of a new composition of government. Thus, cross-party agreement can be beneficial for targets of the more long-term kind. In the context of climate change, however, it is seldom the issue or target per se that is politically contested, at least not for the moment, but rather the strategies and measures for achieving this.

The time frames for the targets chosen by different cities vary greatly (Table 5). Stockholm and Copenhagen have goals set as close as 2015, while the majority of the other cities have goals set from 2020 to 2030. It seems that the cities' short-term goals are more conservative than their long-term goals. Münster is a good example, as it aims to reduce emissions by 20% by 2020 and by 40% by 2030. Not all of the cities refer to the European Union's 20-20-2020 goal, which would seem like a good common goal for cities within the EU. However, this might be because it was agreed after the most recent policy documents and reports were released from the respective cities. None of the cities is discussing goals set later than 2050.

The formulation of the goals themselves also varies, with most cities using percentage reduction in emissions relative to the reference year. Copenhagen and Stockholm have formulated goals that differ radically from the others. Copenhagen aims to become the world's first climate-neutral capital by 2025, while Stockholm aims to become a fossil fuel-free city by 2050. Stockholm also stands out since it uses per capita emissions when formulating its targets, rather than a percentage reduction as in the other cities.

Table 5
Target year and target formulation of the eight cities included in the study.

City	Target year(s)	Target formulation
Copenhagen	2015 2025	20% Reduction Carbon-neutral
Freiburg	2030	40% Reduction
Hamburg	2020 2050	40% Reduction 80% Reduction
Malmö	2030	40% Reduction
Münster	2020 2030	20% Reduction 40% Reduction
Nantes	2025	25% Reduction
Oslo	2030	50% Reduction
Stockholm	2015 2050	Below 3.0 t CO_2e/cap Fossil fuel-free

3.3. Unit of target

What sources of emissions should be included in the target? Should both energy use and GHG emissions be included, and which GHG are included in the target? How should the energy use and GHG emissions be allocated – to the cities' residents or the entire city? These questions are elaborated upon in the following sections.

3.3.1. GHG and/or energy use?

Targets related to climate change can be formulated on different levels. At the global level, two common and related ways are to define the target either in terms of an acceptable global increase in average temperature (e.g. 2 °C) or in terms of an acceptable concentration of GHG in the atmosphere (e.g. 350 or 450 ppm CO_2). Other ways could be to define a limit on acceptable change in the environment, such as a certain increase in precipitation or sea level. All these formulations are related and typically defined on a global scale. For a city, however, such targets are not directly useful. Instead, a city's targets need to be related to the pressure the city places on the environment, either in terms of GHG emissions or more indirectly in terms of energy use.

When speaking of GHG emissions, these are sometimes, erroneously, expressed as just CO_2 emissions instead of CO_2 equivalents (CO_2e), which is a way to compare and aggregate the impact of different GHG on the climate. The GHG accounts tend to use CO_2e, including five of the most important GHG in addition to CO_2 (Murakami et al. (2011); ICLEI, 2009; IPCC (2006); WRI-WBCSD, 2004). In this respect the methodologies reported in scientific papers differ, since they typically include only CO_2 (Heinonen and Junnila, 2011a; Weber and Matthews, 2008) or CO_2, CH_4 and N_20 (Kennedy et al., 2010; Sovacool and Brown, 2010; Matthews et al., 2008; Ramaswami et al., 2008). It has been argued that using CO_2 is adequate from a practical perspective (Kennedy et al., 2010), since emissions of CO_2 tend to dominate when estimating the contribution of cities to global warming if the target is delimited to GHG emissions within the city boundaries. The majority of the other GHG emissions are methane from landfill waste or industrial processes, typically located outside the city boundaries. Thus, the importance of including more than CO_2 is related to the question of how to calculate the emissions from a city, an issue further discussed in Section 3.4.1.

On examining how cities set their climate targets, it is easy to conclude that GHG emissions are commonly included and energy is omitted. Since it is the GHG emissions that are the direct cause of climate change, it might seem logical to set climate targets on these, rather than on energy use. However, maintaining a sole focus on GHG emissions has some problematic implications, as discussed in Section 5.

Malmö, Münster, Oslo and Stockholm all use carbon dioxide equivalents (CO_2e), which comprise emissions of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4), while Freiburg, Hamburg and Copenhagen only account for CO_2 (Table 6). Nantes does most of its emissions accounting as CO_2, but includes emissions from CH_4 and N_2O in the energy sector. Few of the

Table 6
Unit of the target chosen by the eight cities included in the study.

City	Unit of target
Malmö, Münster, Stockholm	CO_2e (CO_2, N_2O, CH_4)
Copenhagen, Freiburg, Hamburg	CO_2
Nantes	CO_2 except emissions from energy, where CO_2e is used

Table 7
The perspective on emissions used by the eight cities included in the study.

City	City or per capita perspective
Münster, Oslo, Stockholm	ton CO_2(e)/year and ton CO_2(e)/cap
Copenhagen, Freiburg, Hamburg, Malmö, Nantes	ton CO_2(e)/year

cities express any metrics about renewable fuel use in terms of volume (m^3) or energy (kWh) in their current calculations or targets, not even the cities that explicitly refer to the EU 20-20-2020 target.

3.3.2. City or per capita target?

Targets can be set either per capita or for an entire city. A per capita target might appear to facilitate achievement of the target for growing cities, since the city's allowance would grow with the number of people moving in. However, the increased population requires new investments in infrastructure, which will contribute to increasing energy use and related GHG emissions. Growing cities tend to have a growing investment capacity and are thus equipped for changing e.g. urban form and location of activities in a way better suited to a city with low energy demands and GHG emissions. It is also true that for cities with overcapacity in the systems for service supply, an increased population might render these more efficient in terms of a lower per capita share of the 'overhead' energy use and GHG emissions from these facilities. A shrinking city, on the other hand, might be better off reaching an absolute target of e.g. reducing energy use to a specified total level, while being much worse off with per capita targets.

All of the cities included in the study calculate emissions in terms of total city emissions (ton CO_2/year). Many also use emissions per capita metric (ton CO_2/cap) (Table 7).

3.4. Range of target

The range of the target depends on two considerations. The first of these is whether the emissions are accounted in accordance with what is being produced or what is being consumed. The second consideration concerns whether just a part or the whole life cycle is included in the calculations. Both these considerations are important due to the fact that activities within a city are dependent on goods and services produced outside the city's boundaries, causing emissions and energy use outside. They are explained below and summarised in Fig. 1 (Section 5).

3.4.1. Consumption or production perspective

When accounting for emissions in a city, one of the most fundamental choices is whether to use a consumption-based or a production-based accounting perspective. With the consumption perspective, the accounting is based on consumption of products and services either by citizens or within the city. In the first case, all consumption by citizens is accounted for, irrespective of where it takes place. In the second case, only consumption within the city is accounted for, irrespective of whether it is performed by a citizen or a visitor.

If, on the other hand, a production perspective is chosen, the focus is on products and services produced within the city. For cities inclining towards either net import or net export of GHG emissions (embodied in goods and services), the chosen way of attribution can make a huge difference for the outcome of the city's GHG account. For example, if there is a paper mill within the city, all climate impacts from the factory should be included if a production perspective is used. If a consumption perspective is used, only the impacts from paper used by the citizens or within the city limits should be included, irrespective of where the paper is produced.

All of the literature reviewed for the present study includes considerations on boundaries of what sources of emissions to include in the account. Three main types of accounting approaches can be distinguished within this: direct emissions, indirect emissions accounts, and consumer expenses-based accounts. Direct emissions are delimited to emissions from within the geopolitical boundaries, while indirect emissions are defined as emissions from outside this boundary (GPC, 2012; ICLEI, 2011). When discussing these, the Scopes 1-3 typology developed and defined by WRI-WBCSD (2004) can be used to help delineate between direct and indirect emissions. Scope 1 is delimited to all direct emissions from sources within the geopolitical boundary. Scope 2 includes single process emissions from the production of electricity occurring outside the boundary as a consequence of activities within the geopolitical boundary. Scope 3 comprises all other emissions that occur outside the boundary, including product chain emissions not included in Scopes 1 and 2. The direct emissions include emissions from production processes and product use, fossil fuel combustion, landfill and other land use activities within the geopolitical area (e.g. ICLEI, 2011; Ramaswami et al., 2011; Kennedy et al., 2010; IPCC, 2006; WRI-WBCSD, 2004). While the direct emission accounts are rather similar in the different protocols and methodologies, indirect emissions accounts vary more widely, especially when considering what is mandatory to account according to the protocols, or what has been included in the study at hand. Neither the WRI-WBCSD GHG Protocol Initiative Corporate Accounting and Reporting Standard nor the ICLEI International Local Government GHG Emissions Analysis Protocol (IEAP) demands more than "Scope 2" emissions to be included in the account.

Some cities are net importers of embodied energy, carbon and GHG emissions while others are net exporters, which also creates problems in comparison and benchmarking. To deal with these problems, Hillman and Ramaswami (2010) propose a typology that distinguishes between producer cities, consumer cities and balanced cities, depending on the relationship between commercial/industrial energy use and residential energy use. The Japanese framework Murakami et al. (2011) distinguishes between industrial and commercial cities. A commercial city (i.e. a consumer city according to the Hillman and Ramaswami terminology) uses a large amount of energy but does not have many production units. Therefore, the emissions and energy usage in the city are much lower than in an industrial city. CASBEE-City uses two ways of assessing environmental loads, the 'emitter pays' principle (allocating all GHG to producing areas) and the 'beneficiary pays' principle (first deducting all GHG emissions from producing areas and then reallocating them to consuming areas) (Murakami et al., 2011). Besides making visible the commercial city's larger share of the GHG emissions and energy use, another benefit is that it removes the possibility of decreasing a city's accounted carbon footprint through moving production facilities outside the geopolitical boundaries.

Baynes et al. (2011) compared a regional production approach with a household consumption approach to measure energy use in Melbourne and concluded that these serve different purposes. The regional approach allows local authorities to benchmark their industries with other similar industries elsewhere, while the consumption approach gives a more realistic picture of the energy use from an urban area and is therefore useful for observing impacts from changing household consumption patterns and lifestyles.

Lebel et al. (2007) distinguish between direct emissions (from goods and services produced and consumed locally), responsible emissions (produced locally, consumed elsewhere), deemed emissions (produced elsewhere, consumed locally) and logistic emissions (from transports passing through). In their 'metropolitan accounting bubble' however, only direct emissions and responsible emissions from electricity and fuels are included.

None of the eight cities included in the present study is actively using terms such as production or consumption perspective. Most of the activities included are delimited by the geographical boundaries of the particular city and it could be argued that a production perspective on the city is used in most cases. However, as stated previously, some activities are not (at least fully) included, such as emissions from harbours, airports etc., so at least some of the emissions have a more consumption-based perspective.

One way to avoid the problems associated with comparing different types of cities is to use a consumer expenses-based account, as developed and used by e.g. Heinonen and Junnila (2011a), Heinonen et al. (2011), Höjer et al. (2011), Weber and Matthews (2008) and Moll et al. (2005). This way of estimating and accounting for emissions is also proposed by Ramaswami et al. (2011) and is one of the accounting approaches that will be supported in the forthcoming ICLEI Community-Scale GHG Emissions Accounting and Reporting Protocol (ICLEI, 2011).

3.4.2. *Life cycle perspective or not*

Products and services produced or consumed within a city may cause environmental impacts outside the city. The question of whether to use a life cycle perspective or not concerns whether the emissions from the whole life cycle, i.e., from raw material acquisition, via production and use to waste management, should be included in the calculations, even if some of these occur outside the city boundaries. A life cycle perspective can be applied to both citizen-orientated and city-orientated consumption accounts. It can also be used for production-based accounts, although in that case it creates the risk of double accounting. To continue the paper mill example, if a life cycle production perspective is used, the impacts from the production of the actual paper within the city should be included, but also emissions and energy use in e.g. forestry and power plants serving the paper mill. However, using a life cycle perspective in this way means that emissions from e.g. forestry and power plants are accounted for twice, namely where they are located and where the paper mill is located. If a life cycle consumption perspective is used, impacts from the production of all paper used by citizens or within the city should be included, even if they are produced outside the city.

In practice, various degrees of life cycle perspective can be used when assessing the climate impacts of cities. The life cycle can be included for some products and services but not for others, or the whole life cycle can be included or only part of it. An example of the latter is when emissions from power plants for electricity used in a city are included, but not emissions from extraction of the fuels used in the power plant.

There are three main methods for handling life cycle perspectives: process LCA, input–output analysis and hybrid LCA (Finnveden et al., 2009; Suh, 2009). Process LCA is a bottom-up approach to assess the potential environmental impacts and resources used throughout a product's life cycle (including goods and services ISO, 2006), where the emissions are assessed one process at a time based on energy and mass flows (Heinonen and Junnila, 2011a). The bottom-up nature of the approach leads to substantial data needs and there is also a cut-off problem, since all processes cannot be included for practical reasons, so some have to be cut off (Suh et al., 2004).

Input–output analysis is a well-established analytical tool within economics and systems of national accounts (Suh, 2009; Miller and Blair, 1985), and uses a nation or a region as the object of the study. It is a top-down approach and uses national economic statistics to derive a representation of transactions between sectors in a national economy, a region or a city. Combined with information on average resource use and environmental emissions from each sector and assumptions on the connections between sectors and product groups, it can be used to calculate environmental impacts of product groups in a life cycle perspective (Suh, 2009; Joshi, 1999; Hendrickson et al., 1998; Lave et al., 1995). Input–output analysis is often used for studies adopting a consumption perspective by combining data on consumption expenditure and environmental data for product groups (e.g. Huppes et al., 2006; Palm et al., 2006; Tukker and Jansen, 2006; Weidema et al., 2006). Since the whole economy is included in the national accounts, the problems with cut-offs can be avoided (Lenzen, 2000). On the other hand, there are uncertainties associated with the high level of input data aggregation, together with a possible temporal (inflation and currency rate) and regional (industry structure differences) asymmetry in the data and the model. However, efforts are being made in terms of databases and methodological developments to further improve the situation (e.g. Wiedmann et al., 2011, 2007; Tukker et al., 2009).

Hybrid LCA is a combination of process LCA and input–output analysis (Suh et al., 2004). For example, process LCA data can be used for the most important processes where there is good data availability and input–output analysis data for the remaining processes. Combinations of input–output data and other types of data have been used in a number of studies, including Heinonen and Junnila (2011b), Höjer et al. (2011), and Moll et al. (2005).

None of the protocols stipulates mandatory calculation of emissions and energy use from a life cycle perspective, mainly due to the associated high demand for data. However, WRI-WBCSD and ICLEI are both developing tools to support such a Scope 3 account and a pilot study was launched in May 2012 (GPC, 2012). While full accounting is rarely conducted owing to data limitations and methodological challenges, there are still good reasons for a life cycle perspective that includes more than the emissions from energy carrier production (i.e. Scope 2 emissions).

A study on eight cities in the U.S. showed that when emissions from four "essential" urban material flows (food, water, cement and fuels for transport) were included together with the Scope 1 and 2 emissions, the GHG footprint increased on average by 47% (Hillman and Ramaswami, 2010). Matthews et al. (2008) also demonstrated that only focusing on Scope 1 or Scope 1 and 2 emissions gives significantly lower results for firms than a full Scope 3 approach. Besides Hillman and Ramaswami (2010; also reported in Ramaswami et al., 2008), Kennedy et al. (2010) have developed methodology which includes all indirect emissions, including upstream (product-chain) emissions, except from food and materials consumed in cities and emissions upstream of electric power plants. Those authors found that on including upstream emissions from fuels only, the GHG emissions attributable to cities increased by 25%.

Only three of the cities included in the present study, Münster, Nantes and Stockholm, specify that they are using a life cycle

Table 8
The LCA perspective chosen by the eight cities included in the study.

City	LCA perspective
Münster	LCA on all emissions
Nantes, Stockholm	LCA on energy
Copenhagen, Freiburg, Hamburg, Malmö, Oslo	Not stated

perspective and in what way (Table 8). Nantes and Stockholm apply a LCA perspective on fuels and energy consumed within the city and Münster aims at using LCA data in all of its emissions accounting. However, the activities included are very similar to those of the other two cities, so it is difficult to determine the effect of this.

4. Other considerations

Besides the methodological considerations elaborated upon so far, there are also a number of other considerations. The methodological considerations are the basic prerequisites for developing a comprehensive and transparent target, but other considerations address political and procedural issues influencing e.g. the distribution of agency and responsibility, the level of the target, and the development of a strategy or roadmap to reach the target. In the following we elaborate only on the issue of agency.

4.1. Agency of target

Cities are not self-sufficient when it comes to resources. The activities taking place in cities have impacts far beyond their agency and legislative boundaries (Hoornweg et al., 2011). At the same time, the city as a political and administrative body has only a limited scope of influence over e.g. citizens' way of life and the production of goods and services. Nevertheless, Hoornweg et al. (2011) found that efforts undertaken by cities in Sweden and Germany between 1967 and 2005 led to major reductions in GHG emissions. While the provision of urban infrastructure and policies (e.g. efficient public transport, expensive parking and congestion charging) do have an effect on the lifestyle of citizens, this influence is mostly of an indirect kind. The type of influence that a city exerts on its citizens depends on the political ideology to which the city ascribes, which in many Western countries means focusing on providing environmentally better alternatives and on using economic incentives and information to nudge people to take the ‘right’ decisions, rather than on restrictions.

Among the eight cities investigated in the present study, the municipal authority is responsible for setting and developing the targets. However, in practice the current targets were usually developed jointly by the city council, the mayor's office and municipal bodies. In some cases, outside expertise within universities and consultancy companies was employed in the process leading up to the target setting itself, but the municipal authority assumed responsibility for the targets set. The eight cities have set targets for activities taking place within the city's geopolitical boundaries, for which they believe they are responsible and accountable. Emissions from goods and services that are consumed within the city, but produced elsewhere, are thus typically not included in the targets.

Apart from this common trait, there are major differences concerning what activities the eight cities have included in their targets. While some of these are well-aligned to the agency of the city, the city has no or only limited agency as regards some other activities included (Table 9). The level of agency depends on two main factors; firstly whether the city is the owner of systems providing or supporting the activity, and secondly the scale of these systems, i.e. a large-scale system encompassing the entire city or one of many contributing systems. Public ownership and a large-scale system increase the level of agency of the city, while private ownership and small-scale systems decrease it. A general example of strong agency is a publicly owned district heating system, where the municipal authority, through policy decisions, can place requirements on the fuel mix, thereby reducing emissions by forcing a switch from fossil fuels to renewables. An example of weak agency is the transport mode chosen by the citizens, since while the city can introduce a number of incentives to promote “green” cars, it does not have the same direct control over the emissions resulting from private transport as over the district heating network in the strong agency example. In many cases the level of agency also becomes a question of interpretation. For example, the municipal authority often has strong agency over the waste treatment process (collection, treatment and disposal), but very weak agency over the amount of waste generated by consumption. Thus while the strong agency over the waste treatment process can be used to reduce emissions, these reductions can potentially be wiped out by increased consumption (even if the consumption perspective is not included).

5. Discussion

This paper provides a fairly comprehensive and consistent overview of important methodological considerations and the different choices that can be made when comparing and setting climate targets for cities. Our review of existing accounting protocols and methodologies reported in scientific papers showed that there are a number of more or less similar approaches to learn from. A common trait in the literature is the recognition of some methodological difficulties associated with setting climate targets for cities, the two main difficulties being (1) the question of what

Table 9
Agency of the targets. Only the agency of those activities included in the cities' targets are presented.

Agency of activities (S=strong agency, W=weak agency)	Copenhagen	Freiburg	Hamburg	Malmö	Münster	Nantes	Oslo	Stockholm
Energy (public/private)				S/W				
Heating (public/private)	S/W	S/W	S/W		S/W	S/W	S/W	S/W
Cooling (public/private)	S/W		S/W		S/W	S/W	S/W	S/W
Electricity (public/private)	S/W	S/W	S/W		S/W	S/W	S/W	S/W
Gas (public/private)			S/W		S/W	S/W		
Transportation (public/private)	S/W	S/W	S/W	S/W	S/W	S/W	S/W	S/W
Waste							S/W	
Industry			W	W	W	W		
Work machines				S				
Food		W						

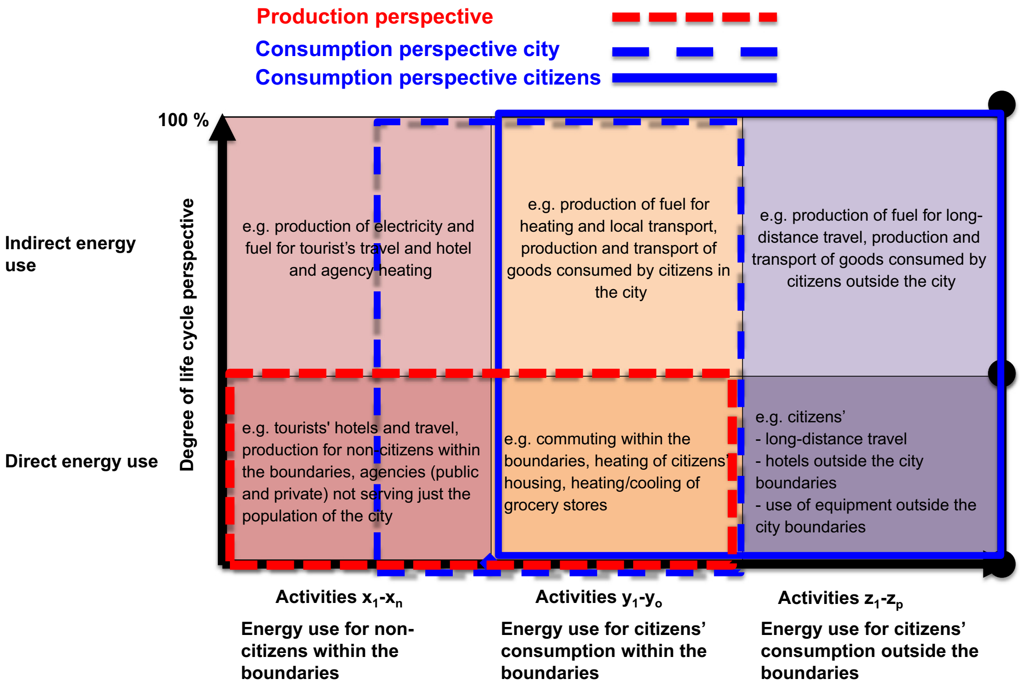

Fig. 1. Relationship between activities, the consumption and production perspectives and the life cycle perspective.

emissions and energy use to account to a city, i.e., how to set the system boundaries, and (2) the lack of data.

In the protocols and methodologies described in the literature these difficulties are dealt with in different ways, mostly through varied combinations of production- and consumption-based attributions and through excluding activities and LCA perspectives for which data were unavailable. However, in contrast to previous practices (ICLEI, 2009; WRI-WBCSD, 2004), an increasing number of protocols and cities are now starting to attribute more than the (Scope 1) emissions that occur within city boundaries in their accounts, although the problem of unaccounted emissions from consumption goods, national transport services and production chain upstream processes persists. An acknowledged reason for the lack of use of LCA perspectives is their high demand for data and computing capability. For local targets the methodology for gathering data must be sufficiently specific to respond to local variations and changes, and thus most national data are insufficient. For accounts where a life cycle perspective is used, another reason for the lack of data is that many goods and services used in a city originate, partially or wholly, from countries in which the types of data needed are unavailable – due to a lack of procedures for data generation and reporting or to a lack of transparency. However, with consumption data, input–output data and databases becoming increasingly available, the possibilities for including life cycle perspectives are increasing. For instance, a study by Stockholm Environmental Institute showed that going from a conventional production-based accounting approach to a consumption-based approach increased the carbon footprint of Stockholm from 2.91 to 15.68 t CO_2(e)/capita and year (SEI, 2012). Similar results have been obtained in Singapore (Schulz, 2010) and Sydney (Lenzen et al., 2004).

Another potential explanation for the reluctance to include consumption of goods and long-distance transport could be a perceived or real lack of agency by the target-setting municipal body; i.e. these areas are considered to lie outside the perceived scope of what politics can or should influence. Based on our analysis of eight European Green Capital Award candidates, the most common developers of city targets appear to be city councils, mayor's offices and municipal departments for the environment. The city (as a political and administrative body) has only a limited scope of influence over e.g. citizens' ways of life and the production of goods and services. According to Hoornweg et al. (2011), cities might have greater agency and scope of influence than they currently believe. Furthermore, it is interesting to note e.g. that when Larsen and Hertwich (2010) studied and displayed the magnitude of indirect emissions (Scope 2 and Scope 3 emissions according to WRI-WBCSD 2004) from the provision of services by Norwegian municipalities, it became difficult for the participating municipalities to neglect these.

One reason for the different perspectives, and hence different ways of accounting for energy use and GHG emissions, is that each city sets its targets in order to fulfil a certain strategy. Therefore even if the accounting is done with full accuracy and the necessary data are available, there will still be difficulties in comparing actual energy use and GHG emissions between cities because of the lack of standardised principles for accounting.

As previously discussed, targeting only GHG emissions can be too narrow an approach. In practice, fulfilling global GHG targets means reducing the amount of fossil fuels used, which currently means restricting the amount of available energy. Until viable and sustainable alternatives exist, energy supply must be treated as a scarce resource requiring its own targets. A sole focus on GHG emissions allows these to be reduced these without reducing total energy use – through using a higher degree of fossil-free energy. This renders it possible for cities to use a higher share of fossil-free energy than is globally available, which leaves other cities either with access to less energy or having to use more fossil fuels. In the first case energy is unevenly distributed and in the second case the target's mitigating effect on climate change is counteracted.

In the present study, we found that the eight cities included scarcely knew what methodological considerations they had made when developing their own targets. It is possible that deeper investigation of some of the target-setting procedures and documents in the cities would have given more encouraging findings. However, information was sought both in official documents and through interviewing city officials. If information regarding what the target includes and excludes does not show up in such an

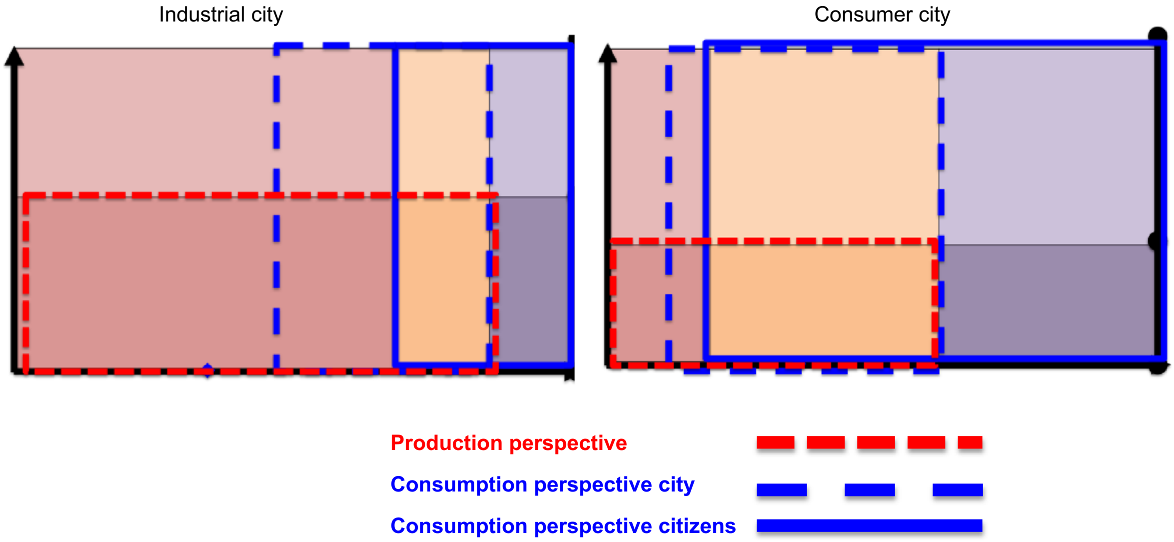

Fig. 2. Relationship between the consumption and production perspectives for two different kinds of cities.

analysis, then the value of that information is questionable. It is also possible that another selection of cities would have given different results. However, the eight cities included here were chosen because of their high environmental profile and examples of better communicated methodological considerations were not found in the literature.

One reason for the lack of knowledge regarding methodological considerations within the cities may be the difficulty in understanding and/or explaining some of these methodological considerations. In order to deal with this, we developed a diagram to explain three of the most difficult considerations: activities included, consumption/production perspective and life cycle perspective (Fig. 1).

The x-axis in the diagram represents activities. Activities x_1–x_n take place within the city, but are related to non-citizens, e.g. hotel stays or industrial production for an out-of-city market (e.g. the paper mill), the headquarters of large companies or national agencies. Activities y_1-y_o are related to the citizens and take place within the city, e.g. commuting, energy use in housing and in buildings for the citizens' services and their shopping and consumption within the city. Activities z_1–z_p are citizens' activities outside the city, e.g. long-distance travel and consumption of goods and services outside the city. The y-axis marks the degree of life cycle perspective, with the lower part of the scale only including direct energy use, i.e. in principle electricity and fuel consumption. The upper part also includes indirect energy use, i.e. energy use for production of electricity, fuel and goods.

A comprehensive *production* perspective would include all activities x_1–x_n and y_1–y_o, but only the direct energy use (the area within the red square). In a comprehensive and consistent production perspective, indirect energy use cannot be included, since it would always be defined as direct energy use elsewhere. However, in practice it can often be reasonable to take full life cycle perspective even when using a production perspective, since otherwise there is a risk of effects at the early stages of the production chain not being counted at all and the effects of production therefore being underestimated. If the choice is between double accounting and no accounting, it might be safer to opt for double accounting.

A *consumption* perspective is based on the consumption of products and services either by the citizens or within the city (Section 3.4.1). A consumption perspective based on citizens would include activities y_1–y_o and z_1–z_p and indirect energy use in order to make it comprehensive. A consumption perspective based on the city would include activities y_1–y_o and some of the x-activities, e.g. those related to non-citizens consumption within the city boundaries, but not production of goods for consumption outside the boundaries. Transport can be used as an example to illustrate the difference. A *city* consumption perspective includes all transport within the city, by both citizens and visitors. A *citizen* consumption perspective includes only the transport of citizens, regardless of whether this is within or across the boundaries of the city (Fig. 1).

Adding energy use from the whole world in any of these three ways (excluding the double accounting in the production perspective) would report global energy use in a consistent way.

There can be a vast difference in energy use depending on >whether a production or consumption perspective is chosen for specific cities (see Section 3). In principle, cities with a low degree of industrial production and with no airport or harbour within their administrative limits can have rather limited energy use from a production perspective, but if they are rich can still have high energy use from a consumption perspective (see examples in Fig. 2).

6. Conclusions

There are a number of problems making it difficult to compare and benchmark cities' climate targets. Firstly, different cities use different system boundaries when setting climate targets. Secondly, the available information about these delimitations is incomplete. Thirdly, there is limited awareness among city administrations and councils about these delimitations and how they influence the targets.

Together, the plethora of differences and the lack of information render it almost impossible to compare the climate targets of cities. To rectify this, there is a need for comprehensive and consistent accounting protocols and methodologies, developed specifically for cities' climate targets. There is also a need for standardised terminology and clearer application of the terminology, so as to enable comparisons between different protocols and methodologies.

In any analysis, cities only cover a certain part of all climate impacts. This means that the majority of GHG emissions and energy use risks being overlooked at the local level, where the practical changes must occur. Thus, life cycle perspectives and/or consumption-based accounts are important to avoid measures simply moving emissions outside the city's geopolitical boundaries. It is also important that cities start working towards including all the impacts caused by their citizens.

The methodological considerations presented in Table 1 can act as a starting point for work to reduce the current ambiguity in cities' climate targets.

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Appendix A

1. The target and the baseline
   - 1.1 How is the baseline formulated? How did you estimate the baseline?
   - 1.2 How is the target formulated?
   - 1.3 Are there any discrepancies between how the baseline was estimated and how the target is formulated and followed up?
2. Understanding and setting the context
   - 2.1 Which organisation(s) have been involved in developing and setting the target?
   - 2.2 What is the time frame for the target and why was this chosen?
   - 2.3 What is the reason for choosing this target?
     - It is an ecologically sustainable level.
     - It is a feasible level (politically, economically, technically, socio-culturally?).
     - Other (what?).
   - 2.4 Is the target set according to other targets?
     - Local programmes (same level or area of jurisdiction or not?).
     - Regional environmental programmes.
     - National programmes.
     - EU targets.
     - IPCC targets.
     - Other (which?)
   - 2.5 How is the area, for which the target is developed, delimited geographically?
     - Politically or administratively (i.e. according to agency and jurisdiction).
     - Functionally (e.g. as when using a commuter shed).
     - Other (in which way?).
3. Choosing the unit of measure
   - 3.1 Does the target concern CO_2 and/or greenhouse gases (GHG)?
   - 3.2 Does the target concern energy and/or CO_2.
   - 3.3 Why was this unit of measure chosen?
4. Defining and delimiting the activities
   - 4.1 Which activities are included in the target (e.g. all transports, private transports, transports by city employees; all energy use, energy use for heating, energy use for heating the city's amenities; all electricity, household electricity; or food, leisure, long-distance travels, and so on).
     - All activities (which?).
     - Some activities (which? And which are excluded)
   - 4.2 Why were these activities chosen?
   - 4.3 How are these activities defined and delimited?
   - 4.4 How are energy use and CO2 emissions calculated? (i.e. life-cycle or not; energy only, or energy and physical/technical structures).
     - Only direct energy use and CO_2 emissions resulting from included activities.
     - Through a life-cycle perspective on the energy used for the included activities.
     - Through a life-cycle perspective on the energy used and also on the embedded energy in physical/technical structures used for the included activities.
     - Other (how?).
   - 4.5 How are energy use and CO_2 emissions allocated?
     - To the producing facility.
     - To the consuming facility.
     - To the end-users in terms of households or individual consumers.
     - Other (how?).
5. Other questions
   - 5.1 In this questionnaire, are there any missing aspects that you would like to add?
   - 5.2 What are the main strengths with the targets, as developed for your City?
   - 5.3 What are the main weaknesses with the targets, as developed for you City?
   - 5.4 If you could change anything in the targets, as developed for you City, what would this be?

References

Baccini, P., Brunner, P.H., 1991. Metabolism of the Anthroposphere. Springer, Berlin.
Baynes, T., Lenzen, M., Steinberger, J., Bai, X., 2011. Comparison of household consumption and regional production approaches to assess urban energy use and implications for policy. Energy Policy 39 (2011), 7298–7309.
Copenhagen, 2009a. Copenhagen CLIMATE PLan – The Short Version. Available from: ⟨http://www.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment.aspx⟩.
Copenhagen, 2009b. Copenhagen Climate Plan – The Short Version. Available from: ⟨http://www.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment.aspx⟩.
Dhakal, S., Shrestha, R.M., 2010. Bridging the research gaps for carbon emissions and their management in cities. Energy Policy 38 (9), 4753–4755.
Dreborg, K.H., 1996. Essence of Backcasting. Futures 28 (9), 813–828.
Ellegård, K., 1999. A time-geographical approach to the study of everyday life of individuals – a challenge of complexity. GeoJournal 48 (3), 167–175.
European Green Capital, 2012. Official webpage. Available from: ⟨http://ec.europa.eu/environment/europeangreencapital/index_en.htm⟩.
Finnveden, G., Hauschild, M.Z., Ekvall, T., Guinee, J., Heijungs, R., Hellweg, S., Koehler, A., Pennington, D., Suh, S., 2009. Recent developments in life cycle assessment. Journal of Environmental Management 91, 1–21.
Finnveden, G., Moberg, Å., 2005. Environmental system analysis tools – an overview. Journal of Cleaner Production 13, 1165–1173.
Freiburg, 2011a. Freiburg Green City, Approaches to Sustainability. Available from: ⟨http://www.fwtm.freiburg.de/servlet/PB/menu/1182949_l1/index.html⟩.
Freiburg, 2011b. Head of Energy Department.
Glaeser, E., Kahn, M., 2010. The greenness of cities: carbon dioxide emissions and urban development. Journal of Urban Economics 67, 404–418.
GPC, 2012. Global Protocol for Community-Scale Greenhouse Gas Emissions. Pilot Version 1.0. Available from: ⟨www.c40cities.org/⟩.
Guinée, J.B., Udo de Haes, H.A., Huppes, G., 1993a. Quantitative life cycle assessment of products: 1. Goal definition and inventory. Journal of Cleaner Production 1, 3–13.
Guinée, J.B., Heijungs, R., Udo de Haes, H.A., Huppes, G., 1993b. Quantitative life cycle assessment of products: 2. Classification, valuation and improvement analysis. Journal of Cleaner Production 1, 3–13.
Guinée, J.B., Heijungs, R., Huppes, G., Zamagni, A., Masoni, P., Buonamici, R., Ekvall, T., Rydberg, T., 2011. Life cycle assessment: past, present and future. Environmental Science & Technology 45, 90–96.
Hamburg, 2011a. Hamburger Klima & Energiportal, Hamburg Climate Action Plan 2010–2011 Available from: ⟨http://klima.hamburg.de./klimaschutzkonzept⟩.
Hamburg, 2011b. Climate Control Center, Ministry of Urban Development and Environment.
Heinonen, J., Junnila, S., 2011a. Case study on the carbon consumption of two metropolitan cities. International Journal of Life Cycle Assessment 16, 569–579.
Heinonen, J., Junnila, S., 2011b. Implications of urban structure on carbon consumption in metropolitan areas. Environmental Research Letters 6, 014018.

Heinonen, J., Kyrö, R., Junnila, S., 2011. Dense downtown living more carbon intense due to higher consumption, a case study of Helsinki. Environmental Research Letter 6, 034034.
Hendrickson, C., Horvath, A., Joshi, S., Lave, L., 1998. Economic input–output models for environmental life-cycle assessment. Environmental Science & Technology 32, 184A–191A.
Hillman, T., Ramaswami, A., 2010. Carbon footprints and embodied carbon at multiple scales. Environmental Science & Technology 44 (6), 1902–1910.
Höjer, M., et al., 2011. Images of the future city, Time and space for Sustainable Development, first ed. Springer.
Hoornweg, D., Sugar, L., Trejos Gómez, C.L., 2011. Cities and greenhouse gas emissions moving forward. Environment and Urbanization 23 (1), 207–227.
Huppes, G., de Koning, A., Suh, S., Heijungs, R., van Oers, L., Nielsen, P., Guinée, J.B., 2006. Environmental impacts of consumption in the European union using detailed input–output analysis. Journal of Industrial Ecology 10 (3), 129–146.
ICLEI, 2009. International Local Government GHG Emissions Analysis Protocol (IEAP). Available from: ⟨www.iclei.org/index.php?id=ghgprotocol⟩.
ICLEI, 2011. Community-Scale GHG Emissions Accounting and Reporting Protocol. Available from: ⟨www.icleiusa.org/library/documents/Community_Protocol_Draft_Framework.pdf⟩.
IPCC (Intergovernmental Panel on Climate Change), 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Available from: ⟨www.ipcc-nggip.iges.or.jp/public/2006gl/index.html⟩.
ISO, 2006. ISO 14040 International Standard. In: Environmental Management – Life Cycle Assessment – Principles and Framework. International Organisation for Standardization, Geneva, Switzerland.
Jeswani, H.K., Azapagic, A., Schepelmann, P., Ritthoff, M., 2010. Options for broadening and deepening the LCA approaches. Journal of Cleaner Production 18, 120–127.
Jonsson, D.K., Gustafsson, S., Wangel, J., Höjer, M., Lundqvist, P., Svane, Ö., 2011. Energy at your service: highlighting energy usage systems in the context of energy efficiency analysis. Energy Efficiency 4, 335–369.
Joshi, S., 1999. Product environmental life-cycle assessment using input–output techniques. Journal of Industrial Ecology 3 (2–3), 95–120.
Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havránek, M., Pataki, D., Phdungsilp, A., Ramaswami, A., Mendez, G.V., 2009. Greenhouse gas emissions from global cities. Environmental Science and Technology 45 (8), 3816–3817.
Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havránek, M., Pataki, D., Phdungsilp, A., Ramaswami, A., Mendez, G.V., 2010. Methodology for inventorying greenhouse gas emissions from global cities. Energy Policy 38 (9), 4828–4837.
Larsen, H.N., Hertwich, E.G., 2010. Implementing carbon-footprint-based calculation tools in municipal greenhouse gas inventories. Journal of Industrial Ecology 14 (6), 965–977.
Lave, L.B., Cobas-Flores, E., Hendrickson, C.T., McMichael, F.C., 1995. Using input–output analysis to estimate economy-wide discharges. Environmental Science and Technology 29, 420A–426A.
Lebel, L., Garden, P., Banaticla, M.R.N., Lasco, R.D., Contreras, A., Mitra, A.P., Sharma, C., Nguyen, H.T., Ooi, G.L., Sari, A., 2007. Integrating carbon management into the development strategies of urbanizing regions in Asia – Implications of urban function, form, and role. Journal of Industrial Ecology 11 (2), 61–81.
Lenzen, M., 2000. Errors in conventional and input–output-based life-cycle inventories. Journal of Industrial Ecology 4, 127–148.
Lenzen, M., Dey, C., Foran, B., 2004. Energy requirements of Sydney households. Ecological Economics 49, 375–399.
Malmö, 2011a. Climate-Smart Malmö, Making Sustainability a Reality. Available from: ⟨http://www.malmo.se/download/18.58f28d93121ca033d5e800079/Klimatbroschyr_090409EN.pdf⟩.
Malmö, 2011b. Miljöprogram för Malmö stad 2009–2020. Available from: ⟨http://www.malmo.se/Medborgare/Miljo–hallbarhet/Miljoarbetet-i-Malmo-stad/Miljoprogram-for-Malmo-stad.html⟩.
Malmö, 2011c. Begränsad klimatpåverkan. Available from: ⟨http://www.malmo.se/Medborgare/Miljo–hallbarhet/Miljolaget-i-Malmo/Miljon-2008.html⟩.
Malmö, 2011d. Miljöförvaltningen, Malmö.
Matthews, H.S., Hendrickson, C.T., Weber, C.L., 2008. The importance of carbon footprint estimation boundaries. Environmental Science and Technology 42, 5839–5842.
Miller, R., Blair, P.D. (Eds.), 1985. Input–Output Analysis: Foundations and Extensions. Prentice Hall, New Jersey.
Mindali, O., Raveh, A., Salomon, I., 2004. Urban density and energy consumption: a new look on old statistics. Transportation Research Part A: Policy and Practice 38 (2), 143–162.
Moll, H.C., Noorman, K.J., Kok, R., Engström, R., Throne-Holst, H., Clark, C., 2005. Bringing about more sustainable consumption patterns: analysing and evaluating the household metabolism in European countries and cities. Journal of Industrial Ecology 9, 259–276.
Münster, 2011a. Klimaschutzkonzept 2020 für die Stadt Münster. Available from: ⟨http://www.muenster.de/stadt/umwelt/klima_energie.html⟩.
Münster, 2011b. Amt für Grünflächen und Umweltschutz Koordinierungsstelle für Klima und Energie.
Murakami, S., Kawakubo, S., Asami, Y., Ikaga, T., Yamaguchi, N., Kaburagi, S., 2011. Development of a comprehensive city assessment tool: CASBEE-City. Building Research and Information 39 (3), 195–210.
Nantes, Métropole, 2006. Assistance à l'élaboration d'un outil d'évaluation des consommations énergétiques et des émissions de CO_2.
Nantes, Métropole, 2011. Project Office, Energies Unit Nantes Métropole.
Ness, B., Urbel-Piirsalu, E., Anderberg, S., Olsson, L., 2006. Categorising tools for sustainability assessment. Ecological Economics 60 (3), 498–508.
Oslo, 2009. Climate and Energy Strategy. Available from: ⟨http://www.byradsavdeling-for-miljo-og-samferdsel.oslo.kommune.no/miljo_og_klima/english/climate_and_energy_strategy/⟩.
Palm, V., Wadeskog, A., Finnveden, G., 2006. Swedish experiences of using environmental accounts data for integrated product policy (IPP) issues. Journal of Industrial Ecology 10 (3), 57–72.
Persson, Å., Jonsson, D.J., Nilsson, L.J., Nilsson, M., Finnveden, G., 2007, Kompletterande miljömål med fokus på sektorsmål. TRITA-INFRA-FMS: 13. KTH, Stockholm.
Ramaswami, A., Hillman, T., Janson, B., Reiner, M., Thomas, G., 2008. A demand-centered, hybrid life-cycle methodology for city-scale greenhouse gas inventories. Environmental Science and Technology 42 (17), 6455–6461.
Ramaswami, A., Chavez, A., Ewing-Thiel, J., Reeve, K.E., 2011. Two approaches to greenhouse gas emissions foot-printing at the city scale. Environmental Science and Technology 45 (10), 4205–4206.
Schulz, N., 2010. Delving into the carbon footprints of Singapore-comparing direct and indirect greenhouse gas emissions of a small and open economic system. Energy Policy 38, 4848–4855.
Schwietzke, S., Griffin, W.M., Matthews, H.S., 2011. Relevance of emissions timing in biofuel greenhouse gases and climate impacts. Environmental Science and Technology 45, 8197–8203.
SEI, 2012. Global miljöpåverkan och lokala fotavtryck – analys av fyra svenska kommuners totala konsumtion (Global Environmental Impact and Local Footprints – An Analysis of the Total Consumption of Four Swedish Municipalities) ISBN: 978-91-86125-39-4. Last accessed 2012-09-20 at ⟨www.sei.se⟩.
Sovacool, B.K., Brown, M.A., 2010. Twelve metropolitan carbon footprints: a preliminary comparative global assessment. Energy Policy 38 (9), 4856–4869.
Stockholm, 2010. The City of Stockholm's Climate Initiatives. Available from: ⟨http://www.stockholm.se/KlimatMiljo/Klimat/⟩.
Stockholm, 2011. Climate Coordinator, City of Stockholm.
Suh, S., Lenzen, M., Treloar, G.J., Hondo, H., Horvath, A., Huppes, G., Jolliet, O., Klann, U., Krewitt, W., Moriguchi, Y., Munksgaard, J., Norris, G., 2004. System boundary selection in life cycle inventories using hybrid approaches. Environmental Science and Technology 38, 657–664.
Suh, S. (Ed.), 2009. Handbook of Input Output Economics in Industrial Ecology. Springer, Dordrecht, Heidelberg, London, New York.
Säynäjoki, A., Heinonen, J., Junnila, S., 2012. A scenario analysis of the life cycle greenhouse gas emissions of a new residential area. Environmental Research Letter 7, 10.
Tukker, A., Jansen, B., 2006. Environmental impacts of products: a detailed review of studies. Journal of Industrial Ecology 10 (3), 159–182.
Tukker, A., Poliakov, E., Heijungs, R., Hawkins, T., Neuwahl, F., Rueda-Cantuche, J.M., Giljum, S., Moll, S., Oosterhaven, J., Bouwmeester, M., 2009. Towards a global multi-regional environmentally extended input–output database. Ecological Economics 68, 1928–1937.
Weber, C.L., Matthews, H.S., 2008. Quantifying the global and distributional aspect of American carbon footprint. Ecological Economics, 379–391.
Weidema, B., Notten, P., Suh, S., 2006. Prioritising within the product-oriented environmental policy – The Danish perspectives. Journal of Industrial Ecology 10 (3), 73–87.
Wiedmann, T., Lenzen, M, Turner, K., Barrett, J., 2007. Examining the global environmental impact of regional consumption activities — Part 2: Review of input–output models for the assessment of environmental impacts embodied in trade. Ecological Economics 61, 15–26.
Wiedmann, T., Wilting, H.C., Lenzen, M., Lutter, S., Palm, V., 2011. Quo Vadis MRIO? Methodological, data and institutional requirements for multi-region input–output analysis. Ecological economics 70, 1937–1945.
Williams, K., 1999. Urban intensification policies in England: problems and contradictions. Land Use Policy 16 (3), 167–178.
Wrisberg, N., Udo de Haes, H.A., Triebswetter, U., Eder, P., Clift, R., 2002. Analytical tools for environmental design and management in a systems perspective. Kluwer Academic Publishers, Dordrecht.
WRI-WBCSD, 2004. A Corporate Accounting and Reporting Standard. Available from: ⟨www.ghgprotocol.org/standards/corporate-standard⟩. World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).
WRI-WBCSD, 2011. Corporate Value Chain (Scope 3) Accounting and Reporting Standard. Available from: ⟨www.ghgprotocol.org/standards/scope-3-standard⟩. World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).