2 DEGREES – understanding the contribution of cities to a carbon neutral society

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Abstract. Climate change is understood to be a factual situation to deal with and the world community has agreed with the Paris agreement of 2015 to limiting global warming to 2 °C above the pre-industrial state. Cities and urban areas are at the core of anthropogenic climate emissions. So far, however, cities are not generally recognized as major action fields for a climate neutral society. Yet, individual examples of cities with a strong climate neutral agenda prove the overall societal and economic advantage of their actions.
This study analyses 15 European cities to understand the influence and potentials, local actions and political activities as well as targets that cities can take and define to mitigate climate change and contribute to the global 2-degree goal. The empirical evaluation of the cities was conducted in 2017, using the science-based targets approach on public buildings as initial pilot. The study identifies critical internal and external success factors for effective climate engagements, particularly from the 1/3 of the cities whose strategies comply with the 2-degrees target. Criteria and levers are derived that help cities transform into low carbon communities. From that, a framework model and operational guidance are developed, binging cities in the position to develop their individual path towards the 2-degree goal.
The results of the study are demonstrated by the case of the Swedish community of Växjö, showcasing how the early and broad adoption of low carbon policies and actions results in overall economic growth and prosperity as a 'green community'.

1. Background and Introduction

The summer of 2018 lead to a fundamental change in the broad public reception of the subject of climate change. To broad parts of society in Central Europe, it became evident that climate change does already take place [1]. The global climate has warmed since the beginning of the industrial revolution of the 18th century by about 1 degree Celsius. Also, until 2013, 12 of the 14 highest annual average temperatures occurred in the time frame from 2000 to 2013 [2]. Overall, a broad consensus has been found on the need for action against climate change and even the youth increasingly raise their voice to demand for action [3].

In 2015, the parties of the Paris COP 21 conference (United Nations Framework Convention on Climate Change, 21st Conference of the Parties) agreed to limit global warming to below 2°C, or even 1,5°C compared to the pre-industrial state [4]. With ¾ of the world's population soon living in urban areas, cities are a major player for effectively mitigating climate change. For municipal administrations, however, effectively acting against climate change is a major challenge, as conventional mechanisms of administrating a city fall short for doing what needs to be done to save the climate.

This study analyzed the activities of 15 European cities to understand their current activities towards mitigating climate change. From this analysis, mechanisms were derived to help municipalities be

successful in working against climate change. Obviously, cities and municipalities have a broad range of action fields to engage in working against climate change. This study explicitly focuses on the municipal building stock, as this is one of the common fields for all municipalities. Also, the municipal building stock is of special interest due to it's potential or actual function as a role model for the private real estate industry. With this focus, the relevance of other sectors like mobility and transportation should not be negated, but here, a more city-wise view into municipal activities is required. Also, some findings are believed to be applicable or transferable to other municipal activities, without further elaboration of this point in the study.

2. Empirical analysis of municipal activities

To gather information on how cities and municipalities[1] act against climate change, data from several European cities is assessed. Both, by means of a questionnaire based inquiry with the cities and by applying the Science Based Target (SBT) method [5] to understand the contributions of cities to the 2°C-target.

2.1. Methodology

Quantifying the carbon emissions of a city or municipality forms the basis for understanding or even defining a carbon reduction target for the city or municipality. The quantification of carbon emissions follows the Greenhouse Gas Protocol, more specifically the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories [6].

This protocol defines three different scopes for emissions. Scope 1 refers to direct emissions from activities and operations within the city boundaries. Scope 2 denotes emissions from Energy production and distribution, both in- and outside the city boundaries and Scope 3 relates to upstream emissions for any goods or services imported into the city boundaries. For municipalities, the three scopes analogously relate to activities and operations that are directly associated with municipal buildings and facilities or that are imported directly to municipal facilities.

For the purpose of this study, the focus lies on municipal buildings. Municipal administrations generally serve as local role models for their cities so that any climate change actions of municipalities most likely relate to their buildings and facilities. In addition to that, municipal buildings are directly available for local administrations to establish climate actions.

With the help of a questionnaire, information was collected from the involved municipalities on their approach to climate action for municipal buildings. The survey covered both, a section on a municipality's perspective on climate change and a section on their actual carbon reduction targets. The aim of the survey was particularly to understand whether the cities' current engagement in climate actions (in the municipal building sector) conforms with the 2-degree target and to identify critical success factors and barriers towards successful climate mitigation actions.

For this, the Science Based Targets method framework [5] is used. It provides a set of mechanisms that allow to derive sectoral, company- or city-specific greenhouse gas emission budgets and reduction pathways from the 2-degree target from Paris. To calculate the required changes in emissions for each of the study cities, the Sectoral Decarbonization Approach (SDA) [7] is used. This method breaks down the overall carbon emission budgets to sectors and finally to individual companies or cities.

The required emission reduction based on the SDA calculations are compared with (partially estimated) current reduction targets that the respective municipalities have defined.

2.2. Results and findings

The survey and the subsequent calculations of the required emission reductions for the cities present a diverse landscape. Some cities have actively used the Science Based Target method before to define

[1] In this article, 'city' refers to the geographical boundaries for a dedicated urban area (and this can also include an entire metropolitan area), while 'municipality' denotes the administrative bodies of a city government.

their individual 2-degree targets and act accordingly. Other cities have no targets in place that exceed national legal requirements and correspondingly have no dedicated climate actions planned.

2.2.1. Cities' current engagement in climate action. A total of 42% of the participating cities with enough data (n=12) have targets defined that comply with the 2-degree target. A much larger portion of the participating cities – 73,3% - however, consider their carbon reduction targets to be very ambitious and only 1/3 of the participants have faith in meeting the targets in the defined time frame. This also stands in some contrast to the finding that all cities state that their city is already affected by the consequences of climate change and that the effects of global warming are a relevant issue for their city.

The carbon reduction targets that cities have defined typically are derived from the current situation and are defined in a way that reaching these targets can be achieved with small or reasonable effort. Two thirds of the cities adopt targets from national or EU-targets, and 1/3 of the cities have targets that reach beyond national targets. Only 10% of the participating cities align their targets with IPCC indications.

The survey also concluded that Scope 1 and 2 emissions from cities particularly stem from fossil fuel. This leads to the conclusion that increased energy efficiency for buildings, optimizing energy systems and grids for the entire city, changing energy sources, e.g. towards biomass, and working to influence citizen behavior are among the most effective mechanisms to mitigate climate change.

In addition to that, the survey also made very clear that cities also highly depend on external factors, particularly the decarbonization of external energy supply. While some cities actively work on reducing dependency from external energy sources, for other cities, this appears to be a significant obstacle towards carbon reduction.

2.2.2. Findings from applying the Science Based Targets model. As said, the carbon emission reduction targets of 42% of the cities are aligned with the 2-degrees target. For this alignment, the cities' building sector requires an average emission reduction of 26% by 2030.

Table 1 sets the required emission reduction targets that have been calculated for each city (if enough data was available) with the Sectoral Decarbonization Approach (SDA) in relation to the cities' actual reduction targets for 2030.

Table 1. Cities' required emission reduction according to SDA & estimated current reduction pathways for 2030.

City	Required emission change (negative = reduction), based on SDA	Current reduction target (estimate) (positive = reduction)
Aachen	-32%	< 32%
Aberdeen	n/a	n/a
Aarhus	-22%	100%
Bergen	-3%	100%
Bremen	-50%	< 60%
Erlangen	-18%	7%
Glasgow	-64%	< 64%
Helsinki	-34%	< 34%
Karlsruhe	-37%	16%
Leeds	n/a	n/a
Limerick	-10%	35%

Munich	n/a	n/a

Table 1 (cont'd). Cities' required emission reduction according to SDA & estimated current reduction pathways for 2030.

City	**Required emission change (negative = reduction), based on SDA**	**Current reduction target (estimate) (positive = reduction)**
Pamplona	-1%	8%
Plock	-55%	< 55%
Växjö	+21%	100%
Average	**-26%**	**n/a**

The table shows clearly that the current ambitions of cities are higly diverse – from a 7% reduction target (Erlangen) to a complete decarbonization (Aarhus, Bergen, Växjö). One exceptional case is the one of Växjö. Due to their very early adoption of climate change mitigation actions – see section 3 – Växjö currently has a lower carbon emission profile than what would be required for a reduction path for 2030. This leads to a hypothetical additional emission budget, which is reflected by the positive number for the required emission change. Obviously, the actual effect of this situation is that Växjö has a major advantage to other cities when moving to their own target of complete decarbonization of the municipal building sector by 2030.

The table makes it clear that most cities face major challenges in the coming decade, when moving towards contributing their share to the Paris agreement.

2.2.3. Critical Success Factors. From the survey, internal and external factors are derived which have significant influence on a city's success in moving towards decarbonization. External factors, particularly the geographical location and the available natural environment have a major influence on the energy demand and on available local energy sources (e.g. availability of power generation from wind and water, availability of biomass). Also, changes in the grid energy mix cannot be easily influenced but have a major impact on the carbon emissions associated with the building sector.

In contrast to those external factors, a set of internal factors are identified as critical to success in achieving significant emission reductions. These critical success factors are

- Commitment,
- Collaboration,
- Funding,
- Capabilities.

Commitment refers to establishing a consistent thinking across all departments of a municipal administration base on developing and sharing a long-term vision. A common understanding towards decarbonization across political parties has repeatedly been reported to be essential for long-term success beyond single legislative periods. Also, higher political support for administrative actions is essential for successful execution of climate change mitigation measures.

Collaboration across departments inside the municipal administration is essential and requires efficient structures. Complex structures with a diversity of ownership and management / operational responsibility for municipal buildings, in contrast, are a significant challenge. Also, effective collaboration with non-municipal stakeholders of a city is critical for success. Available instruments need to be exercised and trained, e.g. Public-Private-Partnerships (PPP) with Energy-Service-Companies (ESCOs).

Funding refers to typically high initial investments for carbon-saving measures. Particularly if long-term financial savings from taking actions are neglected – as is typically the case – funding with available sources may be a challenge. While some funding resources from national and European

programs may be available, climate change mitigation measures require sufficient initial financial resources.

Capabilities refers to the need for skilled and educated staff within the municipal administration to support changes in technologies and approaches. But it also refers to the need for (not only financial) resources, e.g. with enough skilled workers at construction companies to effectively execute measures.

3. Case Study: The City of Växjö, Sweden

One of the forerunners of urban climate actions surely is the city of Växjö in Småland, Sweden. The case of the city of Växjö is elaborated with reference to the above-named critical success factors. Växjö is a city with a population of 92.000 and an economic growth of more than 30% (GDP) from 1993 to 2015.

Commitment: The city's initial focus on environmental issues dates back to the 1960s, when the city started to take action against pollution of their surrounding lakes. In the following decades, the city continued to not only remediate polluted areas but also to step into biomass based district heating, increasing use of local renewable energy and to respond to the United Nation's program for sustainable development, the Agenda 21 [8]. The city of Växjö decided to take a leading role in sustainable development in Sweden and adopted their environmental policy in 1993 and started to monitor per-capita-CO_2-emissions.

As early as in 1996, Växjö announced for the first time the ambition to become a fossil-fuel-free city, which is now targeted for 2030, including homes, industry, and transportation – including planes taking off from the local airport.

Collaboration: Along the long-term chain of activities in Växjö, the municipal administration continuously engaged with all stakeholders in the city. This includes initiatives to influence the behavior of citizens, as well as providing support to act appropriately. Apart from providing cheap district heating (see below) from local biomass-sources, Växjö also secured attractive public transport to encourage citizens to stay away from fossil fuel powered cars, as an example.

Funding: One of the effects of Växjö's early uptake of environmental awareness and actions was that both, national Swedish and European funding was repeatedly available for new projects. Also, because of Växjö's early shift to biomass-based district heating, the city was able to offer cheap renewable energy to their citizens, when Sweden introduced a CO_2-tax in 1991.

Overall, the focus on sustainable development allowed the city of Växjö to reduce CO_2-emissions by 58% from 1993 to 2016, while securing a GDP-growth of 32% from 1993 to 2015.

Capabilities: From the municipality's feedback, it became clear that a general entrepreneurial culture and openness to try new ideas among the citizens was a very helpful basis to engage in sustainable development. Also, a general desire for independence from outside energy suppliers, fueled by the oil crises of the 1970s and 1980s, greatly supported the city's move towards local, fossil-fuel-free energy supply.

Overall, the case of Växjö nicely demonstrates how all of the named critical success factors need to be integrated in a positive way for a city to be successful in integrating sustainable development and mitigating climate change.

4. Framework model to support cities act towards the 2-degrees target

Both, the cities-survey, as well as a study from C40 Cities[2] and ARUP [9] clearly indicate that cities generally need to increase engagement towards climate change mitigation. Also, it is clear that many cities require active support to do so. Overall, required technologies to change to low carbon activities are available, yet the uptake of these technologies and the execution of climate actions is the problem.

[2] C40 Cities is a network of almost 100 of the world's largest cities, aiming at increasing climate actions and promoting sustainable development. www.c40.org

For this means, a management plan is presented, called "Navigating the Path". It utilizes the identified critical success factors and provides a concrete framework for bringing cities into action.

4.1. Navigating the Path

Core of this management plan is designing climate action plans. Such a climate action plan reflects a comprehensive approach to urban concepts, accounting for all aspects that matter, both directly for climate change mitigation, as well as for integrating climate actions into the municipality's and city's traditional activities.

Basis of the management plan is the calculation of the relative contribution of a city to limiting global warming, by using the Science Based Target approach (particularly the Sectoral Decarbonization Approach). With the derived emission reduction targets, a solid, manageable target is defined.

The actual management objectives are developed from interpreting the above-named critical success factors for the respective city. In that sense, it must be noted that a general understanding of the elements of a management plan may be generic, while the concrete management plan must be specifically tailored to a city's situation. Any "one-fits-all" management advice were too arbitrary to provide meaningful guidance.

4.2. Critical success factor "Commitment"

As a basis, accurate and current data is required for any action on climate change. With a solid data foundation, a Science Based Target calculation can be executed. It is important to also integrate the city's future economic development and to differentiate between sectors, in order to provide a clear picture on goals and their economic value. This will form the basis to develop a common understanding, avoiding confusion or uncertainty on the relevance of the information and the targets, bringing faith in the decisions to be taken.

One useful guidance document for setting targets for reducing carbon emissions is a set of four action areas with 12 opportunities that have been identified in a study "Focused acceleration" from C40 and McKinsey [10]. These four action areas are:

- Decarbonizing the electricity grid,
- Optimizing energy use in buildings,
- Enabling next-generation mobility,
- Improving waste management.

The study "Focused acceleration" also estimates the share of 2030 emission targets that a single opportunity may deliver. Using these action areas and the dedicated opportunities in combination with the calculated SBT-based reduction targets, a city can obtain very specific, operational targets to work against.

4.3. Critical success factor "Collaboration"

The imperative of active collaboration should not be considered to be different for climate change mitigation actions. Moreover, a general understanding of the obstacles and barriers for collaboration need to be adopted to the matter.

Important elements to operate with may be transparency on the different and potentially competing objectives of stakeholders, engaging in aligning these objectives, as well as moderating lack of understanding and the different perspectives towards a situation. Quite frequently, the involvement of external experts on the subject as moderators and solution developers is a very feasible means of improving collaboration.

4.4. Critical success factor "Funding"

With about 70% of the surveyed cities lacking the appropriate financial resources, external experts may cooperate with a municipality's budgetary department to identify the required funding. This requires to consider all available funding sources and to develop reliable business cases for urban climate projects.

This may also include the identification and development of alternative financing instruments as well as the development of public-private partnerships.

4.5. Critical success factor "Capabilities"

For the critical success factor *Capabilities*, a direct focus on the above-named action areas helps to understand the need for the right skills. Once the specific opportunities to engage in climate actions are identified, internal and external experts can start with developing project roadmaps.

For the action area *Decarbonizing the electricity grid*, both, a thorough understanding of conventional and innovative electricity generation and storage technologies is required, as well as a solid approach to grid management and organization.

For the action area *Optimizing energy use in buildings*, often a broader perspective than the traditional view on a building, omitting user-induced energy consumption is needed. The required capabilities range from innovative processes and methods (Building Information Modeling – BIM to Lean Construction Management – LCM) to understanding the inter-dependencies of energy consumption with other aspects of buildings, typically integrated by green building certification schemes.

In the action area *Enabling next-generation mobility*, the focus will avert from the car-centric transportation planning to ease transportation without cars and to integrate novel transportation technologies.

In the action area *Improving waste management*, the focus will move from recycling or disposing of waste to real circularity in all material streams. This will increasingly include the cities' buildings and construction works to be understood as valuable resource repositories. Also, focus will grow on aligning supplier, distributor and consumer networks regionally to optimize material streams.

In addition to these action areas, the field of *Digitization* will play a vital role in changing cities' approach to new objectives such as climate change mitigation. Here, this is even more the case as climate actions intensely rely on various stakeholders and large groups of citizens to align on specific actions which are based on solid data. Hence, ICT technologies and solutions are required for a wide range of objectives, typically integrating large sets of data and providing meaningful interpretation of the data to support decision making.

5. Summary and conclusions

The empirical study done with 15 European cities on their current situation in the field of mitigating climate change shows a diverse picture. The cities' engagement ranges from essentially being compliant with current laws to thorough strategies for becoming fossil-fuel free within a decade. Only a small portion of cities have set carbon reduction targets that comply with the 2-degrees target that has been defined in the Paris agreement of 2015.

The Science Based Targets method provides a very useful framework to derive carbon emission reduction targets from the 2015 Paris agreement to the level of an individual city and dedicated sectors of the city. The Science Based Targets method is also used to estimate the cities' current position on the way to comply with the 2-degrees target and the required reduction targets.

One impressive example of how a city has developed into a forerunner of climate action is the city of Växjö, Sweden. This city has managed to achieve significant economic growth while decarbonizing the city to quite an extend already. Moreover, it has a clear plan to become fossil-fuel free (including planes staring from the local airport) by 2030.

From the survey, four critical success factors, commitment, collaboration, funding and capabilities are derived. These critical success factors must be positively addressed to enable successful climate actions.

From these insights, a management plan "Navigating the Path" has been developed, covering the critical success factors on a framework level. This management plan gives guidance on how to tackle

the points raised and on how to engage in climate action to reach carbon emission reduction targets, which have been defined before.

Overall, the study clearly shows the need for cities to actively assume responsibility for their contribution to meeting the 2-degrees target. It shows that some cities did become active quite some time ago and it provides an instrument for other cities to effectively follow. With the developed management plan, cities have been enabled to break down the hard to digest objective of acting to meet the 2-degrees target into operational tasks to reduce carbon emissions.

A more elaborate report on that matter [11] is available with the authors.

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References

[1] Schmitt S 2018 Klimawandel: Zukunft im Schwitzkasten *Zeit Online / DIE ZEIT* **2018**
[2] Mäder C, Richter S and Lehmann H 2013 *Globale Erwärmung im letzten Jahrzehnt?* (Dessau: Umweltbundesamt)
[3] SPIEGEL ONLINE 2019 *Schüler Streiken in mehr als hundert Ländern für Klimaschutz* http://www.spiegel.de/lebenundlernen/schule/fridays-for-future-schueler-streiken-in-mehr-als-hundert-laendern-fuer-klimaschutz-a-1257972.html (accessed 15 Mar 2019)
[4] Umweltbundesamt 2018 *Klimarahmenkonvention* https://www.umweltbundesamt.de/daten/klima/klimarahmenkonvention (accessed 15 Mar 2019)
[5] Science Based Targets Initiative 2019 *What is a science-based target?* https://sciencebasedtargets.org/what-is-a-science-based-target/ (accessed 15 Mar 2019)
[6] Fong W K, Sotos M, Doust M, Schultz S, Marques A and Deng-Beck C 2015 *Global protocol for community-scale greenhouse gas emission inventories: An accounting and reporting standard for cities* ([Washington, District of Columbia]: World Resources Institute)
[7] Linthorst G, Beer J de, Blok K and Meindertsma W 2015 *Sectoral Decarbonization Approach (SDA): A method for setting corporate emission reduction targets in line with climate science: Version 1* (Science Based Targets Initiative)
[8] United Nations *Agenda 21: United Nations Conference on Environment & Development, Rio de Janeiro, Brazil, 3 to 14 June 1992* (United Nations)
[9] C40 Cities and ARUP 2016 *Deadline 2020: How cities will get the job done* (London: C40 Cities and ARUP)
[10] Watts M *et al* 2017 *Focused acceleration: A strategic approach to climate action in cities to 2030* (McKinsey Center for Business and Environemt and C40 Cities)
[11] Blumberg M and Grassl G 2019 *Bridging the climate gap: An assessment of cities' current engagement toward global climate targets* (Stuttgart, Echterdingen: thinkstep AG and Drees & Sommer SE), ISBN 978-3-9820674-0-7.