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CO_2-neutral in cities and neighbourhoods – the European and international perspective

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Dear Readers,

The concentration of greenhouse gas emissions in the atmosphere is at record high. Cities do play a crucial role in reducing CO_2 emissions. Two figures illustrate this: 54 per cent of the world population live in cities and 70 per cent of the global CO_2 emissions originate in cities.

Cities therefore are crucial actors in implementing measures to reducing greenhouse gas emissions. The documentation thus focuses on the city as the field of intervention from a comparative European and worldwide perspective. It focuses on neighbourhood approaches on CO_2 reduction with regard to buildings, mobility and green spaces.

Interviews with partners deliver insights into the strategies of cities in practice. The good practices presented may deliver inputs for decision-takers to take further concrete steps in reaching the targets agreed upon at the UN conferences in Paris and Marrakesh.

I wish you happy and instructive reading.

Director and Professor Harald Herrmann

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AD	Activity Data
AKEF	Amsterdams Klimaat en Energiefonds
BAU	Business-As-Usual
BEECs	Building Energy Efficiency Codes
BEI	Baseline Emissions Inventory
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (GER)
CA	Climate Alliance
CAS/IPM	China Academy of Science Institute for Policy Management
cCR	carbonn® Climate Registry
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CH_4	Methane
CIA	Central Intelligence Agency
CNC	Climate Neutral Cities
CNCA	Carbon Neutral Cities Alliance
COM	Compact of Mayors
COP	Conference of the Parties der UNFCCC
CO_2	Carbon dioxide
$CO_2e(q)$	Carbon dioxide equivalent
CSO	Civil Society Organizations
DEFRA	Department for Environmental, Food & Rural Affairs (UK)
EF	Emission factor
EIA	Energy Information Administration (US)
EnEV	Energieeinsparverordnung (Energy Conservation Ordinance)
EnEG	Energieeinsparungsgesetz (Energy Conservation Law)
EPBD	Energy Performance of Buildings Directive
ESCI	Emerging and Sustainable Cities Initiative
ESG	Effizienzstrategie Gebäude (Energy Efficiency Strategy for Buildings)
EU	European Union
EU-ETS	European Union Emission Trading Scheme
EUR	Euro
FSB	Financial Stability Board
GCC	Green Climate Cities

GCF	Green Climate Fund
GCIF	Global City Indicators Facility
GCP	Global Carbon Project
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GPC	Global Protocol for Community-Scale GHG Emissions Inventories
GRIP	Greenhouse Gas Regional Inventory Protocol
Gt	Gigaton
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HEAT+	Harmonized Emissions Analysis Tool plus
ICAP	International Carbon Action Partnership
ICLEI	International Council for Local Environmental Initiatives
IEA	International Energy Agency
IEAP	International Local Greenhouse Gas Analysis Protocol
IEEP	Institute for European Environmental Policy
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
KfW	Kreditanstalt für Wiederaufbau
KPI	Key Performance Indicators
KSP	Klimaschutzplan (Climate Protection Plan)
LC2	Low Carbon, Livable Cities Initiative
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
LULUCF	Land use, land-use change and forestry
MMR	EU Greenhouse Gas Monitoring Mechanism Regulation
MRV	Measuring, Reporting, and Verification
NAP	National Adaptation Plan
NAZCA	Non-State Actor Zone for Climate Action
NDRC	National Development Reform Commission
NF_3	Nitrogen trifluoride
NGO	Non-governmental organization
N_2O	Nitrous oxide
nZEB	Net Zero Energy Building

PESTLE	**P**olitical, **E**conomic, **S**ocial, **T**echnological, **L**egal, **E**nvironmental
PFCs	Perfluorocarbons
PPM	Parts per million
R20	Regions for Climate Action
SDG	Sustainable Development Goals
SF_6	Sulfur hexafluoride
TUHF	Trust for Urban Housing Finance
UCLG	United Cities and Local Government
UN	United Nations
UN-EP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-DESA	United Nations Department for Economic and Social Affairs
UN-Habitat	United Nations Human Settlements Programme
Urban-LEDS	Urban Low Emission Development Strategies
USD	US dollar
USDN	Urban Sustainability Directors Network
WHO	World Health Organisation
WBGU	Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (GER)
WMCCC	World Mayors Council on Climate Change
WRI	World Resources Institute
WWF	World Wildlife Fund
ZECOS	Communal Zero $C0_2e$ Emission Certification System

1. Summary

(Jointly produced by principal and contractor)

1.1 Background information

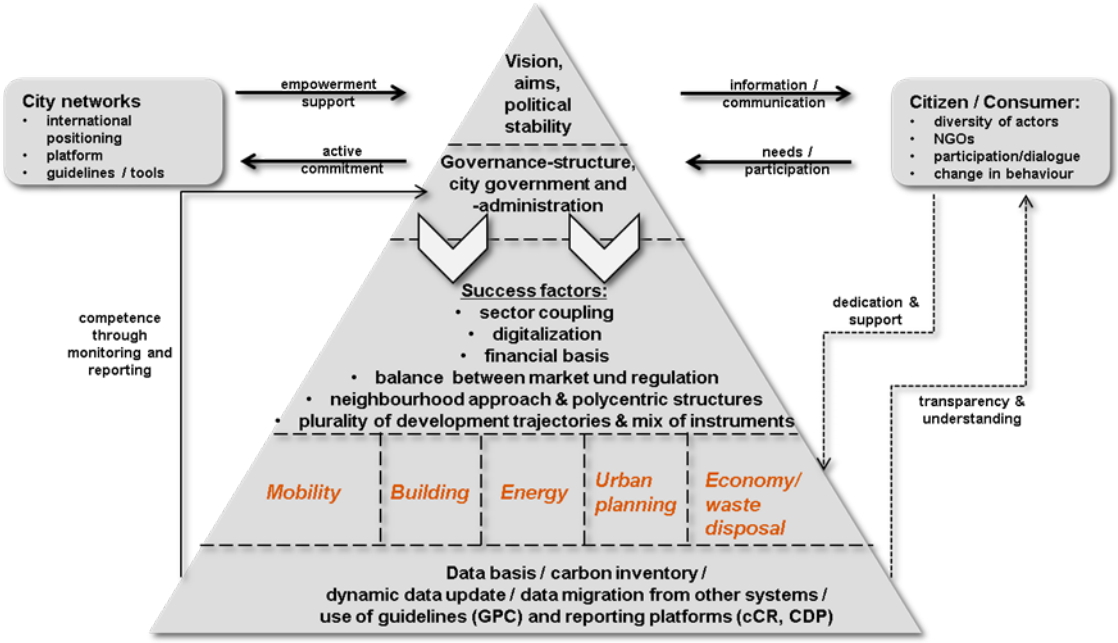
- The current concentration of greenhouse gases (GHG) in the atmosphere is at a record high. Since the year 2011, the anthropogenic (human-made) emissions consistently exceeded the 50 Gt CO_2e/year mark.
- Anthropogenic emissions of GHG are the main cause of climate change and global warming. Cities play an important role, as they cover only 3 percent of the overall land surface, but account for approximately 70 percent of all GHG emissions.
- In 2015, approx. 54 percent of the global population lived in urban areas. Until 2050, this urbanisation rate will increase to 66 percent along with a simultaneous population growth of 2.15 billion people.
- The increasing urbanisation rate has significant consequences as it raises, ceteris paribus, the amount of GHG emissions throughout all sectors. Efficiency enhancements, behavioural changes and other approaches to achieving a sustainable reduction in consumption must therefore not only be useful in order to limit the current level of emissions, but simultaneously be able to compensate for the effects of ongoing urbanisation and population trends.
    - In the context of the 21st United Nations conference on climate change in 2015 (Conference of the Parties COP21), the goal to limit global warming to at least 2° C compared to the pre-industrial level has been agreed. The thus remaining carbon budget amounts to approx. 750 billion tons. In order to achieve this goal, all participating countries have to set up national climate action plans (Intended Nationally Determined Contributions INDCs) and fulfil their defined targets. This especially implies intense efforts at a municipal level. Cities can both be the cause and solution in the context of the urgent need to limit the climate change.

1.2 Key findings of this study

(1) Until now, international agreements and efforts to limit climate change have been insufficient in terms of dealing with the important role of cities within the decarbonisation process. This is due to the fact, that centralistic approaches dominate, which primarily focus on the national level. In some countries, however, national climate goals and INDCs have already been broken down to regional as well as municipal levels and constitute sufficient contributions at this level. Such approaches have to be intensified in order to achieve the overall objectives regarding decarbonisation.

(2) A central finding of this report is the substantial importance of effective urban planning and management processes for the realization of decarbonisation strategies at a local level. Hence there is a strong need for "good urban governance" (see Figure 1). The scope for action at the level of local decision-makers is very heterogeneous and varies throughout the world. Specifically in emerging and developing countries, one can find major inadequacies that constrain effective urban (re-)development. However, as demonstrated by the example of Kigali in Rwanda, environmental protection can be effectively addressed by policy-makers with the support of the majority of the population – even under complex political circumstances and within developing countries. This study hence recommends extending the scope and latitude for action at the local self-government level worldwide and to expand as well as improve local governance structures.

Figure 1: Basic understanding for successful decarbonisation in city and neighbourhood



Source: own research

(3) The role of polycentric structures will become increasingly important in the context of decarbonisation. This will also increase the need for decentralized and accurate databases, which must be able to collect and process information on urban areas - extending the depth of data gathering even to district and neighbourhood level. It is already observable that the precision of data collection is constantly being optimized at the local level. Simultaneously, reporting standards, carbon inventory guidelines and tools are increasingly harmonized and global standards emerge.

(4) Existing guidelines and reporting systems have evolved both quantitatively and qualitatively over the last decade. Tracking emissions of all sectors as well as a stronger focus also on indirect emission sources are current improvements. Regarding guidelines and supporting instruments, there is already a sufficiently broad and impressive spectrum of alternate offers available for the inventory of GHG worldwide. Due to different standards, insufficient data quality, divergent calculation approaches and missing data, the comparability of urban GHG emissions is, however, impeded – even within a homogenous comparison group.

(5) It is now necessary to promote the harmonization of existing protocols, organizations and databases for GHG inventories at an international level. Moreover, the results of the GHG inventories should be subject to external quality assurance in order to ensure robust quantitative progress monitoring even at a city level. To date, this study only identified a stringent and formal process in the sense of a review and ambition mechanism in very few cities.

(6) Further nation-wide standardization of data gathering and processing does not only improve the comparability, but also enhances the credibility of the reported information over time. This standardization should be based upon international guidelines and be compulsory also at the municipal level. Especially the Global Protocol for Community-Scale GHG Emissions Inventories (GPC) has the potential to become the leading standard.

(7) Local emission measurements have to become a common practice in European cities and regions. When selecting reporting platforms, it is advisable to act in a coordinated manner with other (German) cities and publish the gathered data in a common database in order to ensure transparency and comparability – for example via the CDP platform (platform of the Carbon Disclosure Project). Two elements play a critical role

for the precision of the urban inventories: the use of local activity data as well as the handling of cross-border emissions. Reports should be updated at least every four years.

(8) In some countries, there are compulsory rules and obligations for large companies to submit data in order to derive local GHG inventories for cities (for example in China). Comparable obligations should be extended internationally.

(9) Dealing with nationwide/transregional traffic is crucial for results. As an example, the inclusion of aviation in the case of Singapore would lead to a significant deterioration in terms of achieving the defined GHG reduction targets.

(10) Besides addressing primarily carbon dioxide, a greater focus must also be placed on inventory and mitigation strategies regarding the other greenhouse gases. These are currently often neglected or not explicitly addressed within many of the mitigation measures analysed in this report, although they are responsible for up to 40 percent of the global GHG effect.

(11) The monitoring of decarbonisation must not simply end by tracking the GHG emissions and, if necessary, their projection. Rather, a broad range of different key performance indicators has to be used that describe sustainable development in a broader sense.

(12) There is no „one solution" for decarbonizing cities. The long-term transformation of climate-sensitive processes and structures, against the background of the extensive research carried out here, requires a broad mix of instruments. The plurality of the chosen transformation paths and approaches has to be ensured, due to the heterogeneous initial situations of cities, in order to realize significant impacts. Only a mix of technical solutions and a fundamental change in consumer behaviour is expedient. In addition, not only regulatory approaches, but also market solutions have to be included. Due to the dimension of the required action, this study concludes that markets will not be able to shape climate-neutral cities without further help. Policy-makers and regulation play a crucial role in problem solving. The findings also reveal that in almost all cities analysed, the instruments and measures experts refer to as „best practice" are at least applied by a form of pilot projects. Therefore, sufficient knowledge of the instruments and measures for decarbonisation is not the challenge, but rather the necessary scaling of successful projects.

(13) The potential for a successful realization of a significant reduction of GHG in cities is enormous. Mobility, as well as behavioural changes promise most emission savings in the short to medium term. In the long run, a circular economy and an energy-efficient building stock are essential elements of the transformation. In addition to a well-defined time line, the amount of targeted emission reduction has to be broken down to specific sectors and combined with the respective instruments. For example, in order to simplify the operationalization and its monitoring, Chicago has assigned its reduction targets in that way. Each sector has precise targets within a specific time frame.

(14) At the moment, buildings account for about one third of the global energy demand, whereas estimates of possible efficiency improvements indicate that almost 50 percent of this demand could be saved by 2050. Especially in fast growing urban areas, the decarbonisation of building stocks will be decisive. With regard to population growth, almost 85 percent of new construction will take place in emerging economies, whereby China will account for more than 50 percent.

(15) Based on this study, however, policy-makers in the above-mentioned regions primarily focus on increasing the housing stock regardless of its energy efficiency. Therefore, sustainability and embedded carbon are not perceived as the most relevant problems. Obviously, we can find positive examples and some promising pilot projects. Nevertheless, these efforts and results are to date not satisfactory with regard to urban transformation and decarbonisation. The intensive involvement of the GCF (Green Climate Fund) and other sources of capital are hence essential for a climate-neutral property stock.

(16) Worldwide, a strong focus on energy efficiency with regard to the use phase of properties can be observed. Also increasing regulatory intervention is globally on the rise, taking the European EPBD („European Performance of Buildings Directive“) or even the German EnEV regulation as a blueprint. Most action taken by investors or users with regard to energetic retrofits of existing buildings is primarily driven by legal requirements and / or subsidies. Due to the limited amount regarding the remaining carbon budget (see above), a stronger focus must be placed on indirect or so-called „grey“ emissions (and embedded carbon) as well as on the entire life cycle (including demolition). However, this fact has not yet been adequately addressed in any of the investigated cities.

(17) The analysis reveals that the “creativity” of measures to improve the energy efficiency of the existing building stock is on a global scale in most cases limited to energy certificates, subsidies or regulatory frameworks requiring a certain efficiency standard or upgrade. Innovative approaches and new solutions like (voluntarily or compulsory) renovation roadmaps in order to become climate-neutral until 2050 (e.g. in Baden-Wuerttemberg as per „SFP“-directive), should be more intensively promoted on an international basis. Investors are often neglecting such a structured improvement. To speed up (voluntary) activities the discussion should be more intensively linked to risk management and so-called „stranded assets“. Accordingly, the voluntary engagement of investors could be strengthened. Buildings should be made „2-degree ready“. In France, the energy efficiency of commercial real estate is increasingly required by law through linking specific energy efficiency standards as a pre-requisite for operating licenses. In England, a minimum requirement for residential buildings has been established as a pre-condition to offer properties for rent. Internationally, such requirement (e.g. certain energy efficiency standards for new and used properties in order to rent, sell or operate) should be enforced more intensively. Such regulations provide a suitable combination of legal requirements and market-driven solutions.

(18) In order to intensify and plan the energetic retrofit step by step, market participants need clear, long-term and reliable outlooks regarding the increasing (regulatory) requirements set out by politicians. In this respect, many of the examined regulations in the respective countries reveal deficits, since they are not well planned or change over time in various ways. In order to avoid future cost increases and capacity constraints caused by time-bounded excess demand, splitting and allocating the overall refurbishment needs to different moments in time by 2050 seems to be necessary. In the case of renovations investors should have a stronger obligation to include energetic retrofits in the measures undertaken.

(19) A more compact city has advantages with regard to (reduced) energy consumption. Polycentric urban development can, however, also enable a better usage of resources, as supply routes and thus per capita GHG emissions can be significantly reduced compared to a more spread-out city. Moreover, the supply of renewable energy on the neighbourhood level can be facilitated in areas with lower density. Governance and the active participation of citizens are easier to achieve in one’s „own neighbourhood“ and on the basis of decentralized settlements. With regard to a relatively high density, combined with high sustainability standards, this report identified promising best practices in Asia and America. One idea is to allow by law a higher density per square metre if for instance legal energy efficiency standards are exceeded to a great extent. A worldwide promotion of such initiatives and the advancement to „tradeable“ density certificates appear appropriate.

(20) In addition, modified spatial and urban development strategies and plans must support or create a high quality built environment. This will increase the populations’ willingness to spend time outside due to a healthier and safer surrounding and encourage people to engage within their neighbourhood. The promotion of a broader diversity of use types and the reuse of brownfield locations, the extension of bicycle paths and pavements as well as an increase in green areas are progressing, especially in the western industrialized nations. Constructional and spatial design, according to a new „urban design“, also includes the intensification of mixed-use concepts plus the consideration of decentralized and regenerative energy production in urban districts and neighbourhoods. In this respect, very few positive examples could be

identified among the developing countries in Asia and Africa. Interesting approaches for the creation of attractive and walkable neighbourhoods with a high degree of mutual synergies of integrated uses prevail, for example, in Chicago.

(21) It is necessary to inspire people to undertake and support the necessary and indeed radical transformation. A change in consumer behaviuor is fundamental to reducing the emissions. Various low-threshold approaches are available for this purpose:

- In the post-fossil area a sharing and circular economy as well as the downsizing of lifestyles will dominate. Cities are an optimal breeding ground for such innovations and an aware, but voluntary change in consumption patterns. The cost-benefit ratio is perfectly suitable with regard to measures of the city government in this field of action.
- The integration of environmental and climate protection contents into the (educational) curricula has so far been insufficient worldwide. However, education is a so-called „low-hanging fruit" compared to cost-intensive measures like the expansion of renewable energy sources. In the present study, the implementation of an "educational impact plan" is suggested for example based on a UN measure that could be initiated.
- The consumer behaviour can be positively influenced in particular by easily accessible information (via apps). Platforms like www.codecheck.info are a very good example of how end users can inform themselves about ecological product characteristics. Such approaches could, with the use of an app, easily be extended to include the GHG footprint of food and other consumer products. A strengthening of international initiatives in this respect is highly desirable.
- Easy accessibility and comprehensibility of these low-threshold offers is fundamental for the success of measures aimed at influencing consumer behaviour.
- Central to this is, in particular, the provision of maximum information to consumer and citizen through comprehensive dialogue and participation processes as well as education and information platforms. The German participation processes at the urban level constitute an international best practice in this context.
- Regarding the definition of specific and precise targets for emission reduction, citizens should be actively involved in the process of defining and shaping measures to realize these objectives at a local level.
- A clear change in the local payment structures and remuneration schemes of municipal governments and representatives of public administrations is essential as well. In China for example, an almost exclusive focus on increasing local GDP and productivity has been common up to now. Aspects of environmental protection were therefore only taken into consideration as a secondary condition.
- Simple examples, such as the successful „one-degree-less" (related to cooling) initiative in Singapore, could be implemented in Europe in a similar manner and have the potential to strengthen consumer awareness for climate protection.

(22) The *polluter pays principle* is often only taken into account in a rudimentary manner. E.g. the billing of heating costs in China is in most cases not based on actual consumption. There is thus considerable potential for improving the financing of the required transition to climate-neutral cities in a manner that is characterised by social justice. In all emerging and developing markets rising income and personal wealth comes along with a significant increase in carbon footprints. Therefore particular emphasis should be placed on this aspect. Reducing poverty and simultaneously ensuring high environmental quality might lead to short-term conflicting goals. Recent studies, however, indicate a positive present value for a broad range of decarbonisation measures, revealing that financial and environmental objectives might be aligned. In general, communication should enhance the demonstration of the financial benefits of decarbonisation.

(23) It is essential that urban redevelopment supports the green economy movement and actively bans carbon-intensive industries. In this respect, it has been observed that carbon-leakage effects still dominate, especially in Asia. It is essential that such industries will be shut down completely, since pure relocation strategies cannot contribute to decarbonisation on a global level.

(24) The global analysis has outlined the intention of many cities to achieve only relative but not absolute reduction goals by 2050 or 2030. Incentives for ambitious absolute reductions targets that exceed the national INDCs need to be expanded in municipalities proactively. This study proposes the involvement of the 100 largest urban areas in a monitoring process that should be centrally controlled, in order to enhance the transparency of Sustainability KPIs (Key Performance Indicators). The coordination of such undertaking could be aligned by the UN. Annual and continuous reports serve as the basis for steady progress and a high visibility of results. Simultaneously, the population could be better informed about the dimension and urgency of action to fight climate change. Due to ongoing comparative benchmarking, cities would face greater incentives to continuously intensify their efforts. Furthermore, the reports could be used in line with the national progress reports (within the INDCs).

(25) The examined urban areas took part in at least one city initiative for decarbonisation. The level of ambition of municipalities and initiatives was very heterogeneous. For a clearer distinction, the initiatives presented in this report were differentiated into integrated and selective ones. Integrated initiatives have an impact on a variety of sectors and provide comprehensive assistance for a holistic project management in terms of reducing GHG. In contrast to this, the impact of selective initiatives is only in specific sectors or fields of interest (like e.g. the formulation of guidelines, emission measurement, networking platform, research, database, financing or training). Another difference between the initiatives is the intensity of commitment. They either provide a specific roadmap along with a high intensity of commitment or act like a loose network that spontaneously creates synergies between actors and initiative. For GHG Emissions Inventories CDP and carbonn© Climate Registry (cCR) can be seen as role models or best practice initiatives. Regarding networks with a broader focus, C40, R20, UCLG as well as the Compact of Mayors dominate. Due to the broad spectrum of existing initiatives and networks, this report concludes that further initiatives will not drive decarbonisation (- strengthening existing ones is the way forward).

(26) In order to reduce greenhouse gases, the topic of digitalization is of increasing importance for all examined cites. As an integral part of Smart Cities, innovation facilitates data gathering and processing as well as the appropriate management of processes and transparency. Without apps, many innovative projects like car- and bike sharing would not have been possible.

(27) Several cities increasingly implement sustainable procurement processes for products as well as services and serve as a role model in this respect. But looking at the implementation, there is still potential for improvement. International expansion is of particular importance taking pioneers which are mostly located in Europe as an example (e.g. Hamburg).

(28) Most first world countries have already reached the maximum level of waste (“peak waste”). However, in emerging and developing countries, the waste production per capita is still continuously rising. As a matter of principle, the decoupling of consumption and waste production must be addressed more intensively.

(29) Waste management in industrialized countries must develop to become a circular economy going beyond pure recycling. Clearly strengthening recycling and re-use schemes is a first step and has to be intensified. In all examined cities, there is a great potential with regard to just this issue. In developing and emerging countries, a professionalisation of informal waste management is required. The level of waste and resulting problems puts high pressures on several metropolitan cities. This leads to increasing prohibitions of plastic bags and other synthetic materials. Legal steps, as described, should be rapidly expanded by local politicians throughout the world. They offer the possibility of prompt results with only limited effort. Such measures could also support a growing awareness of consumers.

(30) The conversion of the energy supply systems is not a "low-hanging fruit" but an intent that is related to long-term and cost-intensive endeavours. Besides the expansion of the (limited) possibilities within the city boundaries to produce renewable energy, also energy strategies within metropolitan areas must be more intensively supported – reaching beyond city boundaries (the inclusion of municipalities surrounding the city is essential, given limited space for energy production within the city itself). The implementation of coordinated strategies is still in its infancy and needs to be extended. German metropolitan regions like Stuttgart are positive examples. Especially the diversity of stakeholders and citizen participation are important issues in this respect.

(31) The usage of cross-sectoral coupling effects in emerging markets still offers substantial potential.

(32) The storage of energy should be achieved with CO_2-neutral gas that could be produced with renewables. Therefore, innovative methods like "*power to gas"* or "*power to liquid"* are highly recommended for municipalities. Further solutions comprise the implementation of smart grids or the creation of new storage capacity (e.g. batteries or electric cars). Except for university research projects, there are no appropriate large-scale activities in this respect in the analysed cities (yet). Conversely, there are successful neighbourhood-level heating and cooling initiatives in various neighbourhoods all over the world (e.g. district heating in Copenhagen and cooling in Singapore). The further development of such measures in neighbourhoods in combination with renewable energy seems promising.

(33) When it comes to decarbonisation, cities that are located in emerging and developing countries must be enabled to get better access to the (international) capital markets in order to avoid heavy dependence on financial resources that are provided by the GCF or other international development aid. A priority should be placed on initiatives to speed up supply of financial resources for the vast amount of (costly) actions that need to be implemented in third world cites.

(34) With the objective to reduce investment risks in order to attract more private capital, various measures can be adopted. They include the expansion of loan loss guarantees backed by international institutions, the professionalisation of the institutionalised credit worthiness assessment and the evaluation of the underlying project feasibility. Also strengthening the respective national financial sector, especially by supporting more state-controlled banks providing subsidies and grants is a promising approach. In addition, framing decarbonisation as an investment product is essential. This could be achieved by putting the spotlight on the financial benefits derived from cash flows due to energy savings or income from trading carbon credits. In developing and emerging countries, the local opportunities to increase the income of municipalities must be promoted. The instrument of a rise in property tax, based on market value in metropolitan cities, is a prerequisite and a fair opportunity for burden sharing. Furthermore has to be a greater focus on coupling international monetary aid with the implementation of national development goals.

(35) There has been only limited success in funding the transition to low-carbon-cities in developing and emerging countries. Projects of the World Bank, like "Low Carbon, Livable Cities Initiative (LC2)" have ensured only moderate investments. The German KfW Bank providing also subsidised financing can be regarded as a global example of best practice. The grants and subsidies to date were considerable, and crucial sectors within the cities (e.g. water management of La Paz, local public transport in Brazil and India) were addressed. Further expansion would provide viable benefits.

(36) Transferring parts of the credit risk involved when financing renewable energy and energy efficiency projects to third parties is a good approach. As an example, IFC CHUEE (China Utility-Based Energy Efficiency Finance Program of the International Finance Corporation) underwrites such risks and thereby supports local measures in order to achieve a good cost-benefit ratio for local banks and the client promoting the decarbonisation project.

(37) An evaluation of the German KfW-funded projects in the fields of energy-efficient urban redevelopment on neighbourhoods level (so-called "climate neighbourhoods") reveals that this approach results in significant

savings. Nevertheless, the programme, which funded 500 neighbourhoods so far in Germany, is still expandable. The continuation and enlargement of the schemes appears to be useful. A change in the KfW guidelines due to the low-interest environment into a more grant-based programme could be considered. Fiscal instruments (such as a faster depreciation, in German known as „Sonder Afa“) to increase the renovation rate (which has frequently been discussed in Germany) do not provide sufficient incentives for commercial market participants, also because fast expenditure or capitalization and depreciation are possible.

(38) Cities should also demand more compelling „2-degree-ready“ reports provided by (larger) companies based in their municipalities. These reports should demonstrate how the organization tackles climate change and the individual approach to achieve climate neutrality in the long-run. A central element on this occasion would be the non-residential building stock. For this purpose, more active support from international organizations, such as the Financial Stability Board (FSB, or rather their Task Force on Climate-related Financial Disclosures) would be helpful. FSB has repeatedly made reference to climate change as a risk to financial market stability.

(39) Specifically for large-scale commercial properties, it can be difficult in individual cases to produce renewable energy on-site or to achieve low energy consumption. An adaptation of the (car-)“fleet consumption” approach to a neighbourhood-level initiative focusing on properties should be possible (as climate neutrality could be at least possible on that level). A comparable approach for real estate companies as a whole appears to be difficult due to dynamic portfolios. It could also be possible to allocate „area certificates“ for the reclassification of rural land into land zoned for urbanisation. In such cases, cities running out of existing allocations would need to (costly) buy further certificates on the market. Thus efficient land use would be promoted.

(40) The internalization of negative externalities across market-based instruments, such as tradeable emission certificates, would be useful in achieving the objectives. International examples show that the building stock of cities can also be incorporated in markets for emission trading (for example in China). The international expansion of such initiatives should be supported. Price signals, that continuously fail to reflect the „true“ costs of GHG-emissions, should also be (further) „corrected in the future.

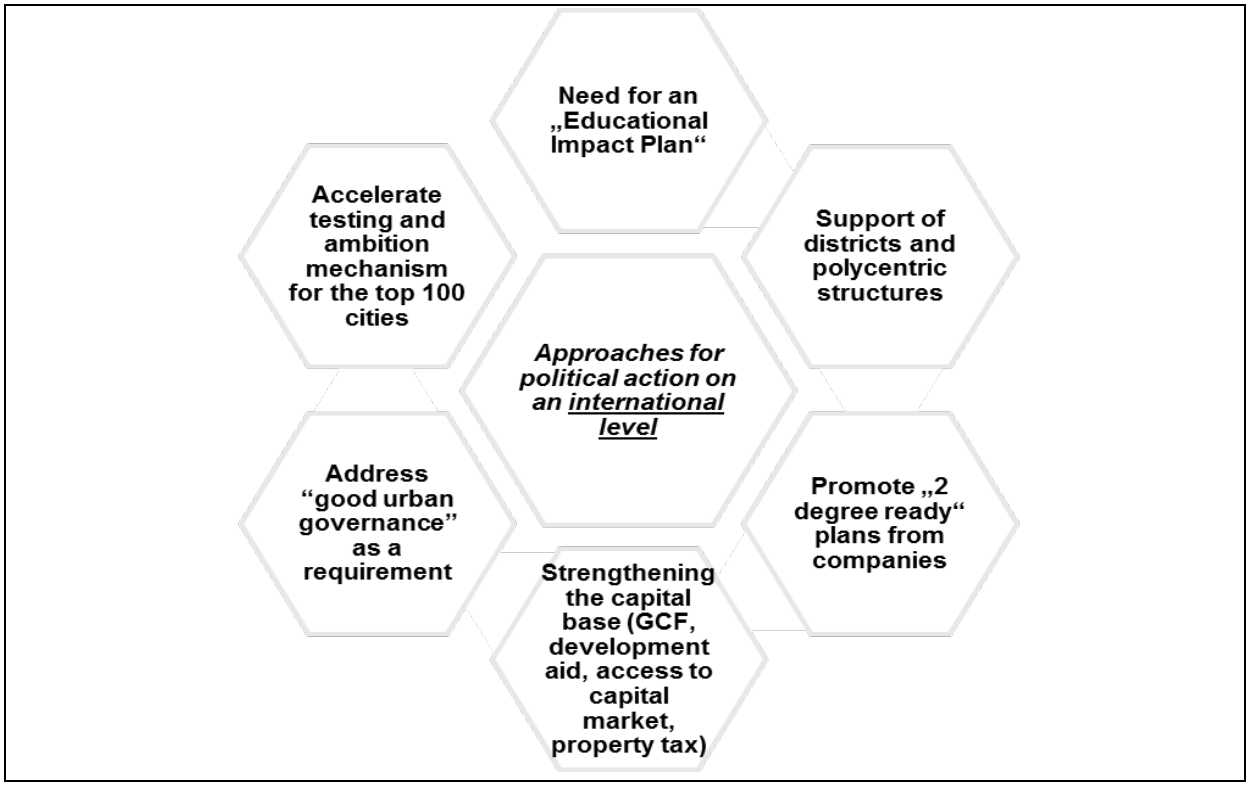
1.3 Future research focus

Further research focus can be summarised as the following (also see Figure 2 and 3):

- working papers on the inclusion and consideration of all forms of so-called „grey“ energy;
- increased transparency with regard to commercial properties and their potential contributions to climate protection;
- research papers on the subject complexes of climate risks and so-called „future-proof-assets“ (i.e. particularly investments with a lower risk-return profile);
- development of consistent platforms for local, regional and nationwide GHG-inventories;
- research to derive local emission factors;
- stronger emphasis on the challenges that will emerge from the German perspective to achieving the climate-protection targets between 2020 and 2030;
- internationally, the “wrong” indicators for managing the economy and society were used. It is important to enhance well known alternate KPIs for sustainable development and to facilitate their implementation in prevailing economic structures;
- research on reducing (short-term) conflicting targets – like e.g. more participation/less poverty and reduced consumption/climate protection efforts at the same time;

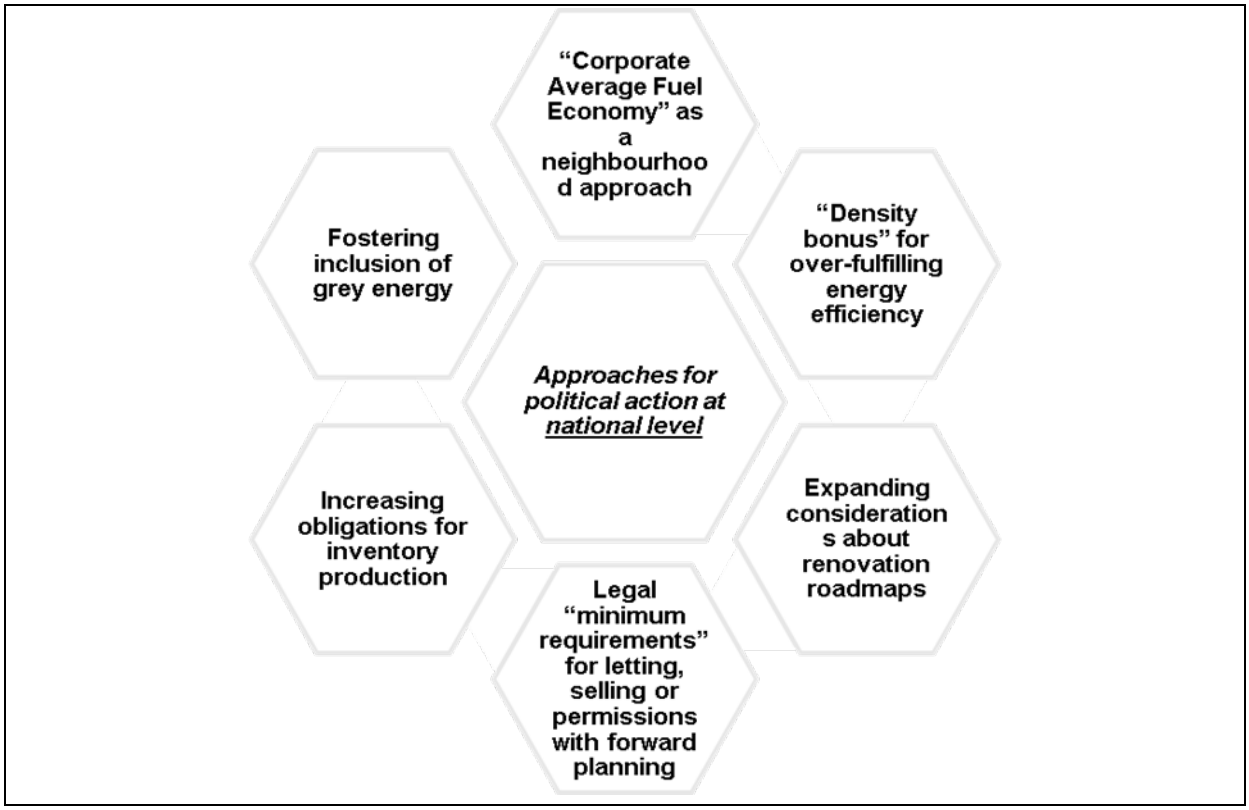
- research on the scalability of positive approaches to a low-carbon participation in developing countries (for example, the success of the Chinese electric scooter);
- further support for developing digital solutions in order to support consumer awareness;
- research on innovative (local) financing measures and further sources to raise capital.

Figure 2: Aspects from the European and international perspective



Source: own research

Figure 3: Aspects from the national perspective



Source: own research

2. Topical introduction

2.1 Overview of the topic area

The planet´s carrying capacity of anthropogenic modifications has been reached and even been exceeded in many aspects. This ascertainment is not only valid for the discussion on a limitation of *greenhouse gases* (GHGs), which will be the focus of this chapter, but also for a plethora of emissions and other permissible limits of key elements (see Chapter 3.3 and 3.4).[1]

From 30th November to 12th December, Paris hosted the 21st session of the Conference of the Parties (COP 21) to the **United Nations Framework Convention on Climate Change (UNFCCC**). 195 states agreed on a new **global climate agreement**, also referred to as the *Paris Agreement*,[2] which seeks to confine global warming to 2 °C compared to pre-industrial levels.[3] By institutionally entrenching the ambitious goal to "pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels"[4], contemporary goals were exceeded to reduce the risks and impacts of climate change.[5] Ever since the Kyoto Agreement, countless conferences sought to streamline efforts into a globally concerted climate policy. An end to the contractual stalemate became evident at the advent of the G20 summit in Turkey where the possibility of an "ambitious agreement"[6] came back within reach. Symbolically, the meeting was signed on "Earth Day" in New York by 175 states on 22. April 2016.[7] The Paris Agreement was bound to enter into force when at least 55 parties to the convention, accounting in total for at least an estimated 55 percent of the total global GHG emissions, have deposited their instruments of acceptance, ratification or accession within the depositary.[8] During the G20 summit in Hangzhou in September 2016, China and USA ratified the agreement.[9] Germany embarked on the process of ratification in June 2016 which was concluded in September 2016.[10] The Paris Agreement entered into force on 4 November 2016 after the above-mentioned prerequisites were met.[11] Meanwhile, 109 (out of 197 UN member states) have ratified the agreement.[12] On 18 November 2016, the Conference of the Parties (COP 22) ended in Marrakech, tasked with further articulation of climate goals embedded in the Paris Agreement. These dynamics fundamentally underpin the topicality of the research nexus "CO2-neutral in cities and neighbourhoods - the European and international perspective". The reduction of GHG emissions[13] plays a pivotal role in limiting the extent of temperature increase to positively influence climate change.[14]

Most notably, *extreme weather events*[15] emerge with increased frequency in diverse regions[16] as a consequence of sustained climate change and global warming. According to the IPCC Fifth Assessment Report[17], a further increase in frequency and intensity is expected.

[1] Rockström et al., 2009 // See Steffen et al., 2015
[2] http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.html
[3] UN-FCCC, 2016, p. 22
[4] Article 2 (1) (a) of the Paris Agreement // UN-FCCC, 2016, p. 1
[5] *Ibid*.
[6] COP, 2015_b
[7] COP, 2015_c
[8] Article 2 (1) (a) of the Paris Agreement // UN-FCCC, 2016, p. 1
[9] Zeit Online, 2016
[10] Bundesregierung, 2016: Germany´s Federal Assembly (Bundesrat) and Parliament (Bundestag) ratified the Paris Agreement in September 2016, thus entering into force in early October 2016.
[11] http://unfccc.int/paris_agreement/items/9444.php
[12] http://unfccc.int/paris_agreement/items/9485.php
[13] IPCC 2014a, p. 1263: This study defines GHG according to the definition embedded in Annex I of the Fifth Assessment Report.
[14] IPCC, 2013a
[15] NB: These include storms, flooding, torrential rains, hail, forest fires etc. // See Chapter 3.3
[16] NOAA, 2015
[17] IPCC, 2014a, furthermore IPCC 2014c for the contributions of Working Group III

Natural disasters with inherently high damage potential tremendously influence the society´s way of life, which fundamentally underscore economic and societal vulnerabilities. Additional adverse effects stemming from global warmings include most notably *sea level rise*[18] as well as *significant alterations to flora and fauna.*[19]

The majority of ***anthropogenic GHG emissions***, which have been rising for decades and been identified as the main trigger of climate change, emanate from urban areas.[20] Primarily, these are direct and indirect *CO_2 emissions* as consequences of diverse human activities.[21] The following factors are included: *Building stock, land use change, manufacturing processes* and *traffic*. The international community, EU member states[22] - and particularly the Federal Republic of Germany[23], as well as its population[24] - are aware of their responsibility to deliver substantial contributions to climate protection in general and *decarbonisation*[25] in particular. Against the backdrop of European regulations, resulting climate protection plans[26] and the Paris Agreement, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) developed the ***Klimaschutzplan 2050 (KSP)***[27] ("Climate Action Plan 2050"). Initiated through interministerial coordination resulting in the Hausentwurf ("house draft protocol") on 6. September 2016[28], the protocol was eventually adopted mid-November. The "2°C-Limit" serves as a benchmark for the climate protection goals of the European Union and Germany.[29] The areas of activity[30] encompassed within the KSP feature a comprehensive set of measures aiming to contribute to the economy´s decarbonisation (see Chapter 3.5.3).

Various forecasts by the United Nations trace the sustained trend of rural migration to urban regions. While 54 percent of the world population lived in cities in 2015, this percentage is expected to rise to 66.4 percent by 2050.[31] In connection with *population growth*[32], this continuing trend of *urbanisation*[33] contributes to the rise of GHG emissions in metropolitan areas. Limits of tolerability exert pressure on cities to develop novel approaches.[34]

Urban adaptation strategies may help urban areas to prepare for, respectively adapt to, changing climate conditions, yet the underlying **guiding principle should (continue) to focus on measures of mitigation – thereby avoiding emissions**.[35] The process "Lokale *Agenda 21* - Global denken and lokal handeln"[36] may form a guideline to develop and effectively realize sustainable city development strategies (low-emission strategies) within the framework of urban development in general and on neighbourhood level in particular.

The regional or, more specifically, urban causal network of GHG emissions is highly complex. A plethora of possible approaches to reduce urban GHG emissions constitute exemplary fields of activities, such as increasing energy efficiency of real estate, transitioning to renewable energy, professionalising waste management or advancing methods of carbon sequestration. Due to the heterogeneity of urban structures (e.g. geographic characteristics, climatic circumstances or disparate social, economic or political frameworks as well as divergent financial capacities) highly individual starting points arise, depending on the city considered, which is why possibilities,

[18] See Chapter 13 "Sea Level Change" in IPCC 2014_a
[19] IPCC 2014_b, p. 6
[20] Seto et al., 2014 // IEA, 2015, p. 3f
[21] IPCC 2007_a, p. 5. // IPCC, 2013_a
[22] Europäisches Parlament, 2009, p. 7
[23] See for example Bundesregierung, 2011, p. 8
[24] Pugliese et al. // Bundesamt für Naturschutz, 2015, p. 1
[25] See Chapter 3.1.6 for a definition of decarbonisation
[26] See BMUB, 2006
[27] BMUB 2016_d // BMUB 2016_e
[28] BMUB 2016_c
[29] BMUB 2015_b
[30] NB: Energy industry, buildings, industry & business/trade/services, transport, as well as agriculture/land use.
[31] UN-DESA, 2014
[32] UN-DESA, 2015, p. 2-8
[33] Chapter 4.2 for an analysis of global urbanisation trends.
[34] UCLG, 2016, p. 96
[35] UN- HABITAT, 2015f, p. 4
[36] The original document is available at: https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

boundaries and latent potentials pertaining to the realization of sustainable urban development strategies require in-depth analysis.

2.2 Project classification and conception

Greenhouse gases, and most notably CO_2, are primarily emitted by urban areas.[37] On this occasion, the building stock plays a pivotal role. Therefore, the transformation of cities and quarters towards CO_2-neutral settlement structures embodies a key element for the implementation of greenhouse gas reduction strategies. A mere isolated view – without casting light on other sectors, e.g. a consideration of waste or transport - is not expedient on this occasion.

In order to evince useful and scalable recommendations for actions, an analysis of existing approaches consequently focuses on the municipal policy as well as the neighbourhood level. A detailed consideration of elements on the neighbourhood level entails a variety of advantages which lend themselves to concrete measures – not least due to the considerably higher visibility of results for all parties involved.

Therefore, the aim of the research project "CO2-neutral in cities and neighbourhoods - the European and international perspective" is to gain comprehensive insight into the role of European and international cities in attaining global targets pertaining to the prevention of CO_2 emissions.

The project´s point of departure is based on the extensive research and evaluation of global, European and national strategies, the range of measures and the built examples within city and neighbourhood development. In addition, the focus rests on the evaluation of sets of contracts and rules as well as networks of cities. The analysis will furthermore encompass funding programmes concerning CO_2 minimisation and energy-oriented refurbishment. Moreover, complementary questions such as the specific measurement of success in reducing CO_2 emissions on the city and neighbourhood level will be covered.

On the basis of identified best practice approaches, recommendations for action will be derived which will subsequently stake out future fields of action and define functional framework conditions. The results of this project aim to offer tangible guidance to policy and administration in order to timely, objectively and transparently assess CO_2 emissions so that these, in consequence, may be specifically reduced, while taking into account cost-benefit considerations.

A representative selection of urban areas (see Chapter 2.4.1) and sound analysis thereof enables the identification and evaluation of best-practice approaches of the decarbonisation of cities. In the course of this study, a comprehensive consideration of the broad literature will be complemented by a closer look at 21 cities. Based on this overall analysis, Chapter 9 contains a structured and detailed analysis of eight cities which incorporate results of in-depth interviews conducted within the scope of this project report. Based on the analysed cities, a number of (city) initiatives were identified during literature review which were deemed to be relevant during the selection process and subsequently taken into account. The cities and initiatives covered by this study can be found in *Appendix II*.

2.3 Formulation of guiding research questions

For the thorough elaboration of the overarching theme “CO2-neutral in cities and neighbourhoods“, the project focuses on the following guiding research questions:

I. What is the significance of the field of action ”city“ in other European and global states in achieving CO_2 reduction targets?
II. In these cases, which role is played by neighbourhood-level approaches with regard to buildings, mobility and green space – considered individually or cumulatively?
III. In what ways do other cities measure their success in reducing CO_2 emissions and what challenges do they face as a result?

[37] Seto et al., 2014 // IAE, 2015, p. 3f

IV. How do other states and cities proceed in recording their building stock, *inter alia*, with regard to data protection, data comparison, access criteria for data as well as accounting objectivities?

V. Analogous to the Energy Saving Ordinance ("Energieeinspaarverordnung (EnEV)"), the Energy Efficiency Directive of the European Union and to the KfW programmes "Energetische Stadtsanierung – Energieeffizient Sanieren" and "Energetische Stadtsanierung – Quartiersversorgung", are there any comparable sets of contracts and rules as well as funding programmes for the implementation of CO_2 reduction targets to be found in Europe or internationally?

Besides factual issues, fundamental relationships as well as essential organisations and principles will subsequently be highlighted while central defining foundations will be laid.

2.4 Detailed presentation of the research approach

2.4.1 Selection of cities

The choice of cities takes geographical distribution into account and covers all continents. In order to establish a representative and heterogeneous panel for the analysis, population density and the city´s age is taken into consideration. Furthermore, metropolitan regions known for their initiatives within the sustainability context, such as Copenhagen or São Paulo, are complemented by cities that evaded the limelight of the conceptual focus. This applies to cities such as Hangzhou and Kigali, whose initiatives towards CO_2 reduction have not been documented within comparable scope or transparency. In addition to that, the selection takes formal obligations into account.

In conclusion, cities were chosen based on the following criteria deemed pertinent to this study:

- data availability in essential databanks with regard to initiatives and actions aimed at reducing GHG emissions,
- availability of referring literature from academic and official sources,
- socio-economic development status of the country,
- diversity with regard to demographic and geographic aspects, whereby each continent ought to be covered,
- heterogeneity in city size, so that initiatives from mega cities will be identified alongside smaller cities,
- significance of existing (international) initiatives in which cities have participated as well as current membership possibilities,
- Existence of formal obligations with regard to emission reduction.

Ultimately, cities from industrialized countries are included in as much as cities from developing countries, whereby the intention of developing towards a **low-carbon city**[38] constitutes the common objective. In addition, new satellite cities or planned cities respectively are included in the sample as these potentially constitute best practice approaches which may generate additional values to answer the elaborated research questions. Three of these so-called "*experimental cities*" are:

- "Masdar City",[39] a six square kilometre large "CO_2-neutral science city" in Abu Dhabi (United Arab Emirates), which hosts the Headquarters of the "International Renewable Energy Agency (IRENA)".[40]
- "Amaravati", an approximately 17 square kilometre large "smart city" in the region of Andhra Pradesh (India), which has been designated as the new seat of regional government and aims to serve as a sustainable showcase project for the entire India.[41]

[38] UN-EP, 2013
[39] Marshall, 2016 // Speed, 2014 // Willmott, 2014
[40] http://www.irena.org/
[41] http://crda.ap.gov.in/

- "Sino-Singapore Tianjin Eco-City", an approximately 30 square kilometre large district of the eponymous city Tianjin (China), which counts as the second sustainable "government-to-government" project between China and Singapore.[42]

2.4.2 Data collection

It is of paramount importance to assess the different strategies, initiatives and policies of cities in the context of their individual starting point or related framework. Most notably, the scalability and transferability of measures depends on it to a large extent.

Against this backdrop, the first step involved defining a database structure. The system of indicators embedded characterise cities in relation to the thematic areas population, density, economic factors, infrastructure, and environment. In order to assert comparable propositions and conclusions, metrically scaled values were used. A complete account of the data format can be found in *Appendix I*. Sources and further references for data compilation for example included:

- international norms, such as ISO 37120:2014[43];
- databases, such as the Global City Indicators Facility (GCIF)[44], the United Nations Statistical Division[45], the Population Division[46], the World Bank Data[47] as well as the BP Statistical Review of World Energy[48];
- carbon & energy agencies and the European Environment Agency database EuroStat[49].

For each of the 21 cities, the data form a part of the resulting project sheets which are accessible in separate documents due to their extent.

2.4.3 City-level initiatives and organisations towards CO_2 reduction

The significance and amount of international initiatives and organisations which offer assistance in the context of the decarbonisation of cities is growing continuously. A sound starting point for the classification of relative relevance and possibilities is a critical analysis whether the respective tools can be effectively applied on the level of metropolitan regions and their potential be harnessed. Furthermore, this partial step of the survey may inform about how ambitious activities in reducing or avoiding GHGs by individual cities and initiatives are.

All in all, a total of 20 initiatives and international organisations were identified based on the literature research which are relevant in the context of the CO_2 reduction of metropolitan areas. They for example include:

- International guidelines, such as the "International Standard for Determining Greenhouse Gas Emissions for Cities" (IPCC)[50] or the "Global Protocol for Community-Scale Greenhouse Gas Emissions" (GPC).[51]
- Significant international reporting platforms, such as the *„carbonn Climate Registry" (cCR)*[52] or the *„Carbon Disclosure Project CDP for cities".*[53]
- Initiatives with a broad catalogue of measures, such as the *ICLEI „Low-carbon City Agenda"* or *„C40 Cities Climate Leadership Group".*
- Collective agreements, such as the *„EU-Compact of Mayors" and the „USDN Carbon Neutral Cities Alliance".*

Significant organisations will be discussed in detail in Chapter 5. Beyond that, Chapter 7 will intensively scrutinise initiatives in the context of a precise inventarisation of greenhouse gases.

[42] http://www.tianjinecocity.gov.sg/
[43] http://www.iso.org/iso/catalogue_detail?csnumber=62436
[44] http://www.cityindicators.org/
[45] http://unstats.un.org/unsd/default.htm
[46] http://esa.un.org/unpd/wpp/
[47] http://beta.data.worldbank.org/
[48] http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html
[49] http://appsso.eurostat.ec.europa.eu/nui/show.do
[50] See Chapter 6.3.2
[51] See Chapter 6.3.5
[52] See Chapter 7.4.1
[53] See Chapter 7.4.2

2.4.4 Evaluation of city initiatives concerning the reduction of GHG emissions

The methodological approach for the analysis of individual endeavours and strategies concerning the CO_2 reduction of each city will be described in detail in Chapter 8. The PESTLE framework was applied as it may shed light on all relevant aspects of the entire framework for action towards CO_2 reduction of relevant cities.

The measures taken by cities encompass diverse individual activities on a range of levels. Against this backdrop, the PESTLE analysis of each city resulted in a comprehensive and annotated assessment matrix, which visualises results at the end of the respective textual analysis. For the purpose of preserving transparency, this report merely emphasises essential results and respective best practice approaches[54] (see Chapter 9). The resulting assessment is a detailed composition of the following aspects, inasmuch representing an integrated evaluation of the respective endeavours:

- Action level “political“
- Action level “economic“ (incentive mechanisms and behavioural change)
- Action level “social“ (participative/cooperative approaches)
- Action level “technological “ (information systems, databases, innovations)
- Action level “legal“ (legal frameworks and regulatory interventions)
- Action level “environmental“ (environmental effects)

2.4.5 Generation of background information through in-depth interviews

Based on the aforementioned analysis, interviews with local stakeholders were conducted in consequence which refines the assessment matrix for selected cities. It serves to gain insight into the perspectives and challenges of decision-makers responsible for the implementation of strategies and projects within CO_2-neutral city and neighbourhood development on a day-to-day basis.

In line with sustainability, a balanced cost-benefit structure was heeded for the planning of journeys. The interviews were conducted on the basis of disposition, data availability and know-how of defined local experts or institutions. Depending on the objective, they were performed in group discussions as well as individual interviews. The interview guidelines orient themselves towards the structure of the PESTLE analysis and on guiding research questions. Likewise, the interview transcripts form part of the resulting project sheets and are accessible in separate documents due to extent.

It should be noted at this stage that personal interviews turned out to be central for essential insights within this report. A plethora of conclusions would not have been possible to be solely drawn on the basis of the existing literature, which is why conducted interviews represent a valuable component of the city analysis in Chapter 9.

[54] See Chapter 8 and 9

3. Introductory annotations on climate change

The following chapter thematises the status quo of climate change and its consequences for population and national economies. In order to comprehend the possibilities, solution approaches and, where applicable, boundaries of GHG emission reduction in urban areas, this overarching context is essential.

The concept of CO_2 neutrality is a crucial milestone for the assessment of progress towards sustainable development. Since terms such as "carbon-neutral", "CO_2-neutral", "net zero" or "CO_2-free" – as well as related German translations like "kohlenstofffrei" – are often used synonymously or with varying preciseness in media reporting, Chapter 3.1 initially defines and delimits these terminologies. Here, the central aspect of "decarbonisation" will furthermore be illuminated with regard to its substantive tenets. As well, additional terms deemed relevant will be contextualised, such as "low-carbon city", "zero energy" and "low energy".

3.1 Definitions relating to decarbonisation

Given the situation that diverse terminologies are used to describe low CO_2 activities within the context of studies, peer reviewed articles and general media reporting, the terminology will subsequently be defined in more detail. Thus, terms which are wrongly considered synonymous in some instances, will be clearly delimited in order to avoid misconceptions.

3.1.1 Greenhouse gases versus CO_2

Aside *carbon dioxide* (CO_2), most international agreements include other *greenhouse gases* (GHGs) embedded within the *Kyoto Protocol*[55] in relation to its corresponding *Global Warming Potential*[56]. The "Doha Amendment to the Kyoto Protocol", also referred to as "*Kyoto II",* contains a revised list of included GHGs, [57] which, with the addition of nitrogen trifluoride (NF_3),[58] have to be recorded in national inventories.

Nevertheless, some GHG emission inventories merely relate to CO_2 and neglect other non-CO_2 gases.[59] The reason for this can often be found in the absence of reliable information on these GHGs. However, these cause up to 40 percent of global surface temperature rise[60] and should therefore not be omitted from inventarisation.

For assuring an easy and transparent approach, the GWP of non-CO_2 gases will converted into units of CO_2. In accordance with the *Intergovernmental Panel on Climate Change* (IPCC) this is made possible in a standardised procedure resulting in the GWP values of each gas.[61] Subsequently, the generated values will be indicated with regard to the *equivalent quantity of CO_2 (CO_2eq or CO_2e)* of the corresponding GWP. One kilo of emitted methane can thusly be expressed as 25 kg of CO_2e.[62]

In literature, the term "carbon" is frequently used when referring to carbon dioxide or to the CO_2eq of other GHGs. Evidently in this context, "carbon" (i.e. "carbon-neutral", "low-carbon", "carbon-free") does not exclusively refer to the chemical element carbon (C), but rather to CO_2 or CO_2eq.

3.1.2 Carbon-neutral

Carbon-neutral as well as the interchangeable term *CO_2-neutral* elucidate a condition where no gross contribution to global CO_2 emissions takes place due to activities of an individual, organisation, city or state. This prerequisite is met when activities themselves do not emit CO_2 or by offsetting respectively creating compensation alternatives within or outside a system which permanently bind positive emissions.[63] The amount of emitted CO_2 inside *system*

[55] UN-FCCC, 1998
[56] See Chapter 7 for a review of GWP values.
[57] N.B.: The Kyoto Protocol (including amendments following "Kyoto II") regulates carbon dioxide (CO_2), methane, (CH4), nitrous oxide (N2O), sulfur hexafluoride (SF6), nitrogen trifluoride (NF3), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs).
[58] UN-FCCC, 2012
[59] See Chapter 6 and 7 for a detailed analysis of greenhouse gas inventories and reporting platforms.
[60] Rao et al., 2005 // IPCC, 2014
[61] IPCC, 2007_d
[62] IPCC 2007c: 1kg CH4 * 25 = 25kg CO2e
[63] See Carruthers (2013) for an analysis of diverse European derivations CO_2 neutrality and UN-EP, 2008, p. 14ff for international definitions. // See Butler et al., 2015, p. 1ff

boundaries during a given time period will either be reduced or completely compensated by the corresponding energy production from renewable sources. This may be realised inside or outside of the system boundary. Alternatively, the same result can be achieved through offset mechanisms such as carbon storage.

Based on this, *prima facie*, intuitive definition, a number of diverse problem areas emerge which warrant further elaboration in order to gain a selective understanding of the contents and are consequently further illustrated: Time frame, system boundaries, compensation alternatives, direct vs indirect emissions.

On this occasion, it is vital that GHGs do not only encompass CO_2 (see Chapter 3.1.1). In as much, the concept of "CO_2 neutrality" exclusively refers to carbon dioxide. If further GHGs are included in the analysis, the term "climate neutrality" or "greenhouse gas neutrality" is used. (see Chapter 3.1.4).

Compensation alternatives and *offsets* are often synonymously used in English literature. However, these are not entirely congruent.[64] The term "offsetting" is primarily used in connection with emission certificates and other cap and trade mechanisms.[65] Fundamentally, both terms address situations in which cities, that cannot reduce emissions within their own system boundaries, are able to offset outside.[66] ***Offsets*** are defined as options that reduce emissions through import or offset outside system boundaries[67], whereas *compensation alternatives* are specified as options that reduce emissions through adjusted production or consumption inside system boundaries.[68]

Systems may take a variety of forms and ought to be delineated by clear system boundaries. Hence, a building, municipality, neighbourhood or city may be regarded as a system. As an example, if one regards a building as a system, a variety of distinctions are possible, such as regarding usage and "grey" energy.[69] This allows analytical flexibility both in assessing and definition of goals.

The term "CO_2 neutrality" is often used as a succinct and incisive formulation to express that a certain object of reflection (i.e. a product, industrial process, building, or like in this case, a city) is neutral with regard to its influence on the net radiation.[70] In doing so, the generally negative effect on the atmosphere will be equalised. As a result, the term "zero carbon footprint" is often used instead of "CO_2 neutrality". Therefore, the terms "CO_2 neutrality" or "decarbonisation" do not imply that no emissions are caused. Rather, positive emissions in given sectors or countries may be compensated through (natural) carbon sinks or negative emissions in other sectors or countries.[71]

In an urban context, this means that all CO_2 emissions generated by a city, its inhabitants, industry and transport have to be accounted for by an equivalent amount of sequestrated (e.g. forests, parks, etc.) or compensated emissions (e.g. sale of excess energy from regenerative energy production). Equally, remaining deltas may be balanced by the purchase of sufficient carbon credits (see Chapter 6 and 7) in order to obtain the value "zero" at the end.

In relation to the (observation) ***period***, levels have to be defined likewise. From an inventarisation point of view, it is the norm to choose the respective reporting year or calendar year.[72] The time frame may as well be considered from the perspective of a determined resource. Plants, for example, are neutral with regard to their ***carbon cycle***. Equally, a ***life cycle analysis*** for products can be chosen as observation period. If the GHG emissions stemming

[64] Compensation may occur through offsetting, but not all offsets are compensations. // See Lau, 2008, p. 2

[65] Both in the Clean Development Mechanism (CDM) embedded in the Kyoto-Protocol and in the European Union – Emission Trading Scheme (EU-ETS), and therefore the largest Cap-and-Trade strategies, reductions are referred to as "offsets". See UN-FCCC, 2007a // See Tokyo Metropolitan Government, 2016: "Tokyo Cap-and-Trade Program".

[66] Sucky, 2015, p. 218 // Rovers, 2008, p. 4

[67] Adapted from the definitions of the "buy-scenario" (See Rovers et al., 2008, p. 8) and the nomenclature of "indirect offsets" (See Linkd, 2014, p. 5)

[68] Adapted from the definitions of the "make-scenario" (Rovers et al., 2008, p. 8)) and the nomenclature of "direct offsets" (Linkd, 2014, p. 5)

[69] I.e. "grey energy" (energy needed for house construction). // See Carruthers, 2013, p. 1

[70] See CIMSS, 2015: "Net radiation is defined by the difference between the absorbed solar energy and the outgoing longwave radiation."

[71] Fay et al., 2015

[72] Here, significant differences exist within diverse directives and methods for the inventarisation of greenhouse gases (see Chapter 6 and 7). The emerging standard "Global Protocol for Community-Scale Greenhouse Gas Emission Inventories" permits the categorisation according to calendar year as well as fiscal year (Fong et al., 2014, p. 29).

from the entire life cycle of a considered product equal the amount of atmospheric CO_2 sequestered in the same time frame, then the product is considered to be "neutral". Wood products, whose captured atmospheric carbon amount is equal or greater compared to the emissions of utilisation, represent an excellent example for this purpose.

In accordance with the statutory requirements stipulated by the Kyoto Protocol and follow-up treaties, ***international reporting*** relating to GHGs is based on a ***production-based assessment***.[73] Specifically when applied to real estate (and, superordinately, to neighbourhoods and cities) not only emissions emanating from ongoing utilisation or management are significant. Rather have ***direct emissions*** within the framework of a comprehensive analysis to be included alongside ***indirect emissions***.[74] In this context, "grey energy" has emerged as a point of discussion.[75] If ***consumption*** is chosen as a view on emission, then indirect emissions – which were produced irrespective of territory while producing intermediates/precursors – have to be included.[76]

In order to measure the CO_2 neutrality of a city, theoretically a complete and comprehensive CO_2 footprint for the entire territory ought to be ascertained. This requires calculations integrating the radiation permeation which reflect less obvious or quantifiable physical parameters (i.e. the reflection potential of forest roofs and condensation trails caused by airplanes). Strictly speaking, all GHG-emitting activities on and also above a city´s territory would have to be measured as a matter of fact. At this point in time, such a sophisticated greenhouse gas account cannot be realised. For this reason, it is customary to apply measured values of greenhouse gases from direct and indirect sources in order to derive a city´s degree of CO_2 neutrality.

If a greenhouse gas inventory (see Chapter 7) becomes more detailed, recommended actions and measures, based on the analysis, can be initialised more purposefully. Therefore, it is especially important for metropolitan areas to work closely with adjacent municipalities. This is important due to the fact that most emission sources are situated outside the geographical city borders.

3.1.3 Co2-free (CO_2-free)

CO_2 ***free***, also referred to as 0-CO_2, signifies that no CO_2 is emitted outside a given system. As a consequence, compensations and offsets are *only* possible within system boundaries (if required for the prevention of a positive net contribution outside a given system).[77]

When this definition is applied on a building, CO_2-free implies that its management does not exhibit any CO_2 emissions, while the emissions of a CO_2-neutral building are equalised through offset mechanisms. Conversely, a CO_2-free city could nevertheless feature buildings and other processes that cause positive emissions, though these positive emissions would have to be absorbed within system boundaries by measures such as carbon sinks (i.e. forests).

Theoretically it is even possible to realise CO_2-free power plants,[78] however, the role of life cycle emissions tends to be neglected on an operational basis.[79]

Notwithstanding the above, if the term "CO_2-free" is used in connection with a building, a neighbourhood or a city, then the term is potentially delusive. The word "free" implies that a process or condition occurs entirely without carbon dioxide emissions. According to this definition, this is not obligatory as emissions may well be accrued, yet would have to be compensated within system boundaries. A specific technology (such as local public transport (PT) exhibits *very low direct* CO_2 emissions, particularly in the event of utilising electric propulsion and energy emanating

[73] Mayer et al., 2016, p. 4
[74] See Chapter 6.2.2 "Limits to the inclusion of emissions" for an overview of the distribution of direct and indirect emissions in accordance IPCC and GHGP-GPC methodologies.
[75] Carruthers, 2013, p. 1
[76] Mayer et al., 2016, p. 8
[77] Rovers et al., 2008, p. 11
[78] See Phys.org, 2016h // N.B: Energy companies which capture and store CO_2 in the course of CCS have been prohibited to call their electricity emissions "CO_2-free" on account of being misleading as consequence of preliminary injunctions Germany (Az: 97 O 297/07).
[79] Hou, 2010, p. 46

from renewable energy sources. However, in practice it is impossible that these occur without emissions, especially when *indirect emissions* are included in the analysis.

Cities with ambitious decarbonisation processes equally consider "Scope 3" emissions within the scope of improving the carbon footprint (see Chapter 6 and 7). By integrating indirect emissions, achieving a CO_2-free condition is practically impossible. While the procurement of a wind power station could have led to a CO_2-free state, this is from a "Scope 3" perspective not possible anymore due to the emissions caused by producing the facility.

3.1.4 Climate neutrality

The concept of CO_2 neutrality (see Chapter 3.1.2) can be expanded through including other GHGs (pursuant to the Kyoto Protocol), which are recorded according to the provision of carbon dioxide equivalence.(CO_2e). On this occasion, the effect of a given greenhouse gas on the atmosphere is expressed by its equivalent amount of CO_2 (see Chapter 3.1.1). In this case, ***climate neutrality*** and net-zero GHG emissions are used.[80]

"The term climate neutrality means living in a way that no net greenhouse gas (GHG) emissions. This should be achieved by reducing our own GHG emissions as much as possible and using carbon offsets to neutralise the remaining emissions."*[81]*

Emission-free consequently describes a condition in which no GHGs are emitted anymore. On the contrary, On the contrary, the condition of ***climate neutrality*** means a situation in which compensations or analogous reductions compensate emissions outside of city. The target of ***net zero*** can only be achieved as a result when current GHG emissions are not only met by compensation, but are rather faced with genuine negative emissions, i.e. by carbon capture and storage.[82]

3.1.5 Net or nearly zero energy

With regard to real estate, the concepts of *net* or *nearly zero energy* are frequently used. Based on the definition of a ***"nearly zero energy building"*** by the European Union (EU) within the scope of the ***Energy Performance of Buildings Directive*** (EPBD)[83], the German *Energieeinsparungsgesetz* (EnEG) ("Energy Conservation Law") defines in § 2a[84] a ***nearly zero energy building*** as a "building exhibiting a very good overall efficiency. The house´s energy consumption has to be very low and should be covered as much as possible by energy from renewable sources"[85]. Since the exact domestic definition of the term resides within each member state´s sphere of influence, a plethora of interpretations was deduced. Voss provides a concise account of various approaches undertaken by the EU member states.[86]

As a result, the observatory focus firmly rests on the utilisation phase of buildings. Aspects such as grey and indirect emissions have not been taken into account pursuant to the EPBD.[87] By virtue of a limited remaining carbon budget, methods examining the entire life cycle of a building from cradle to grave (***Life Cycle Assessment*** (LCA))[88] become increasingly important.

[80] Butler et al., 2015, p. 1ff
[81] UN-EP, 2008
[82] WBGU, 2016, p. 146
[83] See Energy Performance of Buildings Directive, 2010/31/EU, which defines a nearly zero energy building in Article 2 (2) as a „building that has a very high energy performance…. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby".
[84] See Energieeinsparverordnung 2014 (EnEV 2014) ("Energy Saving Ordinance) which is based on the Energieeinsparungsgesetz (EnEG 2013) ("Energy Conservation Law") and EU Directive 2010/31/EU: From 2021 onwards, all newly constructed buildings established according to nearly zero energy standard as stipulated by European requirements.
[85] BEE, 2016, p. 11
[86] Voss, 2013, p. 26-81
[87] Voss, 2013, p. 277
[88] Weissenberger et al., 2014, p. 553 // See Finnveden, 2009

Buildings, districts or cities adhering to the "nearly zero"- or "net zero" considerations have subsequently been referred to as **"n***et/nearly zero buildings"*, **"n***et/nearly zero energy districts"* or **"n***et/nearly zero energy cities"* in accordance with international requirements of diverse projects and publications.[89]

A key realisation in this respect is the comprehension that emissions can be compensated by the utilisation of renewable energy sources. Thus, the term is used in connection with "equilibrating" emissions. For initiatives which cover energy efficiency in a general way the terms "net zero energy" or "nearly zero energy" are already customary. Correspondingly, the authors of the present study apply the term "net zero energy building" (or abbreviated "net ZEB" resp. nZEB) to real estate which consume little energy in the utilisation phase while incorporating renewable energy sources as well.

3.1.6 Low-carbon city and decarbonisation

The terms "*low-carbon city"* and "*decarbonisation"* have been regularly used in literature and in the appellation of initiatives concerned with the reduction of greenhouse gases.[90] The expression "low" , however, implies that emissions are currently existing and that further efforts are required.

Cities should only claim the status "low-carbon" for themselves if the reduction of emissions were inherent in the system – meaning by successful own measures - instead of solely purchasing emission certificates for instance. Otherwise, the application of the concept – albeit widespread- would be deceptive.

The concept of a **"g***reen city"* goes even further. To illustrate, the "Green City Index" by Siemens as a practical definition of a green city encompasses the sectors CO_2, energy, building, transport, water, waste & land use, air quality and environmental governance.[91] The conception of a "**s***ustainable city"* ultimately enfolds socio-cultural and economic aspects besides ecological elements. A multitude of frameworks and toolkits[92] assist the realisation of a sustainable city.[93]

A precise and consistent definition is imperatively important to avert the inflationary and partly delusive usage of positively connotated sustainability terminology (so-called "g*reenwashing*").[94]

In conclusion, the following terminological perimeter shall be used for the clear distinction of the terminology:

- At all times, the usage of the terms "carbon" or "CO_2" shall be observed if and only if carbon (dioxide) is scrutinised. When other greenhouse gases are addressed, these are delineated as "CO_2 equivalents" respectively "CO_2 e(q)", or simply "greenhouse gases".
- When discussing CO_2 emissions with regard to climate change mitigation, the term "CO_2-neutral" is used. Conversely, if other greenhouse gases are analysed or catalogued by inventories, the tern "climate neutrality" is more informative and expedient.

Ultimately, the concept of *decarbonisation* elucidates a process where, in connection with a determined process, the necessary CO_2 emissions are reduced.[95] Decarbonisation is therefore a process in which inefficient, emission-intensive technologies are replaced by efficient and low-emission technologies which have at least the same (energetic) capacity. In this spirit, it is an important methodological guideline[96] - as without a transformation, long-

[89] A precise example is FortZED, a zero-energy district in Fort Colling, Colorado (USA). It combines efficiency measures within a diversified building mix with energy generation from renewable sources on the premises of Colorado State University and an urban location. Various other case studies in this context are available at: http://iet.jrc.ec.europa.eu/energyefficiency/node/9101 // See Hall, 2010.
[90] See for example "Low Carbon City agenda" by ICLEI(2009) , the „Low Carbon City Lab" (http://local.climate-kic.org/), and the "Low Carbon City Initiative" in China (http://en.wwfchina.org/en/what_we_do/climate___energy/mitigation/lcci/)
[91] European Green Cities Index, 2009.
[92] I.e.Global City Indicators Facility, China Urban Sustainability Index, or the Reference Framework for Sustainable Cities.
[93] See EU, 2015, Chapter 2 and 3
[94] Seele et al., 2015
[95] Butler et al., 2015, p. 1ff
[96] Decarbonisation also plays a distinct role in numerous chapters from the IPCC Assessment Report (IPCC 2014_a) // See IPCC 2014_a, p. 74-85 for strategic and operational dimensions of decarbonisation as well as IPCC 2014_a, p. 697 for an exemplary application on buildings.

term goals such as CO_2 neutrality or "green economy" in general – cannot be reached. The entire spectrum of options is based on four pillars[97] which will be briefly outlined. Energy production is mentioned as the central element. Here, the usage of fossil fuels needs to be systematically replaced by renewable energy sources in order to gradually achieve a greenhouse gas reduction. The second pillar constitutes the shift towards sustainable combustibles in the sectors of transportation, heating and industry. As a third element, an increase in efficiency of all sectors is noted, whereby buildings and transportation move into focus due to their role as principle consumers of fossil energy sources.[98] The fourth pillar concerns itself with the preservation and extension of carbon sinks.[99] These pillars are correspondingly considered by organisations,[100] guidelines,[101] and tools[102] analysed.

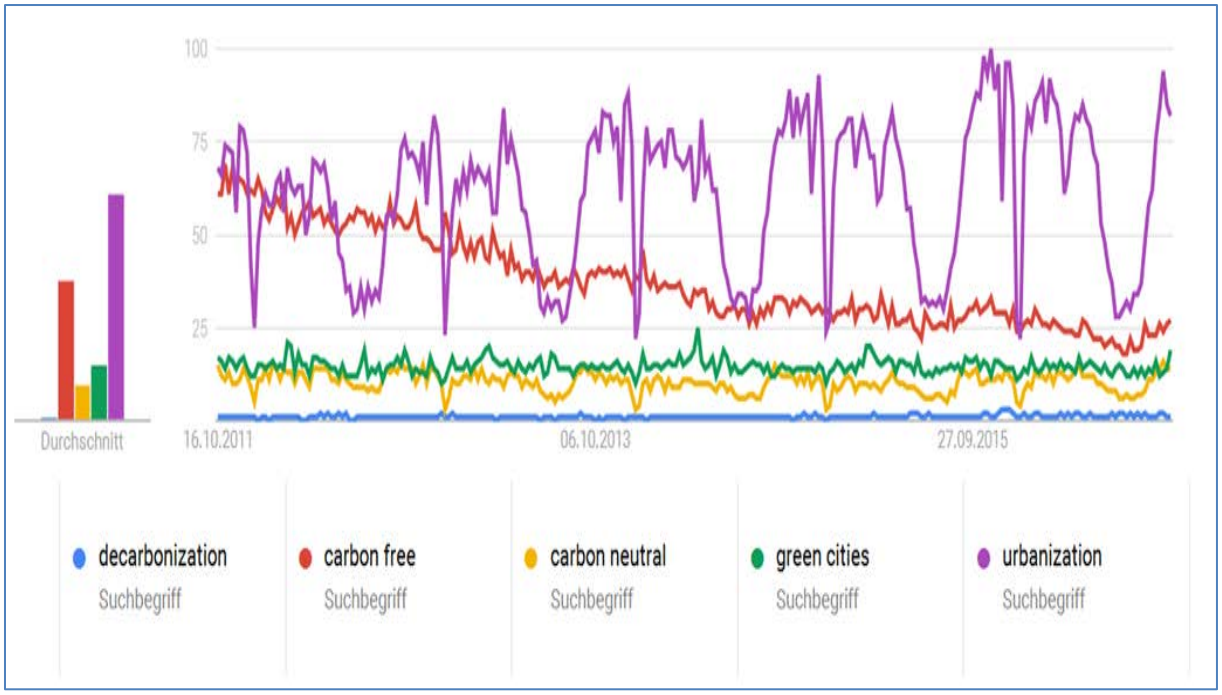
A target-oriented usage of the term is demonstrated by the *Deep Decarbonization Pathways*[103] (DDPP) project. It focuses on climate and policy and illustrates how countries can transform their energy systems by 2050 in order to realise the transition towards a „low-carbon" economy. On the national level, the project offers a long-term frame of reference in the form of examples and recommendations to enable informed and coordinated decisions on the political or economic level. Internationally, the project provides a transparent benchmarking tool for the analysis of national obligations. It currently covers 16 country research teams which account for approx. 70 percent of the global greenhouse gas emissions being situated at diverse stages of development.[104]

3.2 Global tendencies in search queries of key terms

The evolution of our theoretical comprehension of the emerging nomenclature (see Chapter 3) is mirrored by an increased "google queries" of related terms. For this reason, it appears useful to trace current tendencies in order to visualise to what extent elaborated concepts are anchored in the consciousness of a world population which enjoys a historically unparalleled access to information. The following graph illustrates the dynamic relating to the terms "decarbonisation", "carbon-free", "carbon-neutral", "green cities", and "urbanisation":

[97] World Bank Group, 2015, p. 28
[98] Ibid.
[99] Natural environment which absorbs atmospheric CO_2 through carbon sequestration (e.g. forests). For an operational definition relating to urban structures and the calculation of contributions by carbon sinks within the scope of inventarisation (Ravin, 2016).
[100] See Chapter 5
[101] See Chapter 6
[102] See Chapter 7
[103] DDPP, 2015
[104] The 16 states are Australia, Brazil, China, Germany, France, India, Indonesia, Italy, Japan, Canada, Mexico, Russia, South Africa, South Korea, UK and USA.

Figure 4: "Google queries" of sustainability-related terms



Source: Queries from Google Trends (15.10.2016)

As the most queried term, "urbanisation" stands out. In cyclic surges, interest has been constantly increasing which accompanies the intensified global tendencies towards urbanisation within the last decades.[105] Although climate change and urbanisation tendencies exhibit significant influence on populations, terms relating to climate change are less queried. It is noteworthy that climate change conferences by the UN-FCCC[106], albeit widely covered by media reporting, do not lead to an increase of queries in respective years and months. Intriguingly, „decarbonisation" has been queried even less. Since the Paris Agreement – containing clear and ambitious agreements - the volume of queries has been increasing.[107]

The evolution of the analysed terms is not only crucial for the academic discourse, but needs to be whetted by public discussion.

3.3 Status quo of climate change

The term "*climate change*" is referring to a time-related climate variation on the global or regional scale, which, compared to their respective historical averages, implies changes to temperature, meteorology, precipitation as well as other weather phenomena.[108] Public discourse tends to use the terms "climate change" and "global warming" synonymously. "*Global warming*" firstly emerged as a term in 1975,[109] and essentially encompasses the process of rising surface temperature. Conversely, the term "climate change" entails all of the above subsections. Since the first emergence of the term, countless studies have been published over time which contributed to a gradually improving comprehension of the role that carbon dioxide plays in the atmosphere as well as concerning the impact of greenhouse gases on global warming.[110] As a consequence, "global warming" became the standard term to describe this planet´s increasing (average) surface temperature. Nevertheless, "climate change" constitutes the formative term for the various effects of global warming.

[105] See Chapter 3.4.2
[106] See Chapter 3.5.2
[107] COP, 2015_d
[108] IPCC, 2012, p. 557
[109] Broecker, 1975
[110] See NRC, 1979 and NRC, 2010 // IPCC, 2006 // IPCC 2007_a // IPCC 2007_b // IPCC 2007_c // IPCC 2007_d // IPCC 2012 // IPCC 2013_a // IPCC 2014_a

The term "*greenhouse effect*" includes negatives connotations and is principally a natural process that occurs when atmospheric greenhouse gases absorb long-wave infrared radiation emitted by the planet´s surface. As a result, a part of the heat remains in the atmosphere which ultimately enables the perpetuation of life. Yet, increased accumulation of determined gases over the last decade[111] led to an intensification of this greenhouse effect. Various studies[112] have scientifically substantiated the perpetual increase of surface temperatures in this century and that the contemporary mean surface temperatures have reached its highest level during the last five centuries. Cities as well more and more frequently report temperature records.[113] In January 2016, the highest temperature ever measured in this month during a 137 year-long recording period was confirmed.[114]

The negative implications of the sustained climate change[115] for urban areas are summarised in the following table.

Table 1: Climate change implications for urban spaces

Climatic aspect	Commercial and residential real estate	Infrastructural facilities	Misc. consequences on urban areas
Temperature increase	Reductions of proceeds (by changed settlements, revenue potentials/ increased requirements for cooling, hence adjustments to operating expenses)	Increased wear and tear of facilities. Instable subsoil.	Damages to or loss of parks and green spaces. Alterations to landscape and watercourses. Changes to wind and hydropower caused by alternations in precipitation and wind directions. Increased and changing demand to cool/heat buildings. Increased number and intensity of heat days and heat waves which may negatively impact population health.
Water scarcity	Reduced attractiveness of a region thereby decreasing revenues. Higher costs for water procurement and purification.	Lowered supportability of subsoil. Damages to or destruction of water and drainpipes. Contamination of water reservoir.	Negative impact on the availability and quality of water – with related consequences for hygiene and health of population.
Sea level rise	Reduced settlement area in coastal areas.	Hazard to harbour facilities.	Damage to or destruction of sites with cultural value and corresponding damages to tourism and identity.
Increased extreme weather events	1. Direct losses (i.e. hail damages for buildings) 2. Indirect losses (i.e. interruptions in production or rent losses following storms) 3. Consequential losses (i.e. declining tourism Illustrations	1. Direct losses 2. Indirect losses (Damages to infrastructure due to extreme temperatures/congested sewer systems/ hail damages to ports, airports etc./ vulnerability of electric	Damage to or destruction of sites with cultural value and related damages to tourism and identity. Increased population density in safe regions and increase of "environmental refugees". Alterations to supply chains due to climatic changes.

111 See IEA 2012 and IPCC 2007_a for atmospheric accumulation of greenhouse gases.
112 See Hansen et al., 2010 // NOAA, 2016 // GISTEMP, 2015
113 See IPCC, 2013_a, p. 489-530 // GISTEMP, 2015
114 NOAA, 2016, p.
115 See also ZIA, 2014, p. 22

	in flood zones, increased insurance premiums)	utility services towards natural disasters. Interruption to communication systems as a consequence of natural disasters).	Disease and other negative consequences for health arising from natural disasters.
Increased need for regulation as a consequence of climate change	Increased construction costs and ongoing operating expenses. High costs especially in the case of carbon taxation.	Increased construction costs and ongoing operating expenses.	General increase of regulation targeting mitigation and adaptation.
Increased adaptation costs as a consequence of climate change	Increased costs for safety measures as well as energy- and resource-efficient real estate.	Increased costs for safety measures.	Generally high expenditures for the transformation of economies.

Source: own representation

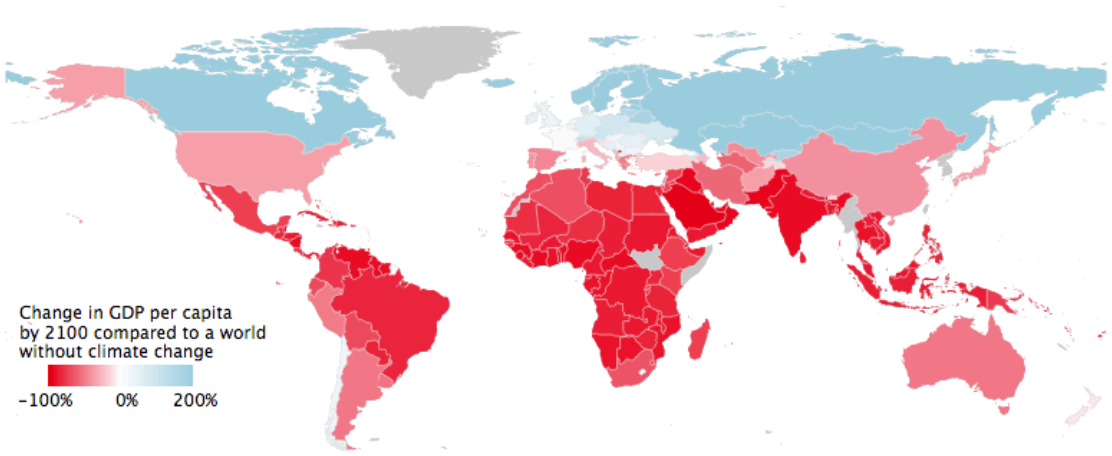
Experts agree that besides "insidious" temperature increase and corresponding risk potential for urban areas, an increase (or return) of extreme weather events, such as heatwaves and sustained periods of droughts, needs to be anticipated. This applies to Germany, too, as a significant increase in losses due to natural hazards has been recorded during the last three decades[116].

Furthermore, a sea level increase is expected.[117] It is estimated that half of the world´s population lives in the immediate vicinity of the coastline.[118] According to new calculations in a high-emission scenario, sea levels are anticipated to increase by more than one metre by the end of this century.[119] It is essential to note that these considerations are flawed by uncertainty and that extreme scenarios may exceed these scales.[120]

More and more studies focus on the *economic consequences of climate change*.[121] As an example, recent studies concerning the US assert that urban areas along the coastline face real estate-related losses amounting to 106 billion US dollars by the mid-century due to rising sea levels.[122] Combined with a global increase in the average temperatures by 3 C°, an estimated 1.1 percent of the total global surface area and 7 percent of the world´s population are anticipated to be affected.[123] Research results reveal how countries with lower levels of income per capita need to master higher economic damages in relation to the overall economic power than countries with higher levels of income per capita.[124] In a BAU[125] scenario and correspondingly high temperature increase, climate change would reduce the global economic performance by 23 percent by the year 2100.[126] In addition, disparities in the income distribution could even further increase.[127]

[116] See Ward et al., 2010, p. 1. // Munich RE, 2015, p. 77 // Kogan et al., 2015.
[117] See IPCC, 2014_a // NOAA, 2016
[118] UN-EP, 2016
[119] Perrette et al., 2013, p. 11-29
[120] Schellnhuber, 2015, p. 151 f
[121] Hochrainer, 2009 and Bouwer, 2010
[122] Gordon et al., 2014, p. 3ff
[123] Marzeion/Levermann, 2015, p. 1
[124] Munich Re, 2013.
[125] BAU: Business-as-usual.
[126] See Burke et al., 2015, p. 238: Best Estimate, SSP5.
[127] See Burke et al., 2015, p. 237: "In 2100 we estimate that unmitigated climate change will make 77 % of countries poorer in per capita terms than they would be without climate change. In our benchmark estimate, average income in the poorest 40% of countries declines 75 % by 2100 relative to a world without climate".

Figure 5: Global change in the per capita GDP (RCP8.5)



Source: Burke et al., 2015, S. 238

In urban areas, an interruption of supply chains may increasingly result in losses regarding supply and revenue. To illustrate, an example from Brazil can be quoted where, simply due to climate change, economic losses from 0.5 percent to 2.3 percent of the GDP are expected from 2050.[128] The so-called PESETA[129] studies engage with the climate change´s consequences for European economies and populations. The most recent PESETA analysis comprises a multi-sectoral analysis of the repercussions of climate change in Europe and is focused on long-term impacts for the period 2071 to 2100.[130] According to the underlying simulation, climate change-related yearly global losses are expected to reach around 190 billion EUR, equalling approx. 2 percent of the EU BIP in 2014.[131]

Against the backdrop of the status quo, climate protection therefore has to be understood as risk management rather than acts of altruism. The German government as well points to a variety of *security risks*[132]. On top of that, *financial risks* may be limited by enhanced climate protection by avoiding *misguided investments*.[133] From a (local) decision-maker´s point of view, it is important in this respect that transparency is *primus inter pares* to the corresponding cost-benefit effect. It is evident that a *delayed response* is accompanied by significantly increasing costs to meet challenges posed by climate change.

Aside financial relevance, the various impacts of *extreme weather events* on society are equally momentous and often target people who live in fragile and less developed countries. Throughout the world, people´s livelihoods are endangered – for example through crop failures, destruction of living space or affordability of food. In addition, raw material prices have been subject to stronger fluctuations when agriculturally dominated regions are affected by changing climatic conditions.[134]

The urgency to meet the challenges posed by climate change is incisively embodied in the following quote: “Climate change does not respect border; it does not respect who you are - rich and poor, small and big. Therefore, this is what we call 'global challenges', which requires global solidarity.“ (Ban Ki-Moon).

[128] See Marcovitch et al., 2011
[129] PESETA is the abbreviation for „Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis“. See https://ec.europa.eu/jrc/peseta
[130] PESETA´s methodology is based on bottom-up biophysical impact models, which take into account the relationship between climate change and biophysical impacts in a structured way. The effects on ten impact categories are assessed (agriculture, energy, river floods, droughts, forest fires, transport infrastructure, coasts, tourism, habitat suitability of forest tree species, and human health). Some of the biophysical effects are integrated into an economic model in order to assess impacts on overall economy and prosperity on EU- and regional-level.
[131] Ciscar et al., 2014, p. 110f
[132] See WBGU, 2007 // See CCC, 2012: “Climate risks“. // See Messervy et al., 2014
[133] BMUB 2016d, p. 6
[134] Brown, 2008

3.4 Anthropogenic greenhouse gas emissions in the context of climate change

A profound decarbonisation is tantamount to a vigorous transformation of our economy and the manner in which we consume and live in the future. It is imperative to provide an apt reason why such intensive transformations are necessary. Most notably, because the (fortunately) dwindling number of climate sceptics continues to argue that climate change is not man-made but rather rooted in natural causes. *The line of argument for an inconvenient truth,*[135] *namely that emissions emanating from consumption, transport, and economy are causally related to the greenhouse effect, has been closed in the meantime.* The incriminating evidence is overwhelming. Within the scientific community, there is a broad consensus for this assertion. Series of measurements confirm the consequences of CO_2 emissons on outgoing longwave radiation (OLR).[136] In comparison to pre-industrial levels of 280 ppm (parts per million) of CO_2e in the atmosphere, the reflected radiation has significantly decreased due to contemporary levels of 400 ppm. Thereby, an increased amount of sunlight is "bound" which in consequence further heats up this planet (detection). To conclude the line of argument, it is furthermore necessary to prove that these emissions are the consequence of man-made actions (as otherwise, the argument of climate sceptics, namely that these may be attributed to the exhaust of volcanoes, would gain impetus). Fossil energy sources (natural gas, oil, etc.) carry specific chemical characteristics with regard to the so-called 14C-Fraktion[137] and therefore differ from the isotope characterisation of natural carbon dioxide in the air.[138] Hereby, the attribution of greenhouse gases to anthropogenic emissions is made possible.[139]

Global greenhouse gas emissions recorded high growth rates.[140] According to the IPCC, global levels of greenhouse gas emissions rose by 70 percent solely between 1970 and 2004.[141] Effects emanating from the global economic crisis only managed to reduce emission growth temporarily,[142] while emissions between 2000 to 2010 collectively rose faster than in the previous three decades.[143] They can mainly be attributed to the growth in emerging economies.[144] *Furthermore, the IPCC asserts that, despite current mitigation efforts, global GHG emissions will continue to rise during the next decades according to diverse scenarios and mitigation mechanisms*.[145]

The slight decline of global warming tendencies, which has been evident during the last years, led to a lively debate that centred on whether this was the result of natural events and fluctuations, or if it can be traced to anthropogenic effects on climatic systems. The ascertainment that long-term global warming is essentially a natural cycle, is universally accepted. Nevertheless, there is a difference between contemporary climate trends and the natural cycle. *Steinman et al.* (2015) determines that internal, multidecadal oscillations of temperatures in the northern hemisphere have less contributed to a surface temperature increase. Rather managed they to partially compensate for an accelerating anthropogenic temperature increase. Previous studies described naturally occurring oscillations as having a substantial and negative effect on the climate change.[146] According to this study, the internal climate variability is rather attenuated than reinforced.[147]

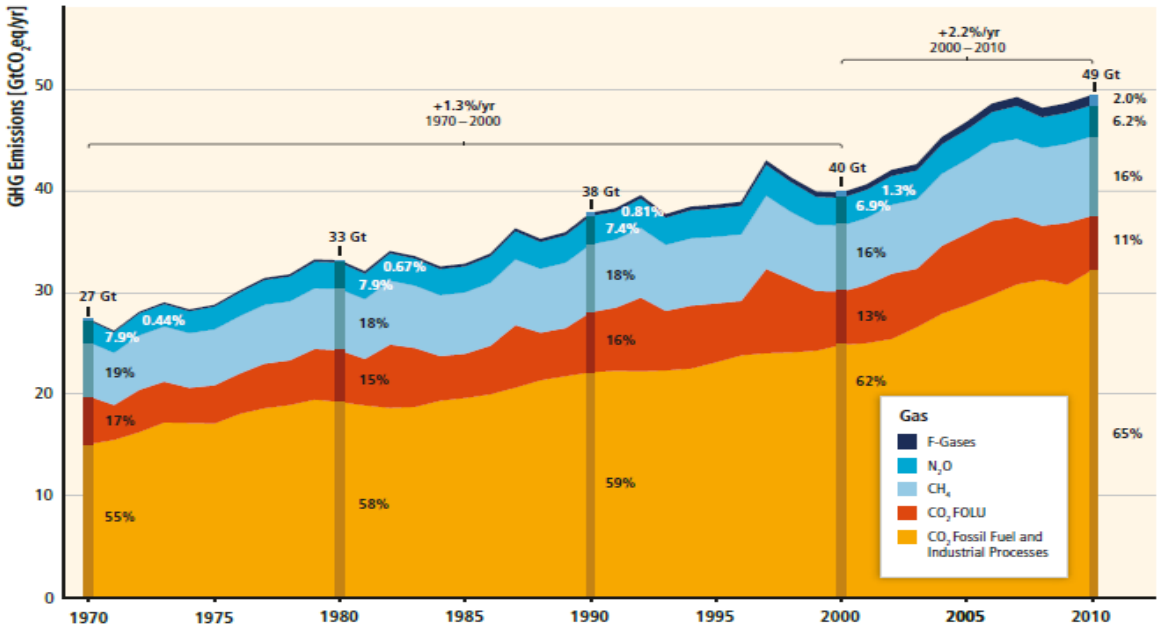
Assuming the pattern of previous historical fluctuations, this trend is likely to reverse and thus intensify the anthropogenic warming in the decades to come.[148] Although our planet has been subject to natural alternations for

[135] Al Gore´s "An inconvenient truth": Among other things, the author has coined the term "inconvenient truth" in this publication.
[136] Feldmann et al., 2015, p. 339- 343 // IPCC, 2013_a, Chapter 13.5
[137] N.B: Approximately zero.
[138] Schellnhuber, 2015, p. 75, for the so-called "Suess-Effekt".
[139] See also Hasselmann, 1979 p. 251-259, and 1993, p. 1957-1971, for the *Detection* and *Attribution* approach.
[140] IPCC 2014_a
[141] IPCC, 2007c and Figure 7
[142] IPCC, 2014_c, p. 42
[143] IPCC, 2014_c, p. 1093 // Cook, 2012.
[144] IPCC, 2014_c, p. 291
[145] IPCC, 2014_c, p. 135
[146] Steinman, 2015, p. 988
[147] Which is caused by an interplay of two multidecadal oscillations in the Atlantic and Pacific regions (Atlantic Multidecadal Oscillation and Pacific Multidecadal Oscillation) // See Steinman, 2015, p. 989
[148] Dai, 2015, p. 555

many times in its history, the current developments clearly have another cause: They are man-made ("anthropogenic").

Anthropogenic GHG emissions de-facto occur in every sector of a given economy.[149] Literature provides a vast array of examples regarding the anthropogenic effects on vegetation, animals, soil, water, terrain, and atmosphere.[150] From a historical point of view, various oscillations of CO_2 emissions have been measured in diverse areas. They can be attributed to events such as the end of subsidised coal mining in the UK, German reunification or - in recent history - the adjustments to Japan´s energy mix following the disaster in the Fukushima prefecture. Yet, such events may only account for short-term oscillations of carbon dioxide, but not for fundamental alterations or essential emission tendencies.

Figure 6: Annual total emissions of anthropogenic greenhouse gases by groups (1970-2010)



Source: IPCC, 2014b, S. 5

These emissions are caused by land use change and subsequent tillage of agricultural areas, the usage of fertilisers as well as by animal husbandry (methane). Equally, emissions result from the usage of fossil energy sources when transporting, from waste management (depending on the method of waste treatment and disposal), from logging and deforestation as well as from production processes, especially the manufacture of materials such as cement, aluminium, iron or steel. In consequence, the term "anthropogenic climate change" is referred to when man-made actions and subsequent elements of value-added chains and related consumption cause emissions, which in turn implicate climatic variations.

Until some years ago, there was no consensus whether anthropogenic GHG emissions are responsible for global warming.[151] The scientific community exerted considerable efforts to explore the role of GHG stemming from anthropogenic sources. From now on, thye can clearly be classified as a key factor concerning sustained climate change.[152] This assertion is further backed by independent studies[153] in which scientists acknowledged human-

[149] Goudie, 2013
[150] See Section 2 // IPCC, 2007a
[151] Studies by Powell (2013) and Cook (2013) analyse abstracts in academic databases, resulting in the recognition that between 82 – 99% of all articles in various disciplines consider humans to be responsible for climate change. Nevertheless, methodological doubts persist which are summarised by Legates (2013).
[152] See also NASA, 2016
[153] See Oreskes, 2007 // Ramaswamy et al., 2006 // Doran et al., 2009 // Anderegg, 2010 // Santer et al., 2012 // Santer et al., 2013 // Cook et al. (2013)

made causes to be the quintessential driver of global warming.[154] To that end, the following citation serves well: "(…) increase of global average temperatures (...) was (…) with high probability caused by the anthropogenic emission of greenhouse gases."[155]

3.5 World-wide targets concerning decarbonisation

3.5.1 Contemporary trends of world-wide GHG emissions

In order to limit the global warming of below 2 C° - according to the climate agreement of Paris (see Chapter 2.1) - *fossil* **CO_2** *emissions need to be completely suspended by 2070*. The necessary physical transformation has been advanced since the conclusion of the first Kyoto Protocol (see Chapter 3.5.2). Nevertheless, previous achievements have been disenchanting. In 2013, concentrations of atmospheric carbon dioxide exceeded 400 ppm. In pre-industrial times, concentrations amounted to 280 ppm.[156] Simply the combustion of fossil fuels and industrial processes (such as the manufacture of cement clinker, metals and chemicals) caused emissions of more than 36 billion tons of CO_2[157] and 35.7 billion tons in 2015.[158] Altogether, anthropogenic emissions exceeded the level of 50 Gt CO_2e/year[159] for the first time in 200, and continued to rise to 52.7 Gt CO_2e/year by 2014.[160] Currently, at least *initial progress in energy intensity* has been achieved in the light of a global rise in the GDP by 3 percent while the GHG emissions stagnated.[161]

When considering emissions that actually occurred according to data of the International Energy Agency (IEA) and additional research[162], it is fair to state that, retrospectively, the trend of the annual global anthropogenic CO_2 emissions stemming from fossil energy sources strongly correlates with past IPCC projections. *Predominately, actual emissions correspond to trajectories at higher emission scenarios, according to the IPCC*.[163]

Without further efforts and while maintaining existing regulatory requirements (business-as-usual scenarios), the US Energy Information Administration (EIA) forecasts a sustained growth of global energy-related carbon dioxide emissions amounting to 46 percent by 2040.[164] The following table encapsulates fundamental global trends regarding emissions:

Table 2: Carbon dioxide emissions in 2014, per capita emissions and changes

Country	Emissions* (2014)	CO_2/cap** (1990)	CO_2/cap** (2014)	Change*** (1990-2014)	Population growth*** (1990-2014)
EU- 28	3,420	9.2	6.7	-27%	8%
Germany	770	12.5	9.3	-26%	3%
Russia	1,770	16.1	12.4	-23%	-4%
China	10,590	2.1	7.6	262%	20%
USA	5,330	19.6	16.5	-16%	27%
Brazil	500	1.5	2.5	71%	35%

** per year and $MtCO_{2e}$ // ** per year and $MtCO_2$ // *** in %*
Source: own representation, UN-DESA, 2015

[154] This is congruent to the interpretation of recent IPCC Reports by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB 2016a, p. 1)-
[155] IPCC, 2013a, p. 7, 33
[156] See IPCC 2007b, p. 2ff // IPCC, 2013a, p. 659
[157] Olivier , 2015, p.10
[158] Ibid.
[159] IPCC, 2014b, p. 5
[160] See UN-EP, 2015, p.16 // IPCC, 2014b, p. 6
[161] IEA, 2015
[162] Boden, et al., 2015
[163] IPCC, 2014b, p. 5
[164] EIA, 2013, p. 159

All developed countries managed to reduce the CO_2 per capita consumption. *In Europe, an absolute reduction of emission levels has been achieved despite population growth.* The United States were unable to fully compensate the growth due to a growing population. Future challenges are particularly rooted in *emerging nations and developing countries. Here, a sustained per capita growth of emissions can be traced to growing consumption.* This effect has been amplified by a significant increase of populations.

If "only" oil and coal deposits were concerned, it would be possible to take a (risky) stance that they run low in the near future, thus solving the dilemma of increased GHG emissions from fossil energy sources virtually by itself (due to scarcity). Spurred by technical progress and new discoveries, deep sea and polar oil as well as gas condensate, oil sands (tar sands), shale oil and other sources gradually come to the fore. *Recent studies anticipate that the amount of carbon sources used since the dawn of industrialization exist another 60 times, approximately.*[165] In spite of the development expenses for these sources being notably higher than historic costs, it is nevertheless imperative to steer economies towards an increased or exclusively long-term use of renewable energy sources. For example, *Steckel et al* (2015) admonish how a massive usage of coal as combustible in developing countries runs contrary to climate protection.

The reduction of GHG emissions therefore assumes a crucial hinge function in limiting the extent of climate change and in avoiding dangerous *tipping points* of our planet´s ecosystem.[166].

3.5.2 International agreements limiting climate change

In order to classify national or regional or communal efforts of climate protection, the related superordinate levels are significant. Ambitious regulatory frameworks on the national state level culminate in tremendous efforts to be undertaken by municipalities to meet stipulated targets. Further, it is possible that national requirements are lenient or missing altogether, which, in consequence, compels cities with considerable environmental problems to act on their own initiative for the purpose of reducing emissions.

The "*Representative Concentration Pathways*"[167] used in accordance with the IPCC demonstrate that even in a socio-economic "sustainability scenario" (RCP 2.6), global warming will reach approximately 2 C°.[168] In order to achieve this target, a global implementation of ambitious climate protection efforts is imperatively important as by 2030, the apex of GHG emissions ought to be reached and emissions must factually cease by 2070.[169] Experts note that the **remaining, culminated budget pertaining to GHG emissions, estimated in the range of 750 billion tons, must not be exceeded in order to comply with the** *2 C° objective*.[170]

The international community is aware of its responsibility to implement and transpose further mitigatory actions. On the global level, the *Paris Agreement* represents the most important and comprehensive step towards the aforementioned goal (see Chapter 2.1). As part of the *United Nations Framework Convention on Climate Change* (UNFCCC), a legally binding and extensive climate protection agreement on the supranational level constitutes a key element.

The agreement is in line with the 17 *Sustainable Development Goals*[171] (SDG) earlier adopted by the United Nations – most notably with SDG 13[172] encompassing "Climate Action" and SDG 11[173] with the aim to "[m]ake cities and settlements inclusive, safe, resilient and sustainable".

[165] Edenhofer et al., 2009
[166] IPCC 2014a
[167] Van Vuuren et al., 2009, p. 428-439
[168] See IPCC, 2014 a / WBGU, 2016, p. 74
[169] WBGU, 2015
[170] See Schellnhuber, 2015, p. 467 // IPCC 2013b, p. 27: 790 bn tons in 2013. This amount has to be reduced by the emissions in the following year, which is why 750 bn tons represent the maximum.
[171] UN, 2015
[172] https://sustainabledevelopment.un.org/sdg13
[173] https://sustainabledevelopment.un.org/sdg11

German and European climate protection efforts are embedded within this global framework. The *Kyoto Protocol*[174] was the first legally binding supranational climate protection agreement with the purpose of limiting climate change[175] within the United Nations Framework Convention on Climate Change.[176] With the ratification on 16th February 2005[177], leading industrial nations have committed themselves to reduce the total GHG emissions by a defined amount compared to the baseline levels of 1990. Within the scope of the protocol, Germany committed itself to reduce GHG emissions by 21 percent on average for the period 2008 to 2012.[178] This goal had already been reached by the Federal Republic in 2007, thereupon obligating itself to not increase the emissions for the next five years (by 2012).[179] After the first commitment period (2008-2012), the 8th December 2012 marked the adoption of the "Doha Amendment to the Kyoto Protocol"[180], which entailed new obligations for signatories for the period 2013 to 2020 (also referred to as "Kyoto II""[181]). In the run-up to COP 32, the heads of government of the seven leading industrial nations ("G7") already agreed in June 2015 (so-called Leaders´ Declaration)[182] to completely cease the GHG emissions by the end of this century by avoiding the usage of fossil energy sources and to legally entrench the goal of limiting global warming to 2 °C. Further, the declarations comprise the intention to place 100 billion US dollars annually from public and private sources for financing climate protection.[183]

Against this background, the climate agreement of COP 21 was subsequently agreed upon (see Chapter 2.1). Besides the central element of limiting global warming to a maximum of 2 °C , several subsections envisioned in previous climate conferences resurfaced, such as the intended establishment of a *Green Climate Fund* (GCF)[184] as well as substantiated reflections on the CO_2 pricing policy.[185]

In the framework of the so-called "Lima Call for Climate Action" – likewise a precursor of COP 21 – the participating states had already been asked in 2014 to submit respective *Intended Nationally Determined Contributions* (INDCs) in the run-up to the Paris Conference. These national climate protection plans incorporate individual target values and intended set of measures for their realisation. ***The level of ambition exhibited by the respective states, as a whole, is very heterogeneous.***[186] Individual research institutes already note that present INDCs will not suffice to limit the global warming to 2 °C.[187]

Noteworthy in a positive sense is the fact that within the context of the INDCs, emissions expected in the future will be significantly lower (for 2025 by 2,8Gt of CO_2 and in 2030 by 3,6 Gt of CO_2) than stipulated in previous scenarios (in this case AR4, Fourth Assessment Report of the IPCC).[188] This would suggest that emissions between 2010 and 2030 would be 57 percent lower than in the time period 1990-2010.[189]

Consensus exists that particularly four fields of action require massive efforts by the international community to realise the envisaged decarbonisation: [190]

- decarbonising the electricity generation,

[174] UN-FCCC, 1998
[175] The agreement concerns itself with the supplementary protocol signed on 11th December 1997 for content-related design of the United Nations Framework Convention on Climate Change (UNFCCC).
[176] Umweltbandesamt, 2016_a
[177] UN-FCCC, 2014_b
[178] UN-FCCC, 1998
[179] Geden, 2013
[180] UN-FCCC, 2012
[181] Van Calster, 2015, p. 621
[182] G7 Leaders' Declaration, 2015, p. 14f
[183] G7 Leaders' Declaration, 2015
[184] UN-FCCC, 2010, p.17, Präambel 102-104: Planungen zum Klimafonds.
[185] See UN-FCCC, 2016, Article 2-a. // see also ANDP, 2016, SDG-13.
[186] Aldy, 2015, p. 4
[187] See WBGU, 2015: "Contemporary climate protection pledges by countries (Intended Nationally Determined Contributions, INDC) would only suffice to limit surface warming to approx. 3°C. Therefore, they have to be urgently tightened."
[188] UNFCCC, 2015, p. 43
[189] UNFCCC, 2015, p. 9
[190] Fay et al., 2015

- implementing massive electrification (in order to increase the share of "green" electricity) or, where not applicable, the change to clean energy sources,[191]
- improving efficiency in all sectors and reducing the waste volume,
- conserving and expanding natural carbon sinks through improved management of forest, soil and vegetation.

In addition, the general conservation of resources and moderation of consumption take a central role.

3.5.3 German climate protection goals

National climate protection goals are, among others, derived from the requirements of the Paris Agreement.[192] Besides this multilateral framework, the German goals are embedded within the framework of the EU climate targets for 2030 and 2050. According to the targets, *, the GHG emissions have to be lowered by 80-95 percent by 2050 (compared to 1990)*.[193] Moreover, in October 2014, the European Council agreed upon a reduction target of 40 percent by 2030.[194] Overall EU targets were submitted to the United Nations in the form of INDCs.[195]

Besides the targets for 2020, Germany thereby faces essential interim goals for 2030 and especially the ***objective of extensive greenhouse gas neutrality*** by 2050.[196] According to the German government, emissions of greenhouse gases (GHG) and their capture through carbon sinks are said to reach an equilibrium ("net zero emissions") in the second part of the 21st century.[197] ,The precise allocation of these general reduction targets to individual sectors, in particular, required intensive negotiation processes, which is why the "*Klimaschutzplan 2050*" ("Climate Protection Plan 2050") was agreed upon only on 14 November 2016.[198]

[191] Pachauri, 2012, Chapter 19: In low and medium income economies, a high dependence on solid fuels persist.
[192] BMUB 2016$_d$, p. 2
[193] BMUB, 2015$_a$, p. 8
[194] Europäischer Rat, 2015
[195] BMUB 2016$_d$, p. 12
[196] BMUB 2016$_d$, p. 5
[197] BMUB, 2016$_c$, p. 2
[198] https://www.tagesschau.de/inland/klimaschutzplan-einigung-103.html

4. The role of cities in meeting the reduction targets for GHG emissions

While GHG emissions have global consequences, the population perceives the impacts of climate change on the local level of the city or municipality. A large share of emissions takes place in an urban context. This chapter makes current aspects of global urbanisation tendencies as well as spatial and sectoral distinctions with regard to emissions a topic of discussion. Furthermore, the necessity of cities to initiate mitigatory changes will be addressed.

4.1 Defining the term“city“

Der *term “city“* is international, chiefly due to disparate minimum sizes that are not consistently defined and delimitable. Aspects such as density, relationship to the hinterland and functional aspects are to be considered.[199] *Metropolitan areas* are, in this context, often linked to the threshold value of 1 million inhabitants.[200] For so-called *megacities*, threshold values regularly amount to around 10 million inhabitants. *Urbanity* generally encompasses the urban way of life characterised by cultural plurality, social infrastructure, public life etc.

In turn, a neighbourhood is comprised of various spatially connected private and/or public buildings, including (public) infrastructure.

4.2 Urbanisation – overview of global tendencies

Not only the progressing climate change, but also a general demographic change, a rising population size[201] and increasing rates of urbanisation will amend the existing building stock – and at the same time the phenotype of the city- in the course of this century. Studies by the *United Nations*[202] prove a sustained migratory trend from rural to urban areas. *Since 2007, more people have been living in urban than in rural areas*[203] as the current urbanisation level is noted at 54 percent.[204] This share is expected to rise to over 66 percent by 2050 along with a population growth from currently 7.4 billion to 9.9 billion people.[205] *The progressive urbanisation* will primarily concern African and Asian emerging economies with low to medium income. 90 percent of the increase, i.e. 2.5 billion urban dwellers, in the period 2014-2050 are allocated to these continents.[206]

[199] WBGU, 2016, p. 59
[200] Bronger, 2004, p. 31
[201] See Seto et al., 2012: By 2030, 55 % of urban expansion is expected to take place through massive urbanisation in India and China.
[202] See e.g. UN-DESA, 2014
[203] UN-DESA, 2015, p. 7
[204] See Population Reference Bureau (PRB), 2016, p. 9 // UN-DESA, 2014, p. 1
[205] See UN-DESA, 2015, p.1 // Population Reference Bureau (PRB), 2016, p. 1 // UN-DESA, 2014
[206] UN-DESA 2014, p.1

Figure 7: The world population by 2050 (prognosis in million people, changes compared to 2016 in %)

Source: own representation, adapted from APA/PRO, 2016

This trend is not uniform in all regions of the world. Some cities in Europe recorded declining population figures.[207] Nevertheless, 73 percent of the European population is living in urban areas, whereby this share will rise to over 80 percent by 2050.[208] Depending on the country, these values differ significantly. For example, the urbanisation level of Germany amounts to 74.3 percent, while an increase to 76.4 percent by 2020 and to 83 percent by 2050 is expected.[209]

This urbanisation trend is particularly relevant in the light of most GHG emissions emanating from urban areas.[210] Emissions result from land use change, construction and utilisation of buildings, urban mobility, production and consumption of goods, and electricity. Depending on the definition and appraisal, urban spaces merely occupy ca. 0.2 percent to 2.8 percent of the total land surface area,[211] yet *urban regions are associated with approximately 70 percent of total energy usage with concomitant anthropogenic, energy-related GHG emissions.*[212] [213] Therefore, cities are major drivers of global climate damage, while at the same time being severely exposed to the risks of climate change.[214]

Against this backdrop, 440 mayors and local officials have agreed during the course of COP 21 to reduce GHG emissions by 3.7 gigatons annually.[215]

Progressive urbanisation entails significant consequences as a higher rate of urbanisation, *ceteris paribus*, will invariably increase the amount of urban GHG emissions in virtually all sectors (such as transportation, waste management, construction industry).[216] Efficiency enhancement, behavioural change and other starting points towards a sustainable reduction in consumption therefore do not only have to be suitable for reducing current levels,

[207] WBGU, 2015, p. 45
[208] Ibid.
[209] UN-DESA, 2014
[210] See UN-Habitat, 2011, p. 9ff // IPCC, 2014b // Hoornweg et al., 2011, p. 217ff: For the central role of cities in the process of decarbonisation.
[211] According to Liu et al., 2014, p. 764f, the share levels close to 3% // See also UNEP-DTIE, 2016.
[212] See IEA, 2015, p. 3f. // See UN (Habitat), 2015f, S. 3
[213] See Seto et al., 2014, p. 923-1000: The IPCC estimates that already by 2010, urban spaces will have induced 67% to 76% of total global energy consumption and 71% to 76% of global CO_2-emissions through energy utilisation.
[214] WBGU, 2016, p. 69ff
[215] Concededly, this corresponds to a 30% difference regarding the 2°C target enshrined in Paris (on the basis of data by the UNFCCC (2015)).
[216] A comprehensive overview of global consequences of (mega) cities on climate can be found in WMO/IGAC, 2013.

but simultaneously have to be able to meet the challenges posed by the trends of "urbanisation" and "population growth".

Equally, high rates of urbanisation are circumstantial evidence for further, potentially negative, changes to life quality and health – especially due to deterioration of local environmental quality (e.g. higher water consumption, higher volumes of waste, higher levels of air pollution etc.),[217] or caused by the heat island effect as a consequence of higher building density.[218] It is of crucial importance to comprehend the dynamics of urban GHG emissions in order to elaborate mitigation strategies on urban level, and, by doing so, limit the extent of climate change.

The following table illustrates the dimensions in which population growth and urbanisation by 2050 primarily proceed in less-developed and emerging nations and BRICS countries. This observation is significant, since affected countries rarely have the financial resources at their disposal to (partly) implement cost-intensive measures of decarbonisation. The great significance of the GCF[219] is thusly underlined as a profound transformation of these regions can only be enabled by financial assistance.

Table 3: Population growth of selected countries and regions until 2050

	Current population growth (in % pa)	**Population in 2050** (in millions)	**Current urbanisation level** (in %)	**Urbanisation level in 2050** (in %)	**Gross national income per capita** (in US dollar)
China	0.45	1,365.7	55	73	13,130
India	1.22	1,660.1	32	54	5,760
Brazil	0.77	226.3	86	94	15,900
Russia	-0.04	134.2	74	83	24,710
South Africa	1.33	65.2	62	80	12,700
Germany	-0.17	76.4	73	83	46,840
European Union	0.22	518	73	n/a	36,280
USA	0.78	398.3	81	90	55,860
Asia	0.98	5,324	47	n/a	11,450
Africa	2.55	2,473	40	n/a	4,720

Source: own representation, adapted from UN-DESA (2015), UN-DESA (2014), CIA (2016), UNICEF (2016)

4.3 Global variations of GHG emissions at city-scale

Within cities, ***electricity and mobility are the principle generators of CO_2 emissions.***[220] Approximately 42 percent of the total CO_2 emissions are rooted in general *electricity and heat generation*, while another ca. 23 percent can be traced to the *transportation sector.*[221]

In this context, cities increasingly started to identify respective GHG emissions with the purpose of enabling the process of mitigation in accord with a "bottom-up" approach. Due to dissimilar levels of general development among countries as well as against the backdrop of heterogeneous climatic conditions, ***patterns of production and***

[217] WHO, 2015
[218] Studies by Gurjar and Lelieveld (2005) and Gurjar et al. (2008) address in detail the effects of anthropogenic greenhouse gas emissions on the microclimate of cities.
[219] For an analysis of the role as well as best practices and lessons learned: See GCF, 2015
[220] See IEA, Report CO2 Emissions From Fuel Combustion (2014 Edition)
[221] IPCC, 2014_a.

consumption regarding energy-related emissions vary significantly in individual cities. The following table elucidates the cited difference while putting it in relation to relevant sectors.

Table 4: Indicators of consumption, emissions and sustainability in various cities

Category	Indicators of consumption and sustainability	Cities
CO_2	CO_2 emissions per capita per year (t CO_2e/p.c./p.a.)	• Stockholm: 3.6 • London: 9.6 • New York: 10.5 • Tokyo: 4.9 • Tianjin: 11.1 • Beijing: 10.1
	CO_2 intensity (tCO_2e/million US dollar)	• Stockholm: 71 • London: 162 • New York: 173 • Tokyo: 146 • Tianjin: 2,316 • Beijing: 1,107
Energy	Energy consumption per capita (gigajoules/p.c.)	• Stockholm: 105 • London: 78 • New York: 129 • Tokyo: n/a • Tianjin: 90 • Beijing 80
	Energy intensity (mega joules/US dollar)	• Stockholm: 2.0 • London: 1.3 • New York: 2.1 • Tokyo: n/a • Tianjin: 18.7 • Beijing 8.8
	Percentage of renewable energy sources	• Stockholm: 20% • London: 1.2% • New York: n/a • Tokyo: n/a • Tianjin: n/a • Beijing n/a
Transport	Percentage of citizens commuting to work by foot, bicycle or public transport	• Stockholm: 93% • London: 63% • New York: 55% • Tokyo: n/a • Tianjin: 92% • Beijing 64%
Land use	Population density (people/hectare)	• Stockholm: 32 • London: 62 • New York: 80 • Tokyo: n/a • Tianjin: 228 • Beijing 145

Source: own representation, adapted from Huang et al (2016:184), based on World Bank (2010), European Green City Index (2009), Sugar et al (2012), City of New York (2010), Singapore Department of Statistics (2010), Baeumler et al (2009), and Bertaud and Malpezzi (2003).

Discrepancies in production and consumption patterns among cities presuppose that municipal authorities must gain a profound comprehension of individual emission sources in order to deduce

effective mitigation strategies.[222] Equally, per capita emissions vary significantly on a global scale, even in cities with a comparable number of inhabitants.[223] In larger cities[224] of industrial nations, the emissions amount to between 10 and 20 tons of carbon dioxide equivalents (tCO_2e) per capita and year, while in Asia, cities with only around half of the emission values[225] subsist.[226] Best practice examples, such as Stockholm, have already been attaining significantly lower values.

Cross-border studies (e.g. the environmental Kuznets curve) have verified that *carbon dioxide emissions per capita increase significantly in countries undergoing a developmental process from low- to medium-income economies.* This sharp rise only flattens when the per capita income increases beyond that.[227] In some cases, urban emissions from developing countries and emerging nations approximate those of industrial nations.[228] Peking, Shanghai and Tianjin, for example, are already exhibiting per capita emissions equivalent to larger European and some North American cities.[229]

When analysing highly developed nations of the "first world", significant differences in emission patterns and levels exist. Among the world´s cities, European capitals have been developing in a "cleaner" style than in the US – per capita emissions are, on average, only half as high.[230] Nevertheless, there are considerable differences to be found in the United States of America. For example, Denver causes twice as many per capita emissions than New York. *Even within a single city, significant variations can be detected which cannot be solely explained by levels of income*. In this spirit, the inhabitants of downtown Toronto – with corresponding access to well-developed public transport - only cause approx. 1,3 t CO_2e per capita and year, while suburban dwellers in remote outskirts are responsible for 13 t CO_2e.[231]

A sectoral and regional analysis thus unearths significant discrepancies with regard to emission levels and their composition. An individual analysis of particular cities appears indispensable for the purpose of implementing individually expedient and adjusted mitigation strategies.

4.4 UN Habitat III

Habitat (III) is a conference hosted by the United Nations (UN) which occupies itself with global obligations for sustainable urbanisation. The *Habitat III Conference*, which took place in Quito, Ecuador, between 17th and 20th of October 2016, *aimed to transpose the SDG requirements and the 2-Degree Goal into a "New Urban Agenda".*[232] Previous conferences took place in 1976 and 1996. Recognising Resolution 66/207 of the UN´s General Assembly, the overall aim of the conferences is to strengthen the political engagement for sustainable urban development and to identify new challenges. Inasmuch, the framework of HABITAT III does not entail any resolutions etc.

The "New Urban Agenda" as leitmotif of the current conference moved urbanisation, as a substantial driver of sustainable development, into the focus of attention[233] (also see Chapter 4.2 as well as 10 and 11). Equally, *strengthening urban-rural linkages*[234] played a crucial role.

The following aspects were highlighted and already debated in the run-up within the 22 so-called "The Habitat Issue Papers" (compiled by the UN Task Force on Habitat III Conference):

[222] Kennedy et al., 2009
[223] Works of Dhakal (2010) and Hoornweg et al. (2011) comprehensively compare diverse emissions in metropolitan areas.
[224] E.g. Calgary, Sydney oder Stuttgart.
[225] E.g. diverse cities in Nepal, India and Bangladesh.
[226] Hoornweg et al., 2011, p. 207ff
[227] Kahn, 2009, p. 3f.
[228] World Bank, 2014, p. 13ff.
[229] Sugar, et al. 2012
[230] Ibid.
[231] Hornweg et al., 2011, p. 8
[232] UN-Habitat, 2016a, p. 3
[233] UN-Habitat, 2016a
[234] UN-Habitat, 2015e, p. 5

- selective national and regional urban planning and regulatory frameworks (Urban Planning and Design)[235] to assure a controlled and sustainable development of growing cities (see Chapter 11.3.1),
- strengthening networks, institutions (Institutional Arrangements) and frameworks (see Chapter 5-7 and 11),
- consolidating and structuring the financial basis of sponsoring sustainable urbanisation (Municipal Finance,[236] see Chapter 11.3.9),
- deducing the necessary general legal frameworks for sustainable cities (Urban Rules and Regulations, see Chapter 11) ,
- urban planning and management processes of transformation (Urban Governance[237], see Chapter 5),
- adaptation measures with regard to climate change (Cities and Climate Change and Disaster Risk Management, see PESTLE-Analysis in Chapter 8-9)[238],
- Adaptation of technological measures with regard to digitalisation (Smart Cities, see PESTLE analysis in Chapter 9).

In this report, *above-mentioned* subsections will be extensively discussed and analysed with a focus on the implementation in observed cities as well as the deduction of best practices. References to individual chapters in this study with regard to the Habitat Issue Papers can be found at the top in brackets.

4.5 General approaches towards emission reduction in cities and neighbourhoods

4.5.1 Preliminary remarks regarding approaches

Taking into account discussed conceptional and political challenges as well as the described status quo of climate change, tremendous efforts are necessary to realise sustainable and, in particular, decarbonised cities. ***Further, multilayered conflicts of objectives need to be resolved.*** The goal of healthy cities necessitates green spaces, runs contrary to the demand of higher density, which, in turn, would be necessary to reduce emissions from the transportation sector. Tools such as a higher density for sustainable real estate or entire neighbourhoods which exceed possibilities of land-use plans, have already been implemented in some cities and may diffuse the conflict cited as an example.

Investments in public and low-emission mobility, waste disposal and building efficiency could potentially enable savings with a net present value of over 15 trillion EUR until 2050. In addition to economic advantages, investments may particularly contribute to a decrease of greenhouse gas emissions by 3.7 gigatons CO_2e per year until 2030, which corresponds to the current annual emissions of India. In synergy with the existing and supplementary national strategies, a reduction of subsidies for fossil energy sources and supporting infrastructure for low-emission innovations, net present values of savings may total up to 19 trillion EUR.[239] ***A growing number of studies prove that climate change "pays off".***

An increasing number of researchers and practitioners have examined the societal costs of urban GHG emissions. One of these publications provides a clear frame of reference for the definition of adaptation to climate change and emphasises how cities ought to address questions of adaptation and mitigation.[240] Within the scope of the present study, only mitigation measures were addressed.[241] In this spirit, ***municipal governments should assume the point of view of the „Local Agenda 21"***, whereby on the one hand, they should ***think global and act local***, and, on the other side, strategies for low-emission urban development need to be conceptualised and implemented[242].

[235] UN-Habitat, 2015d, p. 2ff
[236] UN-Habitat, 2015c, p. 3
[237] UN-Habitat, 2015b, p. 2ff
[238] UN-Habitat, 2015f, p. 4
[239] Gouldson, et.al., 2015
[240] Smith et al., 1999
[241] Hoornweg et al., 2011, p. 207ff
[242] For an analysis of goals and projects, IZT (2007) offers a helpful synopsis.

It is not uncommon for uncoordinated, short-term political measures for the mitigation of GHG emissions, such as an ad-hoc restrictive building legislation or the introduction of prohibited areas for motor vehicles, to have a counterproductive effect. Exorbitant constructional requirements often massively increase e.g. construction costs with the consequence of higher prices and rents. As a result, meaningful ecological developments are often rejected by the population or interest groups – in this case, especially due to an already limited affordability of living space.[243] *Urban GHG emissions represent a complex dynamic which is inherently intertwined with other ecological, economic or social aspects*. Therefore, planning and coordination concerted with national and regional regulatory requirements are the key to the successful introduction of urban requirements. Here, the involvement of the local population and support thereof is essential.

Decision-makers have a plethora of diverse options at their disposal to mitigate GHG emissions, such as improving the energy efficiency of buildings, replacing fossil energy sources by renewable ones, doing without carbon intensive fossil energy sources and introducing innovative waste management, and so forth. Chiefly due to heterogeneous urban structures as a result of geographic characteristics, climatic conditions and a plurality of economic and political conjunctures, the circumstances for strategies towards low-emission urban development vary depending on the city.

4.5.2 Technical and digital innovation

Innovation management (see Chapter 11.3.10 and 11.3.11) is one of the three most important aspects of a business strategy.[244] This can be conferred to cities, especially with regard to the regulation and creation of targeted incentives for the economy. New technologies, (construction) quality standards, materials and processes may be influenced by urban measures. As a consequence, the energy intensity of products or processes in the fields of manufacture and usage are ultimately influenced in a positive way with according reductions in emissions.

As any form of (industrial) production, and consumption in general, is of great significance for the allocation of resource expenditure, both sectors play a pivotal role in the generation (and application) of innovations targeting increased *dematerialisation* (videlicet reduction of material input) and *substitution* (videlicet usage of environmentally responsible products).

The continuous observation of innovative developments facilitates the identification of promising methods of resolution, which can fulfil the customers´ quality requirements, also in the future, while at the same time assuring the achievement of environmental target sets. Innovation, in this context, has to be considered in a very broad definitional interpretation. In this way, ***the promotion of innovation is able to make use of fundamental research, the patronage of early adaptors*****,** the usage of innovative solutions, the introduction of innovative approaches by the city itself (utilisation of the role model function) or in general make use of advantages stemming from increased digitalisation.

4.5.3 Building stock

A large share of existing real estate requires substantial amounts of energetic refurbishment in virtually all countries.[245] The transformation of this building stock carries a hinge function to reduce carbon dioxide emissions in the utilisation phase. For improving energy consumption of properties, the real estate industry has to increasingly *address the mitigation of indirect emissions* resulting from the construction phase of new buildings or refurbishments, and where applicable, from the dismantling at the end of the economic useful life. Energetic advantages (in the utilisation phase) of a new building become frequently relative in comparison to a refurbishment[246] when using a "whole life carbon" approach since already emitted CO_2 (analogous to the disregard

[243] According to ZIA President Mattner, the last intensification of EnEV 2016 resulted in an increase of construction costs "by seven to eight percent." // See Kersting, 2016, p. 2
[244] Capgemini, 2010, p. 7f
[245] See The Economist Intelligence Unit, 2003, p. 3 // Housing Europe, 2015, p. 20
[246] RICS, 2013, p. 18f

of so-called "sunken costs") ceases to affect the decision.[247] Chapter 11.3.4 provides a detailed account of starting points regarding the decarbonisation of the existing building stock.

4.5.4 Spatial planning

In many cities, urban infrastructure in conjunction with high land value determines the overall scarcity of available space, whereby the realisation of new (affordable) real estate projects in central areas becomes less viable. Against the backdrop of only few options in downtown areas, urban expansion frequently takes a horizontal form, following a pattern of so-called "***urban sprawl***".[248] In Germany as well, 69 hectares are currently designated as settlement or transportation area each day.[249] As a goal of sustainability, the German Federal Government aims to reduce the land usage to 30 hectares per day in accordance with the Sustainability Strategy (2002) and the German National Strategy on Biological Diversity (2007). The concomitant ***sealing of green spaces*** leads to the impermeability of the soil with regard to precipitation and therefore destroys natural soil functions. Thereby, cities become susceptible to extreme weather events.

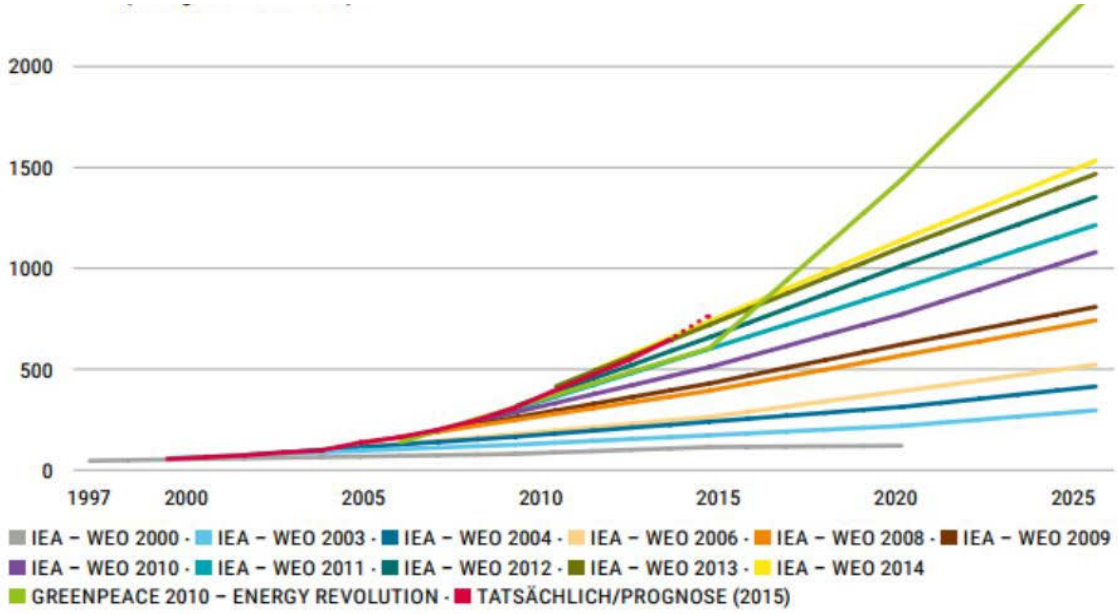
In developing countries, urban sprawl is regularly accompanied by a reduction of arable land and the destruction of forest and green spaces. In addition, urban sprawl is limiting the living space of flora and fauna. Insofar, the ***pattern of unobstructed, uncontrollable urban expansion is not sustainable***. The quest for solutions enabling growth in inner cities must rehabilitate the urban environmental quality as well as the quality of life – namely from a ***perspective of compactness and diversity***. Essentially, the partly competing goals of a liveable city[250] need to be reconciled with the ***requirements of a sufficient building density***, since urban spaces – which exhibit a very low density – are marked by a higher energy and resource usage due to higher levels of individual transportation.[251] Adjusted spatial and urban planning (see Chapter 11.3.5) therefore becomes pivotal.

4.5.5 Renewable energy

In the light of the described political objectives for the reduction of greenhouse gases, renewable energy sources assume a cardinal role in the course of decarbonisation (see Chapter 11.3.7). ***The real pace of growth frequently surpasses the respective predictions***. Thus, the IEA amended the velocity of propagation in the course of its annual study "World Energy Outlook" (WEO).[252] The following figure juxtaposes real developments with historic predictions.

[247] See e.g. Bull 2014, p. 1-17
[248] See World Economic Forum ,2015 // Fulton et al., 2001
[249] BMUB 2015c
[250] See Centre for Liveable Cities, 2015 and 2016
[251] UN-Habitat, 2015f, p.9
[252] For an analysis of critique of WEO data, See Metayer et al., 2015

Figure 8: Predictions and reality of the worldwide expansion of renewable energies in GW



Source: IEA, Greenpeace, IRENA, Prognosis IHS/WWEA, 2015, cited from Rosenkranz, 2015, S .11 // Without large scale hydropower

The *goals of electrification* and providing the necessary energy from renewable energy sources appears attainable when considering current figures. While the *proportion of electricity stemming from all renewable energy sources only accounted for 19 percent of the overall capacity in 2001, this value almost tripled to 58 percent by 2014*. On this occasion, the main drivers were the segments of wind energy and photovoltaics, which experienced significant growth in the course of the years.[253]

Nevertheless, these developments are subject to considerable fluctuations on the global scale. This dynamics is exacerbated through uncertainties surrounding profitability due to volatility of raw material prices and changing intensity of governmental funding programmes. As an example, the development of photovoltaic systems in Europe may be noted. Whereas in 2009, approximately 80 percent of the global capacity expansion were to be found in Europe, this number has dropped to 20 percent nowadays.[254] Notwithstanding, 117 gigawatts of wind energy and another 88 gigawatts of photovoltaics have only been added in Europe since the dawn of this millennium.[255]

4.5.6 Influencing behaviour and stakeholder engagement

The profound transformation of cities is being influenced by a *variety of stakeholders*, whose interaction is determinant for the success of the respective implementation measures. Stakeholder *engagement*[256] is a crucial factor for the definition of necessary adjustments, elaboration and, eventually, the selection of individual approaches leading to the operative implementation.

Besides the general backing of transformation, *alterations to the respective consumption patterns* of the population are of pivotal relevance for success (see Chapter 11.3.11). In the light of countless factors influencing consumption patterns worldwide, it appears analytically useful to limit the focus on three overarching spheres of influence[257], in which cities play a decisive role. First and foremost, the individual purchasing power is influencing behaviour and consumption patterns as studies ascertained how increased salaries are often accompanied by higher consumption levels of energy, water, and food, which consequently result in higher quantities of waste.[258] In

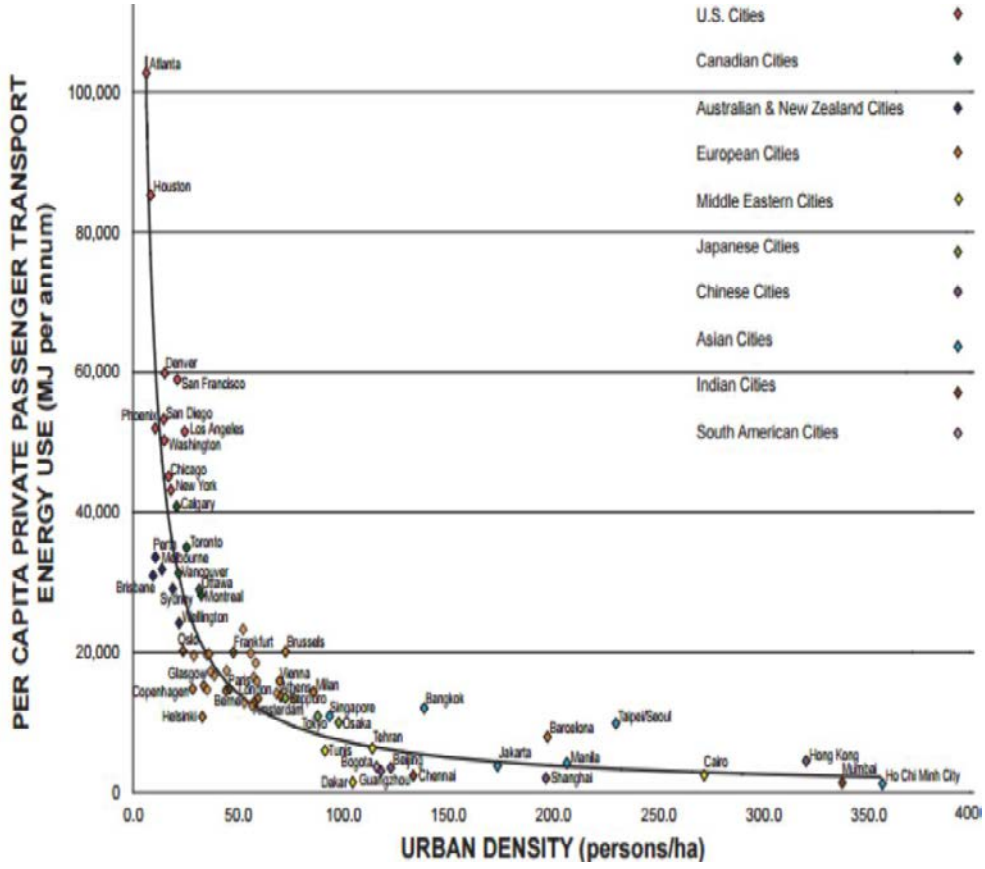
[253] See IRENA, IEA 2015.// See EEA (2016): "Renewable Energy in Europe 2016".
[254] Wirth, 2016
[255] IRENA, 2016
[256] See Bal, 2012. // Lim et al., 2008
[257] United Nations, 2010, p.10ff
[258] Ibid.

this context, conflicts of interests relating to SDGs have frequently emphasised. *Therefore, urban initiatives have to support the decoupling of progress, participation and other aspects of welfare despite increased emissions.* Secondly, the influence of urbanisation itself is noted, which, among other things, influences the global food consumption and trade[259], their demand[260] as well as pricing[261]. Lastly, the role of globalisation is taken into account on the basis of differences in production-based emissions[262] and consumption-based emissions[263] between the 13 highest pollution countries worldwide.[264] In the course of globalisation, *production, and the related resource consumption, have often been "relocated" to emerging economies"*. Thus, production-based emissions have been rising in discrepancy to consumption-based emissions, given the situation that manufactured products tend to be exported to developed countries.[265]

4.5.7 Mobility

As the second largest source of urban CO_2 emissions, the transportation sector has regularly been identified. Mobility therefore assumes a leading role in the reduction of GHG.[266] Within Europe, approximately one fifth of the total CO_2 emissions are solely caused by individual transport, which corresponds to a rise of 20.5 percent compared to 1990.[267] Besides a broad range of public transport options, a central element of reducing CO_2 emissions through mobility is the role of urban density as the following figure shows:

Figure 9: Correlations between urban density and transport-related per capita energy consumption



Source: Newman et al., 2015

[259] USDA, Regmi, 2001
[260] WHO, 2003, p. 13-29
[261] Kearney, 2012
[262] All emissions occurring within the boundaries of a country.
[263] Emissions occurring through consumption within the boundaries of a country.
[264] Russia, China, Brazil, Canada, India, Mexico, USA, France, Republic of Korea, Germany, UK, Italy and Japan.
[265] United Nations, 2010, p. 10
[266] Olivier, 2015, p. 3-4
[267] Ibid.

Against this backdrop, it appears reasonable that cities and neighbourhoods strive to increase density in order to counteract *urban sprawl* as well as high transport-related consumption. Nevertheless, one has to be aware of the impact of higher densities on (the reduction of) green spaces. Chapter 11.3.6 aggregates the possibilities and limits to changed mobility, while the recommendations for action (11.3.5) depict the central concerns of cities to preserve and expand green spaces. In this light, the recommendations for action will focus on brownfield developments for the purpose of finding a sound balance between density and green spaces.

4.6 Summary

It is evident that cities play a pivotal role within the scope of decarbonisation. Urbanisation and population growth in general exponentiate challenges to meet targets, particularly in less developed economies. Fundamentally, a cornucopia of possible starting points exists to reduce the GHG emissions in urban areas. In this light, Chapter 8 will trace diverse and specific measures taken by analysed cities. The embedded potential will be specifically scrutinised. Besides aspects of technical and legal feasibility, aspects such as acceptance and scalability as well as governance are essential. However, financial feasibility as well as cost-benefit trade-offs in the context of the market-based conditions of the respective city are equally pivotal.

Apart from economic advantages emanating from a large-scale transformation towards a sustainable future, several studies underline the substantive potentials for GHG reduction in urban areas. Nevertheless, doubts persist whether the currently defined efforts will suffice to attain the goals encased in the Paris Agreement.[268] All this points to the ***relevance of low-emission initiatives in cities*** and the critical relevance of an internationally concerted collaboration for accelerating the implementation as well as the extension of ambitions.[269]

Currently, ca. ***850 million urban dwellers worldwide live*** in informal settlements.[270] Their way of life is characterised by a lack of access to potable water, insufficient electricity supply, inadequate housing conditions, and a general lack of infrastructure. This **way of life presupposes qua poverty a very low consumption of CO_2**. It becomes evident that the **improvement of participation and living standards** – at least with contemporary instruments – quasi *automatically leads to an increase of the carbon dioxide footprint*.[271] As an example, only 34 percent of the population in the least-developed countries have access to electricity compared to a global average of 85 percent.[272]

[268] See UN-FCCC (2015) for an analysis of submitted INDCs in relation to the 21 targets.
[269] Gouldson, et al., 2015, p. 3ff
[270] See WWAP, 2015 // UN-DESA, 2013
[271] See also WBGU, 2016, p. 73
[272] Population Reference Bureau (PRB), 2016, p. 9

5. Selected supranational initiatives and organisations on “low carbon cities“

5.1. Preliminary remarks on the selection and categorisation

This chapter presents world-wide renowned initiatives of international organisations or associations that are aimed to support cities and the local authorities in reducing GHG emissions. For the sake of clarity and against the background of relevance to the key research questions, precedence will be given to those initiatives which have the highest priority for political and economic decision-makers. The presented initiatives enable administrative levels below the national government to implement mitigation measures. In particular, this is made possible by the communication of successful approaches („best practice“), the harmonisation of data collection, the underlying reporting regulations and the mutual appreciation of efforts to combat climate change.

The analysed initiatives can be subdivided into four segments which can be differentiated according to two criteria. Initially, the main criterion is the extent of the individual areas of action linked to the initiative. Following this argumentation, holistic initiatives can be differentiated from punctual initiatives. The analysed initiatives in the following subareas or areas of action support the following:

- **guidelines** (summary and presentation of best practices),
- **emission measurement** (support for recording GHG emissions),
- **platform for networking and knowledge transfer** (providing a network to exchange activities and best practices among participants),
- **research** (institutes with research on climate change and decarbonisation),
- **database** (registration of decarbonisation activities),
- **finance** (support the financing of decarbonisation measures),
- **emissions trading** (trading platform concerned with emission certificates).

Holistic initiatives thus support decarbonisation efforts to a very large extent and have an effect on several subareas. They are able to permanently accompany cities on the way to a significant reduction of GHG emissions while not being limited to a specific region. The following three aspects were used as criteria, which have to be fulfilled in order to qualify initiatives as holistic:

- inventory and data collection of greenhouse gases,
- supporting the governance structure of the municipality,
- sectoral comprehensiveness via addressing the fields of energy supply, transportation, urban planning, behaviour, infrastructure, and waste management.

Conversely, *sectoral initiatives* concern themselves with only one or a few subareas and on purpose thereby do not haven a holistic or comprehensive effect. For example, the *Non-State Actor Zone for Climate Action (NAZCA),* which is a pure information platform, does not claim to be holistic. Due to mutual interconnections, the transitions between holistic and sectoral impacts are often fluent.

The second criterion refers to the *intensity of connection*. In this context, initiatives are subdivided into those which categorically follow a predefined schedule - within this programme format, clear action catalogues and targets are derived for the participating cities. In turn, others leave the intensity of membership open and are thus located in a free format. These initiatives do not formulate predefined programmes and are loose networks which focus less on concrete ambitions. For example, this could be a pure collective declaration of intent.

Accordingly, interested parties can individually control the scope as well as the intensity of the connection or programme design. Based on the described distinguishing features, the initiatives can be differentiated as follows:

Table 5: Distinguishing features of analysed initiatives

		Intensity of connection (involvement)	
		Programme format	Open format
Functional reference	Holistic	• CNCA – Carbon Neutral Cities Alliance • COM – Compact of Mayors or now "Global Covenant of Mayors for Climate & Energy" • ICLEI, GCC – GreenClimateCities®	• C40 – Cities Climate Leadership Group • R20 – Regions for Climate Action
	Selective	• CA – The Climate Alliance • ESCI – Emerging and Sustainable Cities Initiative • ICLEI - Energy-safe Cities East-Asia Initiative • ICLEI Urban LEDS – Urban Low Emission Development Strategies	• CNC – Climate Neutral Cities • GCP – Global Carbon Project • ICAP – International Carbon Action Partnership • IEEP – Institute for European Environmental Policy • LC2 – Low Carbon Livable Cities Initiative • NAZCA – Non-State Actor Zone for Climate Action • UCLG – United Cities and Local Government • WMCCC – World Mayors Council on Climate Change

Source: own representation

Against the backdrop of the present classification, decision-makers of municipalities can decide which profundity of effects, sectors and intensity of connection should be chosen based on the individual needs of the respective city. In consequence, both central action mechanisms and specific measures are presented to the reader in a continuous text. Subsequently, the essential facts of the respective initiatives are summarised in tabular format.

Specifically, in the EU, there are various subsidised research projects in the area of decarbonisation, which also include cities and – by definition – represent initiatives for low-carbon cities. These projects, which have been concluded to some extent, such as "TRANSFORM.eu"[273] or "ZECOS-Communal Zero CO2e Emission Certification System",[274] will not be presented in detail as membership of cities in terms of an ongoing initiative is no more possible. Only the "URBAN-LEDS" project is presented here. The corresponding best practice results are picked up in the fields of the recommended actions or instruments.

5.2 Holistic initiatives

5.2.1 Holistic initiatives with programme format

5.2.1.1 ICLEI - GreenClimateCities® (GCC)

The "GreenClimateCities®" (GCC) programme is a subprogramme under the auspices of the *International Council for Local Environmental Initiatives* (ICLEI). The international association ICLEI was founded in 1990 and is one of the world's most important umbrella associations. This status is underscored by the large number of programmes concerned with sustainable urban development and the formulation of a low-carbon city agenda for the decarbonisation of cities. Cities and comparable networks can join the ICLEI initiative online without any further formal obligations.[275] Other programmes of ICLEI, for example, includethe "Climate Mitigation Program", the "Climate Resilient Communities Program" as well as the "Sustainability Program". Very important in the context of

[273] See Chapter 11.3.5
[274] See Chapter 11.2
[275] http://www.iclei.org/climate-roadmap/contact-us/join-the-local-government-climate-roadmap.html

decarbonisation is the "Low Carbon City Agenda", which includes three subinitiatives that will be presented in the following: "GreenClimateCities®" (GCC), "Urban Low Emission Development Strategies" (Urban-LEDS), and "Energy-safe Cities" – East Asia Initiative.

Due to its scope and procedural structure, participants of GCC are included in a predefined structure plan. The period-based structure of the GCC methodology is broken down into the three major phases of „Analyse", „Act" and „Accelerate", which in turn contain three subphases. Principally, these sections can be characterised as an initial assessment and evaluation phase. Based on this, strategies are developed and implemented. In conclusion, intensive monitoring is expected to be carried out in order to evaluate and control defined measures and thus to ensure the achievement of the targets.

As one of the broadest guidelines, the GCC provides its participants with the following tools and resources, which represent the best practices of the programme as well as of ICLEI:

- global, harmonised software for greenhouse gas measurement and analysis via **HEAT+**[276]**,**
- "**Measuring, Reporting, Verification"** (MRV) framework and checklists,
- stakeholder, advisory or consultation tools,
- creating scenarios for emission reduction and identification of priorities,
- "**Solutions Gateway**" database,
- pool of experts,
- reporting platforms (*carbonn® Climate Registry*, cCR).

Particularly noteworthy in this extensive spectrum of instruments are HEAT+, MRV and "Solution Gateway". The former is used to collect and analyse greenhouses gases as well as to feed them into a web-based databased (cCR). Accordingly, the development of emissions can be monitored via a standardised tool, for example, and optimisation potentials can be identified specifically.

The MRV framework offers its users a broad spectrum of informational material and standardised checklists for measuring, recording and verification of relevant greenhouse gas emissions. In particular, the main focus is on standardising the process to ensure comparability between the values.

The best practices of the initiative are complemented with the "Solution Gateway" database. The "Solution Gateway" is a database for activities that contribute to the decarbonisation of cities. Using a search mask, users are able to look specifically for general solution approaches or case studies, which can be implemented in their own local context in an analoguous form.

The holistic nature of the programme plays a crucial role in the context of decarbonisation of German cities. Among the considered initiatives, the GCC is one of the most comprehensive ones. Thereby, the access of all municipalities worldwide is explicitly emphasised, without demanding specific characteristics of region, size or development status. The whole process is in accordance with the GPC (see Chapter 6.3.5).

Despite the very extensive and clear approach of GCC, it is unclear whether cities are committed to a tangible goal and how many cities are actively involved, based on participating municipalities of ICLEI.

Table 6: ICLEI - GreenClimateCities® (GCC)

ICLEI - GreenClimateCities® (GCC)	
Approach / elaboration	• programme
Regional focus	• global
Support via	• emission measurement • tools and software for decarbonisation • scenario analysis • expert consultation • reporting platforms • financial advising (approaches via „Solution Gateways")
Founded in	• 1990

[276] http://www.heat.iclei.org/: "Harmonized Emissions Analysis Tool plus."

Headquarters	• Bonn, Germany	
Legal structure	• association	
Project coordinators	• ICLEI	
Impact level	• city level	
Number of members	• unknown for GCC (ICLEI total of >1.000)	
Membership type	• full membership	
Registered member	• city	
Duration of membership	• unlimited	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	X
	• behaviour	X
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• building a worldwide movement of municipalities to achieve a better global sustainability through the entirety of local activities	
Membership requirements	• none	
Relevance for German officials	• entirety • extensive tool-kit	
Highlights / best practice	• HEAT+ • MRV • Solutions Gateway	
Website	• http://www.iclei.org/activities/agendas/low-carbon-city/gcc.html	

Source: own representation

5.2.1.2 Compact of Mayors (COM) or now known as Global Covenant of Mayors for Climate & Energy

The "Compact of Mayors" (COM) was essentially a global city network whose primary target was to record greenhouse gases and to support approaches for emission reduction while increasing the resilience of urban areas. The organisation provided tools to meet targets via greenhouse gas recording, risk assessment, technical support, training materials and in-depth analysis.

In June 2016, the COM merged with the "European Covenant of Mayors" into the "Covenant of Mayors for Climate and Energy". The fusion created the world's largest coalition of cities and the network now includes about 7,100 cities with an overall population of 600 million people.[277]

Scale effects can be identified as the central driving force of the merger. Thus, the newly formed network fundamentally aims to formulate **common principles like the "Vision 2050"** as well as reciprocal benchmarking and shared use of data. Methodically, the network *inter alia* reverts to the tools of the COM.[278]

Since the foundation of the platform during the *UN Secretary General's Climate Summit* in New York (2014) via various organisations (like *C40*, *ICLEI*, *UCLG* and the *UN*), the COM has been put in charge of the *UN-Habitat*, the *UN Secretary General's Special Envoy for Cities and Climate Change,* and the *UN Secretary General's Climate Change Support Team*.[279] Besides the aforementioned partners, there are further partnerships with reporting partners (*CDP* and in particular *cCR*), municipal, local and regional governmental networks (such as *Metropolis*, *CITYNET*) as well as supporting partners like the *WWF*, *VEOLIA* or *Bloomberg Philanthropies.*[280]

[277] https://www.bbhub.io/mayors/sites/14/2016/06/Global-Covenant-of-Mayors-Press-Release-FINAL.pdf
[278] http://europa.eu/rapid/press-release_IP-16-2247_de.htm
[279] https://www.compactofmayors.org/globalcovenantofmayors/
[280] https://www.compactofmayors.org/who-we-are/

In principle, the programme of the COM consists of a four-stage process, starting with the phase of "commitment" and concluding with the phase of "plan" via "inventory" and "target". Throughout the course of completing these stages, the city is acquiring the right to obtain the **certificate** of the Compact of Mayors.

Within these phases, **predefined substeps** are traversed as **part of a complete decarbonisation process**. All phases include mitigation activities. In the first phase "commitment", a shared definition of target values is specified in addition to the registration on the platform. For example, the City of Philadelphia/USA aims to reduce its GHG emissions by 80 percent by 2050.

During the first twelve months, the second phase is primarily used for **recording and measuring GHG emissions** through standardised frameworks and tools. The third phase is marked by renewed measurements, revision and – if necessary – adoption of target values as well as reporting. The process is finalised in the third year by the precise formulation of an action plan for the time period following the phases described.

The individual tools can be highlighted as best practices of the initiative. In the first phase, a broad set of frameworks for compliance is provided in particular. In addition, an offline reporting scheme is provided to collect and document information in a standardised manner.

In the second phase, the network especially offers best practices for GHG measuring. With its *"Clear Path GHG Inventory Tool"*, a web-based software for standardised recording and automated storage to the database (working with CDP or cCR) is provided. The measurement in this phase is supplemented by providing extensive information material, for example in connection with the categorisation of emission sources. The second fundamental element is the *"CRAFT brochure"*, which is a framework for assessing environmental risks.

Within the third and the fourth phase, the focus rests on the *"City Action for Sustainability Tool"*. This instrument, which is still under development, is intended to demonstrate concrete reduction opportunities on the basis of the "ClearPath GHG Inventory Tool" for the purpose of reducing GHG emissions. They concern the key sectors of transportation, buildings and waste management.

In addition, the *"eLearning Modules and Training Resource"* accompanies the participants throughout the entire process while providing web-based trainings.

From the perspective of potential participants, the initiative offers a clearly structured roadmap to initiate precise decarbonisation steps, to measure the status quo and success as well as to provide specific starting points for actions. Tools, structural requirements and additional information are extensive.

Table 7: Compact of Mayors (COM)

Compact of Mayors (COM)	
Approach / elaboration	• emission measurement and -reduction in a four-phases model / programme
Regional focus	• global
Support via	• GHG measurement tools • information materials • coaching • clear process including a certificate
Founded in	• 2014
Headquarters	• New York City, USA
Legal structure	• NGO
Project coordinators	• C40 • Michael R. Bloomberg • ICLEI • UCLG • UN-Habitat
Impact level	• city level
Number of members	• 596 cities (only COM)
Membership type	• full membership
Registered member	• mayor as representative of the city

Duration of membership	• open, yet scheduled for a three-year implementation period	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	-
	• behaviour	-
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• The Compact establishes a common platform to capture the impact of cities' collective actions through standardized measurement of emissions and climate risk, and consistent, public reporting of efforts.	
Membership requirements	• none	
Relevance for German officials	• conducting GHG measurements	
Highlights / best practice	• "ClearPath GHG Inventory Tool" • "CRAFT Brochure" • "eLearning Modules and Training"	
Website	• www.compactofmayors.org	

Source: own representation

5.2.1.3 Carbon Neutral Cities Alliance (CNCA)

The "Carbon Neutral Cities Alliance" (CNCA) of the "Urban Sustainability Directors Network" (USDN) is a joint venture developed by the USDN in cooperation with the Innovation Network for Communities-INC and C40 – Climate Leadership Group, founded by various cities in 2014. Essentially, CNCA is a global alliance on the city level that supports its members in reducing the GHG emissions by 80 percent by 2050[281]. Generally, the core activity area of the alliance is the development of best practices in urban planning as well as the support of strategy changes and the establishment of a CNCA innovation fund.

In essence, analogous to other initiatives, the CNCA identified the four operational areas of energy supply, building efficiency, waste management and transportation as the essential modules for decarbonisation.

The best practices in particular include the subareas of the standardised framework, knowledge transfer and the financing of activities related to the decarbonisation of the urban building stock, energy supply and infrastructure.

The framework is essentially documented in the latest publication of the "**Framework for Long-Term Deep Carbon Reduction Planning"**[282]. With this publication, CNCA supports the necessary standardisation of analysis techniques, instruments and measurement methods for the operationalisation of ambitious reduction targets. CNCA addresses the city's key challenges such as reorganising supervision and accountability, creating technical capacity, stimulating innovation, engaging stakeholders, financing climate action plans and ensuring the long-term focus of measures. For all these areas, the CNCA provides detailed instructions for the operationalisation of reduction targets.

The infographic published by the CNCA on the consumption of fossil fuels in five large American cities can be cited as a previous success. They were developed based on external measurements between 2011 and 2014 and show the consumption, costs and origin of fossil fuels.[283]

The second component of knowledge transfer for the purpose of partitioning applied best practices is essentially secured through formats like conferences and the integration of external partners.

[281] CNCA, 2015
[282] CNCA, 2015
[283] http://usdn.org/uploads/cms/documents/infographic_methodology_final_04.28.16.pdf

The catalogue of best practices is completed by the **CNCA Innovation Fund**.[284] It is aimed at fundraising to provide capital for the financing of municipal projects which directly contribute to the decarbonisation of cities. The main contribution is the direct financing of measures identified within the framework of the project.

As an applicant, members can apply for capital allocation within fixed cycles. This application process consists of several steps and evaluates project ideas of the cities using a nine-part scoring model. Currently, the process is in the second round for 2016 with a requested capital of about USD 1 million for a total of nine projects.[285] Thus, the approach is praiseworthy, but the sums are marginal so far.

Participation for German municipalities seems particularly useful for cities aiming to implement potentials for GHG emissions reduction in the listed fields of energy supply, building efficiency, waste management and transportation.

Table 8: Carbon Neutral Cities Alliance (CNCA)

Carbon Neutral Cities Alliance (CNCA)		
Approach / elaboration	• guideline • platform for knowledge transfer • proprietary fund	
Regional focus	• global	
Support via	• funding solutions • framework • planning standards	
Founded in	• 2014	
Headquarters	• San Francisco, USA	
Legal structure	• association	
Project coordinators	• Urban Sustainability Directors Network (USDN)	
Impact level	• city level	
Number of members	• 17 cities	
Membership type	• full membership	
Registered member	• city	
Duration of membership	• limited to 2050 (based on the decarbonisation goals)	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	-
	• behaviour	-
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• identification of necessary measures for the decarbonisation of cities	
Membership requirements	• not specified	
Relevance for German officials	• financial resources • potentials in energy, building stock, waste management and transportation	
Highlights / best practice	• guideline • CNCA „Innovation Fund“	
Website	• http://usdn.org/public/page/13/CNCA	

Source: own representation

[284] http://usdn.org/public/page/91/CNCA-Innovation-Fund-Products
[285] http://usdn.org/uploads/cms/documents/infographic_methodology_final_04.28.16.pdf

5.2.2 Holistic initiatives with open format

5.2.2.1 C40 - Cities Climate Leadership Group

The C40 – Cities Climate Leadership Group represents one of the largest holistic initiatives, which supports large cities in reducing GHG emissions in the context of a cross-sectoral approach. Regarding contents, the initiative is divided into seven subsections: adaptation of water usage, energy industry, financing, measuring and planning, waste management, transportation and urban planning. While the initiative has no fixed time schedule, it currently offers 16 networks for exchange in the seven areas.

Since its foundation in 2005, the initiative has been able to put about 86 cities under its umbrella and establish itself as one of the leading global networks. The participants are differentiated into "Mega Cities", "Innovator Cities" and "Observer Cities", which are subject to the strategic regulations by the "Steering Committee"[286]. The "Steering Committee" is a changing advisory council of the mayors from currently eleven cities.

In addition, *C40* has numerous partners and sponsors, including Clinton Foundation, ARUP, MasterCard, Citi, Siemens, World Bank, Novorisk, Ford Foundation, *CDP* (Carbon Disclosure Project), *IAA* (International Advertising Association), *ITDP* (Institute for Transportation and Development Brazil), *CCAC* (Climate and Clean Air Coalition), *ICLEI* (International Council for Local Environmental Initiatives) and *EMPARQ* (the World Resources Institute). Through extensive individual projects and initiatives, the **C40 cities have a significant global influence both in the reduction of greenhouse gases as well as climate risks.**

C40 offers its participants an effective forum where they can promote their own decarbonisation on the basis of knowledge transfer and clearly defined, measurable actions. Participants of the initiative benefit from two basic group characteristics: supply and size. The range of measures and instruments offered by C40 is the most comprehensive in comparison to the other considered initiatives. In addition, the network is one of the largest analysed according to the number of members. This characteristic makes the group appear as a rich source of potential (positive) spill-overs in the context of the knowledge transfer between participants.

Especially the open configuration of the catalogue of measures can be considered as best practice. **It is explicitly up to participants to decide in which of the seven divisions activities shall be implemented.** Potential C40 instruments representing a proactive contribution to the decarbonisation of cities are complex and in particular include the following:

- energy sector: efficiency of public and private buildings.
- waste management: sustainable waste systems and "Waste-to-Resource" approaches.
- transportation: low-fuel mobility and "Bus Rapid Transit" systems.

The most relevant thematic area for the operational decarbonisation within the C40 measures catalogue is the section "Urban Planning and Development". In this context, C40 offers the **"Climate Positive Development Program"** (CPDP), which supports climate neutral and thus particularly ambitious project developments in the areas of energy, waste management and transportation.[287] A **unique selling point is the goal of developing „climate positive" projects**, i.e. to go beyond climate neutrality.

In addition, the **"Open Data Portal"** is presented as a cornerstone. On the basis of the portal, the explicitly **data-based quantification of the operability of individual measures** is to be advanced and reported via a partnership with the CDP. The open data portal includes information on greenhouse emissions, urban risks from climate change, time scales and greenhouse gas reduction targets. It provides information on anticipated economic opportunities within a transformation. This multi-disciplinary data approach therefore creates opportunities for participating municipalities to identify and implement resource conservation potentials.[288]

[286] C40 Cities, 2016_a
[287] C40 Cities. 2016_b
[288] C40 Cities, 2016_c

In the context of the decarbonisation of German cities, particular attention is given to the "Urban Planning and Development Initiative",[289] under which the CPDP is carried out. Particularly against the background of the operational optimisation of energy, waste and transportation systems, a participation appears useful.

Table 9: C40 – Cities Climate Leadership Group

C40 – Cities Climate Leadership Group		
Approach / elaboration	• platform for a septempartite approach in the form of a network	
Regional focus	• global	
Support via	• best practices (expert analysis, case studies) • remarkable broad spectrum of tools and instruments	
Founded in	• 2005	
Headquarters	• London, UK	
Legal structure	• NGO	
Project coordinators	• "Steering Committee" of 11 members	
Impact level	• city level	
Number of members	• 86 cities	
Membership type	• miscellaneous memberships („Mega City" starting at 3 Million habitants, „Innovator City", as well as „Observer City")	
Registered member	• city (with regard to „mega cities")	
Duration of membership	• variable	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	X
	• behaviour	X
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• implement effective, sustainable climate protection actions at a local level, which tackle climate change globally	
Membership requirements	• population • economic power • ecological leadership commitment	
Relevance for German officials	• best practices with regard to the transportation, waste management and energy sector level	
Highlights / best practice	• „Open Data Portal" • "Climate Positive Development Program" (CPDP)	
Website	• www.c40.org	

Source: own representation

5.2.2.2 R20 – Regions for Climate Action

The R20 "Regions for Climate Action" is another holistic initiative supporting cities and regions to reduce GHG emissions through a broad set of measures. The initiative can be divided into three main themes: ***diplomacy, technology and financing***.

Since its foundation in 2010, the R20 initiative has been able to set up a network of over 560 participants. These are members at different subnational levels, whereas in contrast to other networks, the focus here is primarily on entire regions and not just cities. Contrary to other holistic initiatives, e.g. C40, R20 puts a ***broader focus on the financing aspect of sustainable investment.***

[289] formerly *Sustainable Communities Initiative*

The key feature is that concrete projects are accompanied from their identification to the preparation of a feasibility study culminating in the implementation and subsequent monitoring with effective GHG savings.

Participants of the initiative in particular benefit from the access to project financing for low-carbon investments and from the network for knowledge transfer, from further training measures and frequent events. In each of the three areas outlined above (diplomacy, technology and financing), the R20 can present appropriate best practices.

In the area of technologies, participants benefit from programmes in the fields of public transportation, building technology, street lighting, wind and solar energy as well as waste management. As concrete best practices on these topics, the project offers ***toolkits for the implementation of, for example, LED street lighting, improved building efficiency*** through modernisation and new construction as well as ***"cool roofs"***. The latter relates to the reduction of greenhouse gases by the use of innovative technical solutions for the cooling of roofs.

In the second thematic area "diplomacy", the focus is on the transfer of knowledge and political work in the form of international lobbyism. The network sees itself as an active platform for information exchange. In addition to the provision of publications, conferences are held frequently.

As best practice in financing, the R20 has a mechanism that combines greenhouse gas reduction projects with potential investors. These projects can, for example, be located in the area of renewable energies, energy efficiency improvements or waste management.

Both instruments to finance feasibility studies and other preparatory measures and funds for respective investments exist.

The R20 draws capital from a pool of partners from government funds, private equity funds and other bank financing. The network has a total of 110 potential investors. The *Planet Pledge Fund* (PPF) has set itself the goal of investing 10 billion US dollars in decarbonisation projects. The *Green Investment Accelerator Fund* (GIAF) has an additional 300 million US dollars of equity available. This process is actively supported by political work at a subnational level. Project proposals for financing are submitted via the R20. The R20 carries out a due diligence process within the framework of the mediation activity in order to ensure the completeness and correctness of the financing application. From the point of view of potential donors, a risk-adequate return is promised. Moreover, backup devices are used.

Particularly noteworthy is the **"SCALING UP: Local to Global Climate Action"** report (2015)[290] It contains nine very well-founded and detailed case studies of subnational climate protection programmes, which go beyond the respective national requirements. In essence, the report deals with the most effective mechanisms for reducing emissions. The results show that the greatest potential lies in the three areas of renewable energies, the reduction of deforestation and the taxation of emissions as well as their trade.

In contrast to other formats, the R20 does not have any guideline to go through a particular process or to implement predefined emission reductions within a specified period of time.

For German participants, therefore, a broad spectrum of potential approaches as a reason for membership is conceivable against the backdrop of the three-part best practices. In principle, the mentioned reports as well as the different toolkits help all stakeholders to get a picture of different potential measures with divergent scope and focus.

Table 10: R20 – Regions for Climate Action

R20 – Regions for Climate Action	
Approach / elaboration	• platform / network
Regional focus	• global
Support via	• funding solutions • technological support • representation of interests / lobby
Founded in	• 2010
Headquarters	• Geneva, Switzerland

[290] R20 Regions for Climate Action, 2015

Legal structure	• NGO	
Project coordinators	• R20 executive committee	
Impact level	• subnational level (provinces, municipalities etc.)	
Number of members	• 560 subnational regional governments	
Membership type	• miscellaneous memberships („member“, „observer“)	
Registered member	• city or region in its entirety	
Duration of membership	• variable	
Costs of membership	• fixed: 1,000 USD membership fee per annum • variable: 5,000 – 25,000 USD programme fee (depending on the regions GDP per capita)	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	-
	• behaviour	-
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• helping sub-national governments to develop and disseminate GHG and climate-related projects.	
Membership requirements	• commitment to climate protection • appointment of an authorized representative • willingness to share best practices	
Relevance for German officials	• especially with regard to building technology and funding solutions	
Highlights / best practice	• cool roofs • Building Efficiency Toolkit • LED Street Lighting • subnational climate reporting programme • various financing funds • Diplomacy in Action programme	
Website	• www.regions20.org	

Source: own representation

5.3 Selective initiatives

5.3.1 Selective initiatives with programme format

5.3.1.1 ICLEI - Urban Low Emission Development Strategies (Urban-LEDS)

The "Urban Low Emission Development Strategies" (Urban-LEDS) programme is one of the most extensive initiatives within this selection. In principle, the initiative initiated by UN-Habitat and ICLEI in 2012, unlike the already presented GCC, is explicitly aimed at supporting municipalities in developing and emerging nations such as Brazil, India, Indonesia and South Africa.[291] The project has been financed by the European Commission.

The implementation of the measures and the transformation of cities to municipalities with moderate GHG emissions is to be supported by a comprehensive methodological framework at the municipal level. As a cornerstone of the concept, the project identifies the following areas:

- staff training,
- resources and tools, esp. for GHG measuring and monitoring and monitoring software (HEAT+),
- technical and financial solutions,
- reporting platform, *"carbonn® Climate Registry" (cCR),*
- representation of interests.

[291] ICLEI, UN-Habitat, 2016_a

Central components of the "Urban-LEDS" programme[292] , in particular, arethe widely-used tools with diverse focus. The best practices include the greenhouse gas quantification and monitoring software HEAT+ and the global reporting platform cCR. Another special feature of Urban-LEDS is constituted by the stronger emphasis on political lobbyism.

With regard to the German urban development, the city of Hanover is one of eight European municipalities in the network of participants. The participating cities can be classified in the prioritised "Model Cities", the "Satellite Cities" and the "European Cities". Clearly, the former two are the focus since they are directly affected by the above implementations. To name examples for "Model Cities", Fortaleza (Brazil) or Rajkot (India) may be pointed out.

"European Cities", such as the City of Hanover, particularly assume the role of networking partners, who should benefit from the experience reports of prioritised "Model Cities" and "satellite cities", respectively to apply good European measures in low to medium income economies. In addition, for European participants, both study visits and mentoring events took place. Thus, the specific benefit from these "European cities" can be reduced to the pure information gained from the experiences of the "model cities" and "satellite cities".

The completed project represents an effective approach to the dissemination of the very good ICLEI instruments. The North-South dialogue has also been promoted extensively.

Table 11: ICLEI - Urban Low Emission Development Strategies (Urban-LEDS)

ICLEI - Urban Low Emission Development Strategies (Urban-LEDS)		
Approach / elaboration	• programme	
Regional focus	• developing countries (Brazil, India, Indonesia, South Africa)	
Support via	• educational programme • resources and tools • technical and financial support • global networking	
Launched in	• 2012	
Headquarters	• Bonn, Germany	
Legal structure	• EU-financed project (2012-2016)	
Project coordinators	• UN-Habitat, ICLEI	
Impact level	• city level	
Number of members	• 37 cities (including the city of Hannover, Germany)	
Membership type	• Mmscellaneous memberships („model cities", „satellite cities" and „European cities") – currently closed	
Registered member	• city	
Duration of membership	• planned for 48 months	
Costs of membership	• sponsored by the European Union	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	X
	• behaviour	X
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• supporting cities in developing countries towards more low -carbon urban areas.	
Highlights / best practice	• spreading ICLEI instruments in emerging and developing countries.	
Website	• www.urbanleds.iclei.org	

Source: own representation

[292] ICLEI, UN-Habitat, 2016b

5.3.1.2 ICLEI - Energy-safe Cities East-Asia Initiative

The "Energy-safe Cities - East Asia Initiative", founded by ICLEI and the Wuppertal Institute, principally is a combination of 70 representatives from industry and science as well as eleven regional governments with the clearly defined objective of a *conversion to 100 percent renewable energies by 2030 in East Asia.*

A three-period system was developed for this purpose. The project started after the expert symposium in 2014. Based on this, in the second and currently active phase, data collection and processing is to be carried out through workshops on local scenario analyses in order to initiate specific technical measures on the basis of the analysis results. This 26-month phase is completed by a second symposium on the exchange of knowledge (to be expected in December 2016). The programme is completed by a twelve-month phase in which the action plans are to be implemented by 2030. The focus of the initiative is explicitly on energy systems, which will consist of 100 percent renewable energy sources by 2030. The goal is thus to realise the rapid transformation towards low-emission, resilient, and safe urban energy systems for East Asian regional governments.

With regard to a sustainable urban development in Germany, the present initiative can only be regarded as an implementation example, since active participation is not possible due to the regional focus. The most useful element is the presentation of detailed scenario analyses of individual cities or the complete conversion to renewable energies.

Accordingly, the initiative is an example of potential programme plans for the formulation of specific operational plans for a decarbonisation strategy in the area of energy supply.

Table 12: ICLEI - Energy-safe Cities – East Asia Initiative

ICLEI - Energy-safe Cities – East Asia Initiative		
Approach / elaboration	• programme in a three-stage model	
Regional focus	• Eastern Asia	
Support via	• expert knowledge and case studies • funding models • tools (of the broad ICLEI network)	
Founded in	• 2014	
Headquarters	• Seoul, South Korea	
Legal structure	• association	
Project coordinators	• ICLEI East Asia secretariat • „Wuppertal" institute	
Impact level	• city level	
Number of members	• industrial and scientifically members: 70 • regional governments: 11 from e.g. China, South Korea, Japan and Mongolia	
Membership type	• full membership	
Registered member	• city	
Duration of membership	• objective: 2030	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	-
	• behaviour	-
	• infrastructure	-
	• waste management	-
	• energy supply	X
Mission statement	• achievement of a resilient as well as low-risk and low-GHG energy system in eastern Asia.	
Membership requirements	• none	
Relevance for German officials	• regionally restricted to eastern Asia	
Highlights / best practice	• programme with a structure for decarbonisation of the energy supply.	
Website	• www.eastasia.iclei.org	

Source: own representation

5.3.1.3 Emerging and Sustainable Cities Initiative (ESCI)

Since 2011, the "Emerging and Sustainable Cities Initiative" (ESCI) of the *Inter-American Development Bank* (IDB) has placed the focus of its activities on **providing** *financing plans and funds for projects related to the decarbonisation of cities*. The regional focus is on small and medium-sized cities in developing countries throughout Latin-America and the Caribbean. Applicants can be any municipalities of the named regions.

The total funds available are provided by the IDB directly as well as by external sources of capital and are available for a period of three to four years. The initiative is financially supported by the following organisations: Ministry of Finance of Japan, Ministry of Finance of Austria, State Secretariat for Economic Affairs, the countries of China and South Korea as well as the Nordic Development Fund and the International Community Foundation. In addition, there are supporters and flanking academic institutions and companies as well as foundations that provide assistance. The network consists of about 68 donors and scientific partners.[293]

The three-dimensional evaluation matrix can be named as best practice for the development of an individual action plan. It covers the dimensions of climate change, urban development and fiscal control ("*ESCI Dimensions*"). These dimensions can again be divided into 23 thematic blocks, which are assessed with a total of 120 indicators using a traffic light system.[294] *ESCI provides a comprehensive set of indicators for the standardised assessment of an individual action plan´s financial requirement*. The underlying creditworthiness of the municipality is determined by the IDB on the basis of the development state of single sectors. The specific financial framework for the specific action plan is determined afterwards.

In the implementation phase, specific feasibility studies on specific projects (investments) are subsequently created and a citizen participation concept is implemented as well. This concept *("Citizen Monitoring System") is intended to involve the civil society in the process of decarbonisation* in the long run. This is primarily achieved through public surveys to obtain data on the specific changes in the quality of life.

The development of the capital of Trinidad and Tobago, Port of Spain, can be mentioned as an example. In the course of the project, the city is developed in alignment with decarbonisation goals. The whole project includes 196 million USD. The sustainable endeavours , for example, are changes in waste management, transportation and water management. ESCI can be cited as a good international example for the standardisation of financing solutions. Even small cities with limited fundraising opportunities can revert to this possibility.

Table 13: Emerging and Sustainable Cities Initiative (ESCI)

Emerging and Sustainable Cities Initiative (ESCI)		Remarks
Approach / elaboration	• financing	• Three-pillar-programme: • "Environmental and climate change pillar" • "Urban development pillar" • "Fiscal sustainability pillar" • development phase (1 year) • pre-investment & monitoring (3 years)
Regional focus	• Latin America • Caribbean	
Support via	• designing an action plan • developing concrete financing solutions • supplying financial capital	
Founded in	• 2011	

[293] IDB, 2016
[294] IDB, 2014

Headquarters	• Washington D.C., USA	
Legal structure	• stock corporation	• programme as a part of the Inter-American Development Bank (IDB)

Project coordinators	• Inter-American Development Bank (IDB)		
Impact level	• city level		
Number of members	• 71 cities		
Membership type	• miscellaneous memberships		• regular (26 cities) • separate programme (45 cities)
Registered member	• city		
Duration of membership	• 4 years		
Costs of membership	• not specified / the objective is to finance concrete measures		
Attended problem areas / sectors	• transportation	X	• Principally, focus on the financing of concrete measures
	• urban planning / buildings	X	
	• behaviour	X	
	• infrastructure	X	
	• waste management	X	
	• energy supply	X	
Mission statement	• technical assistance programme to support national and subnational governments with the implementation of action programmes		
Membership requirements	• not specified		
Relevance for German officials	• experience reports		
Highlights / best practice	• ESCI dimensions		
Website	• http://www.iadb.org/en/topics/emerging-and-sustainable-cities/emerging-and-sustainable-cities-initiative,6656.html		• 3 dimensions • 23 topics • 120 indicators

Source: Advisory Council

5.3.1.4 The Climate Alliance (CA)

The Climate Alliance (CA) is a purely European network founded in 1990 with three central areas of activity: exchange of experience, implementation of operational climate protection activities and the international representation of interests. In order to achieve these goals, the Alliance is developing intensive activities within the course of representing interests, such as setting up specific working groups, developing accompanying tools, compiling publication, conducting workshops and supporting the "Covenant of Mayors on Climate and Energy" (formerly COM).[295]

Currently more than 1,700 municipalities and other federal states, regions and NGOs participate in the CA, turning the network into the largest initiative in Europe among those regarded in this study. The network is subject to the so-called European Office[296], which acts on the 26 European countries via national coordinators.

The cities within the alliance have made binding local decisions on the voluntary reduction of CO_2,. They intend an emission reduction of 50 percent (compared to the base year 1990) by 2030. About 25 percent of the cities involved even joined the German effort of reducing the emissions by 40 percent until 2020. *The prerequisite for participation is the obligation to reduce the local emissions by 10 percent every five years*. In addition,

[295] Climate Alliance, 2016
[296] http://www.klimabuendnis.at/climate-alliance-europe

the emission of CO_2 equivalents per capita is aimed at 2.5 tons per year.[297] The Climate Alliance, as a holistic approach, epitomises more than 25 years of climate protection.

The fact that an aid programme approved by the German Federal Government is linked to the signing of the agreement was certainly a motivation for many German participants to join the self-commitment. This external incentive and the general public – both domestic and international – perception of measures motivate cities to participate more intensively in climate projects as well as to display these commitments.

Current projects are for example in the area of *water management ("POWER")*, energetic renovation in disadvantaged quarters *("Climate Active Neighbourhoods")* or the climate protection contribution of forests *("SpeicherWald")*. All of these projects last until 2019.

A particular element of the network is the partnership with indigenous people in the Amazon Region. This network pillar is institutionally supported by the Alliance's partnership with the umbrella organisation of the Indigenous Peoples' Associations of the Amazon Region (Coordinator of Indigenous Organisations of the Amazon River Basis COICA). The relevance of this partnership is based on the recognition that the Amazon region is one of the key regions for global climate.

From a German municipal perspective, this network is especially relevant to those focussing on the issues of land use, urbanisation and carbon sequestration.

Table 14: The Climate Alliance (CA)

The Climate Alliance (CA)		
Approach / elaboration	• platform in a network form	
Regional focus	• Europe • (Amazon region with a specific cooperation)	
Support via	• financing • monitoring	
Founded in	• 1990	
Headquarters	• Frankfurt am Main, Germany	
Legal structure	• registered society	
Project coordinators	• The Climate Alliance	
Impact level	• city level	
Number of members	• 1,716 cities • unknown number of other members (federal states, provinces, NGOs)	
Membership type	• miscellaneous memberships (full membership for municipalities, or associate members such as federal states, NGOs etc.)	
Registered member	• city	
Duration of membership	• variable	
Costs of membership	• 0.00073 EUR per resident/year • outer limits: 220 – 15,000 EUR	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	-
	• behaviour	X
	• infrastructure	-
	• waste management	X
	• energy supply	X
Mission statement	• climate protection • undercut the threshold of 2.5 tons of CO_2 equivalents per resident/year	
Membership requirements	• approval of the network agenda	
Relevance for German officials	• especially working groups for financing, monitoring and energy supply.	

[297] http://www.climatealliance.org/fileadmin/Inhalte/7_Downloads/Climate_Alliance_Annual_Report_2015.pdf

Highlights / best practice	• distinctive monitoring of CO_2 (see Chapter 7, "Eco2Region" CO_2 accountig tool) • connection: Europe – indigenous partners
Website	• www.klimabuendnis.org or www.climatealliance.org

Source: own representation

5.3.2 Selective initiatives with open format

5.3.2.1 United Cities and Local Government (UCLG)

The global "United Cities and Local Government" (UCLG) initiative was founded in 2004 and primarily operates within the three areas of ***lobbying***, ***regional governance*** and ***knowledge transfer.***[298] The activities of UCLG clearly go beyond supporting the cities' decarbonisation measures and, for example, includemeasures for the resilience of cities, which are addressed under "disaster risk reduction". The network mainly pursues the mission to bundle and articulate the political will of municipalities from different regions. The topics, for example, include strengthening the municipal autonomy, human rights and public finance. The UCLG formulates in its guidelines that "cooperation between the local governments and the higher level of the international community should support the united voice for the values, objectives and interests of democratic, regional self-determination*."*[299]
In total, the UCLG brings together more than ***1,000 regional governments*** as well as ***175 national city and regional associations from 140 nations***, representing more than 5 billion people according to the organisation. Membership of the network is possible irrespective of a municipality´s size, and is therefore possible for smaller municipalities as well.[300]

In order to meet the goal of empowering democratically legitimate regional governments, the organisation cooperates with the United Nations and serves as a network for UN initiatives.[301] Moreover, the UCLG maintains partnerships to 17 additional organisations like OECD, UNESCO, World Bank as well as seven corporate partners like IBM, MNG Holding and VEOLIA Environment. The United Nations as well as the European Union can be identified as the key partners. In this context, the UCLG emphasises the importance of liaison with supranational institutions.

In connection with the decarbonisation of cities, three subsections can be highlighted, in which the UCLG plays a key role or can potentially assume in the future. The initiative already provides a strong representation of interests and networking. In the context of the support of a "good urban governance" to reduce greenhouse gases, the UCLG could be even clearer for the future. ***Against the background of the decarbonisation of cities, the UCLG's representation of interests is of particular importance at a global level***. Due to the size of the organisation, the positions represented are relevant to the implementation of global regulations. This international representation of local authorities is documented by participation in various political decision-making processes. For example, the UCLG was able to shape the decision-making process in the course of the COP 21 in Paris. Within the framework of the conference, the UCLG pooled and mobilised about 400 representatives of municipal institutions, thus contributing to the final agreement.[302]

Concerning the second area of network formation, an exchange of best practices is organised through conferences and seminars. The World Conference in Disaster Risk Reduction, which was held in association with the prevention of environmental risks in March 2015, is an example of such meetings. These UCLG best practices are completed by the dissemination of practical approaches to urban planning and climate change and are shared via the "***Learning UCLG***" platform.[303] The latest report "Gold IV 2016 – Fourth Global Report on Decentralization and Local Democracy" summarised UCLG approaches, particularly in relation to sustainable cities with strong local governance.[304]

UCLG supports the interests of local governments and municipalities, giving them an "own voice" on an international level. This is necessary as the interests of local governments might differ from those of the respective central

[298] See UCLG, 2016_a
[299] See UCLG, 2013, p. 2
[300] https://www.uclg.org/en/organisation/about
[301] https://www.uclg.org/en/node/26192
[302] See UCLG, 2014
[303] See UCLG, 2016_b
[304] See UCLG, 2016, p. 1ff

governments. As an example, this study has repeatedly indicated that good urban governance must also have a minimum level of local degrees of freedom and influence. Often, this does not apply to countries with a very centralistic political structure.

Participation for German representatives is particularly interesting for those municipal representatives who want to participate explicitly in the political decision-making process at the international level.

Table 15: United Cities and Local Government (UCLG)

United Cities and Local Government (UCLG)		
Approach / elaboration	• platform / network / umbrella association	
Regional focus	• global	
Support via	• best practice knowledge transfer within that network • international lobbyism as core mission	
Founded in	• 2004	
Headquarters	• Barcelona, Spain	
Legal structure	• NGO	
Project coordinators	• UCLG	
Impact level	• international level	
Number of members	• 1,000 + cities, regions, municipalities, etc. • 175+ city and regional associations	
Membership type	• municipality • national government • international organisations • associated members (e.g. NGOs)	
Registered member	• city	
Duration of membership	• variable	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	X
	• behaviour	X
	• infrastructure	X
	• waste management	-
	• energy supply	X
Mission statement	• representation and articulation of local governments' interests at an international level.	
Membership requirements	• not specified	
Relevance for German officials	• broad agenda • international lobbyism • knowledge platform	
Highlights / best practice	• 12 "Committees" • 6 "Working Groups" *inter alia*: staff training, networking, economic development • 2 "Task Forces" • participation in international climate negotiations	
Website	• www.uclg.org	

Source: own representation

5.3.2.2 World Mayors Council on Climate Change (WMCCC)

The "World Mayors Council on Climate Change" (WMCCC) is essentially a global information platform for regional politicians (e.g. mayors, governors, city councillors), who seek to strengthen the involvement of municipal politicians and representatives in improving the global transparency of examples for the successful implementation of adaptation or mitigation measures or general pioneering work in a sustainable context.

Due to its linkage with other initiatives, intersections exist with other, more advanced programmes. The WMCCC explicitly supports cCR as the global initiative to centralise and harmonise local climate data (actions, participations, ambitions). Initiatives like COM, ICLEI and C40 are supported as well.

The WMCCC is one of the few initiatives whose membership directly addresses natural persons. At the moment, the council consists of 80 members. Only personal membership of mayors or their equivalent municipal representatives is possible. The involvement of cities themselves is therefore only indirect.

The council's main objective is to underline the relevance of cities in the context of decarbonisation: "We have to tell the international community that it's in the cities where the battle to slow global warming will be won", Marcelo Ebard, chairman of the WMCC and mayor of Mexico City.[305]

The WMCCC highlights its networking purpose. The global network serves a platform for knowledge transfer and political exchange. The evaluation of the WMCCC as a potential partner of German participants focuses on these network and platform characteristics.

Table 16: World Mayors Council on Climate Change (WMCCC)

World Mayors Council on Climate Change (WMCCC)		
Approach / elaboration	• platform in the form of a network	
Regional focus	• global	
Support via	• political lobbyism	
Founded in	• 2005	
Headquarters	• Bonn, Germany	
Legal structure	• NGO	
Project coordinators	• Park Won Soon, Mayor of Seoul • Jürgen Nimptsch, Mayor of Bonn • Yorikane Masumoto, former Mayor of Kyoto	
Impact level	• personal level of members	
Number of members	• more than 80	
Membership type	• full membership (personalized)	
Registered members	• person	
Duration of membership	• variable	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	Not specified
	• urban planning / buildings	Not specified
	• behaviour	Not specified
	• infrastructure	Not specified
	• waste management	Not specified
	• energy supply	Not specified
Mission statement	• strengthen the political focus towards sustainability by pooling regional officials. • representation of regional officials at a global level.	
Membership requirements	• leading position at municipal level	
Relevance for German officials	• personal commitment	
Highlights / best practice	• network of political players	
Website	• www.worldmayorscouncil.org	

Source: own representation

5.3.2.3 Non-State Actor Zone for Climate Action (NAZCA)

The "Non-State Actor Zone for Climate Action" (NAZCA) is essentially a sole *register for the collection of commitments* – thus concerning declarations of decarbonisation intents. The portal relies on the registered activities of currently seven connected data partners, such as CDP and cCR. The central objective is *to record a*

[305] World Mayors Council on Climate Change, 2010

specific commitment embodying reduction targets and corresponding timeframes ("registers commitments to action").

The focus is on bringing together the five levels of companies, cities, regions, investors and society. Thus, the focus is not limited to the urban sector and is therefore broader than other initiatives solely focussing on local government activities. *The target furthermore encompasses the acceleration and multiplier effect* ("accelerate cooperative climate action").

Principally, the reduction targets are structured in sectors such as energy, waste management etc. and are web-based via a database search mask, giving the user the option to select those areas of information that fit best to individual needs. At the city level, the presented examples are again subdivided into cooperative actions, which are pursued in cooperation with other networks and measures that are implemented individually. *More than 2,300 declarations of intent have been recorded at the city level.*

The best practice of this registry is to be found in the scope and mode of access in the form of a web-based database. Furthermore, it shall ensure *data-based implementation and success control* ("track commitments over time to ensure progress").

For the total of 55 German participants in the initiative on municipal level, a wide spectrum emerges depending on the number of inhabitants. Thus, very heterogenic cities participate such as Berlin and Hamburg, yet also Böhl-Iggelheim, Rhineland-Palatinate or Altötting, Bavaria. The regional focus is on North Rhine-Westphalia, Baden-Wuerttemberg and Bavaria. Nevertheless, the formulation of individual GHG reduction targets in combination with a corresponding timeframe is consistent.

The creation of transparency and the striking presentation of the partly ambitious goals of certain cities are to be positively assessed. A useful expansion of the database would be to add input and output masks concerning specific starting points, measures and projects, which in sum illustrate the desired target achievement and, where applicable, provide a starting point for further cities to embark on the transformation process towards decarbonisation.

To a certain extent, CN Net can be cited as a precursor. Until 2011, The "Climate Neutral Network" (CN Net) had been a web-based platform for the exchange of strategies, ideas and information in order to reduce the GHG emissions of cities, companies and other stakeholders and was initiated by the United Nations Environment Programme (UNEP).[306] One of the founding members of the initiative, the city of Arendal, Norway, remains in the initial target corridor of reducing 90 percent of its GHG emissions by 2017 (compared to 2007).[307] *When closely monitored, programmes with high visibility and ambitious goals can actively support the realisation of progress in an effective GHG emission reduction.* CN Net encouraged its 300 members to participate in comparable initiatives (such as ICLEI) following the conclusion of the programme runtime.

For potential new participants, the uncomplicated generation of data is a possible driving force for involvement. The data portal provides a very fast and barrier-free way to systematically search for activities at different levels to learn from the experiences of other participants. Moreover, participants can present their own goals in a striking way.

Table 17: Non-State Actor Zone for Climate Action (NAZCA)

Non-State Actor Zone for Climate Action (NAZCA)	
Approach / elaboration	• database for registration of activities / network
Regional focus	• global
Support via	• collection of data regarding decarbonisation goals • presentation of data via search engines
Founded in	• 2014
Headquarters	• Bonn, Germany
Legal structure	• project
Project coordinators	• Peruvian presidency of COP20
Impact level	• city level

[306] UN-EP, 2011
[307] Hirsch, 2009

	• subnational level • national level • private level	
Number of members	• 2,364 cities • 2,090 companies • 448 investors • 236 CSOs	
Membership type	• declaration of intent for emission targets in specific sections	
Registered member	• depending on registered activity	
Duration of membership	• no fixed time period	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	X
	• behaviour	X
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• merging planned GHG reduction targets of companies, cities, subnational governments, investors and the overall civil society.	
Membership requirements	• none	
Relevance for German officials	• uncomplicated, fast recording of activities	
Highlights / best practice	• pooling large amounts of data (CDP, ccR, The Climate Group, Investors on Climate Change, UN Global Compact, Covenant of Mayor, Climate Bonds Initiative) • a total of 11,615 commitments have been registered so far (until 09/2016), including 2,364 urban commitments.	
Website	• www.climateaction.unfccc.int	

Source: own representation

5.3.2.4 Climate Neutral Cities (CNC)

The "Climate Neutral Cities" initiative of the UN "Economic Commission for Europe" (UNECE) is primarily a ***platform for knowledge transfer*** completed by guidelines. The contents can be categorised into the five key areas of energy infrastructure, building technology, low-emission mobility, public green areas, water systems and waste management.[308] It is the aim to develop and promote approaches for the transformation of climate-neutral urban areas.

The main contribution of the organisation relating to the decarbonisation of cities is the study "***Climate-Neutral Cities: How to make cities less energy and carbon intensive and more resilient to climatic challenges***", published in 2012.[309]

The report sets out specific approaches for the decoupling of economic growth and GHG emissions in different sectors. In doing so, the report includes a summary of new challenges for cites as well as an analysis of individual resilience culminating in suggestions for managing the urban administration. Specific approaches for individual sectors and strategic guidelines on decarbonisation are presented as well. The report focuses on the area of waste recycling and biofuels, as well as on low-emission mobility, the incentive of renewable energies and the creation of green spaces to prevent „heat islands"[310] in urban areas.

From a German perspective, the benefits of the initiative / reports consist of the scientific preparation or derivation of individual recommendations for action with regard to the five subdivisions mentioned.

[308] UNECE, 2011
[309] https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/climate.neutral.cities_e.pdf
[310] Crutzen, 2004

Table 18: Climate Neutral Cities (CNC)

Climate Neutral Cities (CNC)		
Approach / elaboration	• network-shaped platform for knowledge transfer • Guidelines	
Regional focus	• Europe	
Support via	• composition of guidelines and frameworks for the decarbonisation of urban areas	
Founded in	• not specified	
Headquarters	• Geneva, Switzerland	
Legal structure	• not specified	
Project coordinators	• UN Economic Commission for Europe (UNECE)	
Impact level	• city level	
Number of members	• not specified	
Membership type	• not specified	
Registered member	• city	
Duration of membership	• not specified	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	X
	• behaviour	-
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• promote climate neutrality in cities via the decarbonisation of essential urban systems.	
Membership requirements	• not specified	
Relevance for German officials	• publication of guidelines as well as best practice	
Highlights / best practice	• "Climate Neutral Cities: How to make cities less energy and carbon intensive and more resilient to climatic challenges" (2012)	
Website	• www.unece.org	

Source: own representation

5.3.2.5 Institute for European Environmental Policy (IEEP)

The "Institute for European Environmental Policy" (IEEP)[311] is a research institute in the legal form of a non-profit organisation, which publishes research papers in the eight working areas of agriculture, climate change, green economy, industrial pollution, water usage, natural resources and waste management, global challenges as well as environmental governance. *Besides providing the above-mentioned aspects, the IEEP has been providing consulting and specific approaches to the implementation and evaluation of the environmental policy in Europe for over 40 years.*

The Institute is embedded in a close network of institutions of the European Union, international organisations like NGOs, national governments, think tanks and private companies – making it an important interface for research, civic population and politics. The online library[312] offers around 800 articles on different topics. In addition to scientific publications, the central output of the institute is the *development of politically relevant (decision-making) recommendations.*

These studies and recommendations are helpful for interested stakeholders at the municipal level when identifying specific approaches – especially in the field of governance. The publication "Opportunities for a better use of

[311] www.ieep.eu
[312] http://www.ieep.eu/publications/

indicators in policy-making: emerging needs and policy recommendations" (2011) can be cited as a good example.[313]

Table 19: Institute for European Environmental Policy (IEEP)

Institute for European Environmental Policy (IEEP)		
Approach / elaboration	• research-platform	
Regional focus	• Europe	
Support via	• scientific publications	
Founded in	• 1976	
Headquarters	• London, UK	
Legal structure	• institute	
Project coordinators	• European cultural foundation	
Impact level	• supranational (EU) • national • subnational	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	X
	• behaviour	X
	• infrastructure	X
	• waste management	X
	• energy supply	X
Mission statement	• non-profit institute for the development of sustainable policies in Europe.	
Highlights / best practice	• 9 research fields • „Climate Change & Energy"	
Website	• www.ieep.eu	

Source: own representation

5.3.2.6 Low Carbon, Livable Cities Initiative (LC2)

The World Banks' "Low Carbon, Livable Cities Initiative" (LC2) is an initiative that basically focuses on two directions of impact: ***preparatory planning and subsequent elaboration of financing solutions.***[314] In contrast to previously presented approaches, the focus of this initiative is clearly limited to financing solutions. Furthermore, it can fall back on a substantial network of project partners. Accordingly, there are broad connections to initiatives like C40 or ICLEI.

The initiatives' best practice can be particularly identified as the close interlocking of financial solutions ***on the basis of specific emission reductions***. The intricate connection of financial solutions and emission measurement is continued in the following phases of ***„planning"*** and ***„financing"***.[315] Specifically, the potential for reducing emissions of possible investments at the municipal level is evaluated using ISO standards. To that end, greenhouse gas inventories are drawn up and training is offered to support local decision-makers in the planning of meaningful low-carbon investments. The best alternatives are identified on the basis of the possible savings potential of various investment opportunities.

Key features are the innovative financing products and the ***focus on improving the creditworthiness via the „City Creditworthiness Program"***. It consists of two parts – the „City Creditworthiness Academies" and the „City Creditworthiness Implementation Program". The former serves the purpose of providing targeted training for municipal decision-makers in the context of external financing, whereas the latter provides technical support for the specific planning of infrastructure projects for decarbonisation. The targeted promotion of creditworthiness provides cities with the possibility to attract more funds from capital markets in the long run.

[313] Bassi et.al., 2011
[314] World Bank Group, 2012
[315] World Bank Group, 2014

The programmes are particularly interesting for cities having no experience in the area of capital market procurement or only having moderate creditworthiness.

The initiative, which was announced in 2013 and aimed at reaching 300 of the largest cities in developing countries (like Rio de Janeiro or Kampala) within four years, can only present rudimentary results so far. For example, specific training courses for the creditworthiness of African municipalities have been organised[316] while since 2014, no further result reports, that would indicate volumes and implementation success, are to be found.

Table 20: Low Carbon, Livable Cities (LC2)

Low Carbon, Livable Cities (LC2)		
Approach / elaboration	• GHG emission measurement • financing	
Regional focus	• developing countries	
Support via	• measurement based on ISO Standards • improving the creditworthiness • development of innovative financial products	
Founded in	• 2012	
Headquarters	• Washington D.C., USA	
Legal structure	• commission	
Project coordinator	• World Bank Group	
Impact level	• city-level	
Duration of membership	• variable	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	X
	• urban planning / buildings	-
	• behaviour	-
	• infrastructure	X
	• waste management	X
	• energy supply	X
Highlights / best practice	• financing solutions • improving the creditworthiness („City Creditworthiness Program“)	
Website	• www.worldbank.org	

Source: own representation

5.3.2.7 Global Carbon Project (GCP)

The “Global Carbon Project” (GCP) is essentially a platform for knowledge transfer. Founded in 2001, the project attempts to promote appropriate measures for decarbonisation on various levels through the dissemination of scientific findings. The considered levels exceed the boundaries of municipalities and thus concern global, national and supranational issues. The GCP especially focuses on exploring the carbon cycle.

The GCP is integrated into a network of other programmes, which consist of the International Geosphere Biosphere Program (IGBP), the International Human Dimension Program on Global Environmental Change (IHDP), the World Climate Research Program (WCRP) and Diversitas. The aforementioned programmes constitute the so-called *„Earth Systems Science Partnership (ESSR)”*. The central activities of the GCP are the *„Carbon Atlas“* and the *„Carbon Budget“*.

The former essentially results in the detection and visualisation of emissions. The web-based tool currently documents the GHG emissions of 217 participants at country level.[317] The „Carbon Budget“ is an annual publication series, which concisely summarises trends of GHG emissions. This is differentiated both regionally and with regard to emission sources, which facilitates targeted monitoring.[318]

[316] World Bank Group, 2013b
[317] Global Carbon Project, 2015
[318] Global Carbon Project, 2016

Since its inception by the GCP in 2015, *"Urban and Regional Carbon Management" (UCRM)* has been focusing on the promotion of a sustainable, low-emission and climate-friendly urban development. Activities include in-detail research on urban and regional carbon management, networking with institutions and other research facilities as well as the dissemination of the compiled content to relevant stakeholders.

Similar as with other strictly scientific platforms, particularly those German municipalities aspiring to further substantiate their past and future activities scientifically can benefit from this project.

Table 21: Global Carbon Project (GCP)

Global Carbon Project (GCP)		
Approach / elaboration	• network-shaped platform for knowledge transfer	
Regional focus	• global	
Support via	• scientific material	
Founded in	• 2001	
Headquarter	• Canberra, Australia	
Legal structure	• NGO	
Project coordinators	• Earth Systems Science Partnership (ESSR)	
Impact level	• international level • subnational level • city level	
Number of members	• unknown	
Membership type	• scientific (knowledge) exchange	
Registered member	• respective municipality, organisation etc.	
Duration of membership	• variable	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	-
	• behaviour	X
	• infrastructure	X
	• waste management	-
	• energy supply	X
Mission statement	• fundamental scientific research for understanding the carbon cycle	
Membership requirements	• none	
Relevance for German officials	• scientific (knowledge) exchange	
Highlights / best practice	• „Global Carbon Budget" • „Global Carbon Atlas" • heat maps for GHG emissions	
Website	• www.globalcarbonproject.org	

Source: own representation

5.3.2.8 International Carbon Action Partnership (ICAP)

The "International Carbon Action Partnership" (ICAP) is a global platform for the exchange of policy-makers who are planning to or have already implemented an *emission trading system (ETS)* at an international, national, subnational or municipal level. In contrast to other initiatives, this initiative ***focuses on CO_2 trading*.**

In the context of an ETS, CO_2 certificates, i.e. documented emission rights for the emission of carbon dioxide (see Chapter 5.1), are generally traded in two market segments: in the mandatory market, or in a voluntary market. The nature of these markets is characterised by scientists and actors as fragmented[319], plurilateral[320], decentralised[321] and bottom-up[322]. The central mechanism is marked by the „Cap-and-Trade" principle. A „cap" ensures that CO_2 is

[319] Tangen et al. 2005
[320] Sandor, 2002
[321] Victor et al., 2005
[322] Ibid.

a scarce commodity while „trade“ provides for the formulation of a price for CO_2 emissions through supply and demand. Firstly, an upper limit[323] is defined in relation to the CO_2 emissions. Based on these binding values, market participants (often companies) are allocated with a certain number of emission rights. Companies with moderate own abatement costs will tend to avoid more GHG emissions and sell the corresponding certificates (and vice versa in case of high costs). Current systems are therefore statistically and dynamically efficient when a nuanced „cap“ is set.

The main contribution of ICAP is the global overview of different ETS, which is published every quarter.[324] They can be implemented at the international level, at the level of the EU (through the EU Emission Trading System EU ETS), at the level of the UN (through the „Clean Development Mechanism“) and at the national level (e.g. by the „Swiss ETS“ in Switzerland) or at the municipal level (e.g. through the „Tokyo Cap-and-Trade Program“).

The collection of running or planned ETS can be outlined as the best practice of ICAP. For each of the trading systems, general information on size, allocation, flexibility and compliance is processed.

For active ETS at the municipal level, the ICAP provides a total of seven systems. They, for example, include the „*Tokyo Cap-and-Trade Program“*, which is a pioneer in municipal ETS. The City of Tokyo, for example, has been the first municipality to issue certificates since 2010, resulting in a 25-percent reduction in emissions by the end of 2014.[325] A further reduction of 15 percent is planned for the 2015 to 2019 period. Overall, the allowance covers 20 percent of the GHG emissions in the City of Tokyo.[326] New ETS at the municipal level are being formed in Beijing, Shanghai and Shenzhen (PRC each, see Chapter 9).

Table 22: International Carbon Action Partnership (ICAP)

International Carbon Action Partnership (ICAP)		
Approach / elaboration	• network-shaped platform for ETS	
Regional focus	• global	
Support via	• information (best practices) about ETS • registration of ETS at the platform	
Founded in	• 2007	
Headquarters	• Berlin, Germany	
Legal structure	• NGO	
Project coordinators	• 15 national governments	
Impact level	• city level • subnational level • national level • international level	
Number of members	• 31 full members • 4 „observers“	
Membership type	• miscellaneous memberships (ETS operators as well as „observers“)	
Registered member	• operator of ETS (e.g. EU, nations, regions etc.)	
Duration of membership	• variable	
Costs of membership	• not specified	
Attended problem areas / sectors	• transportation	-
	• urban planning / buildings	-
	• behaviour	-
	• infrastructure	-
	• waste management	-
	• energy supply	X

[323] The decision on the upper limit is made by various bodies within the 17 different systems on four continents. For an overview // See ICAP (2015)
[324] https://icapcarbonaction.com/en/
[325] TMG- Bureau of Environment, 2016
[326] ICAP, 2015

Mission statement	• international forum for the planning and implementation of emission trading platforms.
Membership requirements	• planning or deploying ETS
Relevance for German officials	• emission reduction as a political instrument • registration in ETS databases for knowledge transfer
Highlights / best practice	• decarbonisation via ETS • overview of ETS in ICAP database
Website	• www.icapcarbonaction.com

Source: own representation

5.4 Summary: overview of the participation of project-based cities in selected initiatives

Table 23: Summary of participation in city initiatives

Projekt: CO2-neutral in Stadt und Quartier												
Städte, Organisationen und lokale Behörden												
Länder-Kennung	Land	Stadt	#	Reporting initiatives		Inventory	Memberships				
				carbonnCR	CDP-cities	WRI-GPC	ICLEI	SexCom	C40	R20	Alliance
AT	Österreich	Wien	1	0	0	0				1	1
BR	Brasilien	Rio de Janeiro	2	1	1	1	1		1	1	
		São Paulo	3	1	1	0	1		1	1	
CA	Kanada	Toronto	4	0	1	1	1		1	0	
CN	China	Schanghai	5	0	0	0			1	0	
		Tianjin	6	0	0	0				0	
		Hangzhou	7	0	0	1				0	
DK	Dänemark	Kopenhagen	8	1	1	0	1		1		
FI	Finnland	Helsinki	9	0	1	0	1	1			
FR	Frankreich	Lyon	10	1	0	0					
		Paris	11	1	1	0	1		1		
DE	Deutschland	Berlin	12	1	1	0	1		1	0	1
		Freiburg im Breisgau	13	1	0	0	1	1	0		1
		Hamburg	14	0	1	0	1		0		1
		München	15	0	0	0	0		0		1
IN	Indien	Andhra Pradesh New City (Amaravati)	16	0	0	0	0				
NL	Niederlande	Amsterdam	17	0	1	0			1		
RW	Ruanda	Kigali	18	0*	0	0	1**				
SG	Singapur	Singapur	19	1	1	0	0		1		
ZA	Südafrika	Durban (eThekwini)	20	1	1	1	1	1	1		
KR	Südkorea	Seoul	21	1	0	0	1	1	1		
ES	Spanien	Madrid	22	1	1	0	0		1	0	
SE	Schweden	Stockholm	23	1	1	1	1		1		
AE	Vereinigte Arabische Emirate	Abu Dhabi (Masdar City)	24	0	0	0					
GB	Vereinigtes Königreich	London (Greater London Authority)	25	0	1	1	0		1		
US	USA	Chicago	26	1	1	0	1		1		
		New York City	27	0	1	0	1		1		
				* für die Gesamtstadt Kigali, der Stadtteil Nyarugenge berichtet Maßnahmen							
				** durch den Kommunalverband von Ruanda							

Source: own representation

6. Guidelines and systems for local GHG inventories

6.1 Necessity of guideline standardisation

Even though the role of cities as culprit and solution of climate change has been neglected over a prolonged period, the focus in current climate negotiations[327] is increasingly put on urban structures as transformative elements of mitigation concepts.[328] The importance of the formation of emission targets with the aim of responding to climate issues has already been realized by responsible representatives of the city administration in industrial countries.[329] **Based on the status quo, it is indispensable to form structured inventories for GHG emissions in order to track the attainment of goals.** Corresponding recordings facilitate the development of strategies while providing a leitmotif for monitoring.

Structural requirements help to identify GHG sources and to allocate them to actual sectors within a city. They conduce better understanding of the extent and origin of emissions. In this spirit, the aforementioned documents are indispensable for analysing the anthropogenic climate change. Furthermore, they include an important system of indicators to prepare action plans and programmes to reduce the GHG emissions and enable an appropriate use of municipal (financial) resources.[330]

Especially at a local or neighbourhood level, these findings carry enormous significance, as for the most part, direct greenhouse gases share common origins with indirect emissions, which in turn equally influence air and living conditions within cities.[331] The question of direct, indirect and cross-border emissions is differently answered throughout analysed initiatives and instruments covered in Chapter 7.

The guidelines and requirements for inventories also fulfil an effective role as a planning instrument as they are able to identify opportunities and risks which are inextricably tied to different scenarios by means of simulations of alternative urban development concepts as well as identification and prioritisation of sectors with the highest GHG reduction potential. Those instruments make a participation in the “Clean Development Mechanism” or the “Carbon Credit Market” possible in the first place.[332]

Especially **the opportunity to participate in international emission trading** serves as an incentive for cities to drive the development of inventories. Furthermore, such information can be called on for funding applications, which embody climate protection measures in line with the “National Appropriate Mitigation Actions” (NAMAs).[333] This mechanism is currently reviewed. It is the implicit aim to stimulate the willingness of local administrations to participate in related initiatives.[334]

Different city-level initiatives for climate protection, such as the “Climate Alliance” (see Chapter 5.2.2.4), have enforced ambitious aims to reduce GHG emissions within a framework based on the voluntary self-commitment of members. Against this background, **a clear and structured analysis of the starting position as well as internal benchmarking with other participants is essential**.

The most important reason for the necessity of a consistent bottom-up inventarisation of greenhouse gases is rooted in the realisation that, on a national level, they consequently facilitate the monitoring of INDCs as well as to reach the decarbonisation target or at least to enable it.

[327] Climate negotiations, such as COP 21, COP 22, Habitat III and Lima Paris Action Agenda.
[328] The focus on sub-national parties lead to a definition of city-relevant goals on an international basis, which focus primarily on resilience, transport, green buildings and energy use as well as energy efficiency // See also COP, 2015.
[329] CCC, 2012, p. 52
[330] Li, 2011
[331] Defra, 2007, p. 3
[332] See Ravindranath, 2008, p. 2525; for an analysis of the role of inventories in the Clean Development Mechanism.
[333] UN-FCCC, 2014c
[334] Linner, 2012, p. 56

Greenhouse gas inventories, often known as *emission registers* or *statistics*, are ideally created on the basis of a permanent process, which, departing from a defined starting point, traces the development of emissions of a specific institution or area to subsequently derive optimisation measures.

Even on a national basis, estimates of GHG emissions are subject to high uncertainty, which is traceable to the intricacies of obtaining aggregated and consistent data sets. This problem is even more pronounced on a city level, given the inherent difficulties to define city borders or system boundaries. Additionally, the operating direction is frequently obscure while the risk of double counting or its complete negligence exists. Therefore, it appears necessary to refer to accepted methods or protocols for the preparation of GHG emission inventories.

Nevertheless, this assertion is often difficult to be realised in practice. The **primarily used IPCC method**[335] was originally designed for countries and is henceforth unsuitable for urban regions without certain adjustments as this collection method does not adequately cover the spatial distribution of emissions within a city.[336] Against this background, the respective organisations developed their **own GHG inventories and monitoring programmes** for cities to expediently assess environmental policies and measures on a neighbourhood level.[337]

6.2 System boundaries and value chains

6.2.1 Introductory remarks

If cities are interested in introducing emission inventories, three fundamental (technical) questions have to be raised, which ought to be clarified before implementation. They can be represented in the form of conceptional guiding questions:

- **Which emissions should be measured?**

  Only specific GHG emissions (such as those seven specified in the Kyoto Protocol[338]) or all?

- **Whose emissions are included and measured?**

  Which system boundaries and scopes are defined?

- **How are emissions measured?**

  Which inventory method is used and what does the conversion to CO_2 equivalents (CO_2e) entail?

The challenges resulting from these questions are multilayered. Regional emission inventories (on a city or neighbourhood level) should be compatible with national and international standards to ensure aggregation, among others. Additionally, those inventories should be practice-oriented, consistent and comprehensive.

The accuracy of research findings is primarily dependant on the data quality and data availability, whereby the availability of data may have a substantial influence on the method selection and extent of the data survey. Where data is limited and different administrative levels and external sources are causing difficulties, cities can be forced not to follow certain analysis approaches. **Therefore, approaches are expedient if they guarantee a gradual improvement or expansion in the following years depending on a constantly improved data situation.**

In conclusion, it is possible to deduce two different general methodologies, which directly influence system boundaries as well as value chains.[339] On the one hand, the top-down approach derives emissions from national statistical data. Regionalisation is achieved through the use of different locations and different population densities. On the other hand, **bottom-up approaches** estimate the locally relevant emissions on the basis of specific activity data and individual emission factors (see Chapter 6.2.1.). A temporal and spatial resolution is used via existing activity and surrogate data, such as land use and population size.

[335] IPCC, 2006
[336] Dodman, 2009, p. 188
[337] A comprehensive analysis of monitoring tools and rules, from a German perspective, has been published by the *ifeu – Institute for Energy and Environmental Research Heidelberg GmbH //* See Hertle, 2014, p.6ff
[338] See Chapter 3.1.1
[339] based on ERDF, 2010, p. 6

6.2.2 Emission factors and activity data

A direct measurement of all emission sources and resulting GHG emissions is not feasible on the city level. Therefore, the preparation of inventories is mainly based or dependant on estimation techniques, which in particular comprise the following:

- emission factor method;
- energy balances (measurement of specific forms of energy);
- simulation models (more complex method, which requires specific activity data); and
- inverse modelling (atmospheric measurements, to refine additional estimation methods).

The selection of the appropriate estimation method for each case is dependent on several factors. Especially the local situation and data availability counts. **Essential guidelines predominately use the emission factor method.** An emission factor[340] (EF) is a coefficient, which converts activity data[341] (AD) into GHG emissions. According to the *US Environmental Protection Agency* (EPA), an EF generally is a representative value linking emitted pollutants with a specific activity associated with the pollutant.[342]

An example within the context of a city is the calculation of emissions produced by an industrial cement manufacture. An exemplary, simplified calculation can be the following:

Table 24: Emission factor calculation

A	B	C
Produced amount of cement (in tons)	Emission factor of cement (per ton) (in this case: CO_2 per ton)	CO_2 emission (in tons) C = A * B
9,500,000	0.50	4,750,000

Source: own representation

In the case of this example, the total production (a) is multiplied by the context-specific emission factor (B = 0.5) to reach an estimate (C). An emission factor is typically derived from a regression line, which represents a total quantity of observations. There are different data sources to determine this line. **Relevant in our context is the so-called** ***IPCC EFDB[343] as one of the most reliable sources to provide default emission factors.***[344]

These universal default EFs can be replaced by country-specific EFs, which include additional country-specific information. Despite attempts to increasingly utilise national data, city-level activity data continue to be associated with high uncertainty. This can potentially lead to useless results or false assertions, if and when such data is used to create city-level inventories. Where applicable, the producer of any inventory can potentially generate own emission factors, which nevertheless have to be calculated on the basis of particular characteristics of fossil fuels and activities.

Primary sources to identify emission factors[345] are the following:

- IPCC (Intergovernmental Panel on Climate Change) – Emission Factor Database (EFDB)[346]
- DEFRA (Department for Environmental, Food & Rural Affairs) – Emission Factors Toolkit[347]
- IEA (International Energy Agency) – Online Data Service 2015 Edition[348]

[340] According to the IPCC (1996) the emission factor is defined as the average emission rate of a greenhouse gas for a certain source and relative to an activity unit. // See GHGP-GPC, 2012a
[341] *Ibid.*; Is defined as data, which records the extend of human activities that result in a generation or reduction of emissions
[342] https://www.epa.gov/air-emissions-factors-and-quantification/basic-information-air-emissions-factors-and-quantification
[343] http://www.ipcc-nggip.iges.or.jp/EFDB/main.php
[344] IPCC, 2006
[345] See Hertle et al., 2014, p. 27ff // Hertle et al., 2016, p.12
[346] GHGP-GPC, 2012a, www.ipcc-nggip.iges.or.jp/EFDB/main.php
[347] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html
[348] www.iea.org/statistics/relateddatabases/co2emissionsfromfuelcombustion/

In Germany, this complex assessment area is guided by the *Federal Ministry for the Environment, Nature Conversation, Building and Nuclear Safety*, which follows the methodical background of *IPCC*, *DEFRA* and *IEA*.

It is based on the „polluter pays“ and the territorial principle: The emission sources for all greenhouse gases produced within national borders are determined to subsequently investigate each emission amount and its release conditions. If the resulting emission factor (EF) is multiplied by its activity data (AD), it results in an emission value for the analysed activity. This task is covered by the national coordination centre for emission reporting. For the preparation of an emission inventory, a large quantity of data is required, which is derived from other regulatory bodies and authorities, research institutions and the Federal Statistical Office.[349]

6.2.3 Limits of emission involvement

The systematic collection of the GHG emissions of an organisation – company, public authority or local authority – to prepare a greenhouse gas balance is also known as “carbon accounting”. The importance of unequivocal limits to reporting is emphasised by the *World Bank*.[350] The *specification of so-called inventory boundaries* is one of the first steps within the scope of inventory preparation, according to the GPC.[351] The *World Bank* and other organisations recommend the GPC as the best standardised approach to produce city-level GHG emission inventories (see Chapter 6.3.5).[352]

Existing greenhouse gas inventories generally use different “Scopes”, which are differentiated by the nature and boundary effect of a given greenhouse gas. Initially developed for enterprises, emissions emanating from business-related activities (Scope 1; direct emissions) as well as other indirect emissions, such as the use of electricity to run the business (Scope 2), have been collected. Additionally, emissions emitted outside the specific enterprise through the purchase of services (“Upstream”) or the sale and later use (“Downstream”) have been included (Scope 3).[353] Since 2009, intensified efforts have emerged to standardise these scopes. For the last two years, the scopes have been customised for cities according to the GPC:[354]

- *Scope 1:* These emissions are *directly emitted* by the respective city, its residents and companies, and are therefore *physically rooted* within a city`s borders. It is also known as “territorial emissions in geographic boundaries”. The emissions produced by factories and the emissions produced by private transport serve as examples.
- *Scope 2:* These emissions result from network-based energy consumption (electricity, cooling, heating and steam) by residents and companies. In this case, *indirect emissions* can be produced inside and outside city borders. If the emissions emanating from a coal-fired power station outside the city boundaries are caused by the consumption by a city´s residents and companies, then they correspond to the categorisation of Scope 2 emissions.
- *Scope 3:* These *indirect emissions* arise as a consequence of the manufacture or transport of products or other activities. While the final product is used within the city borders, its associated emissions are caused outside city limits. They are often called “embodied” or “upstream emissions” and specific examples are to be found in the context of the consumption of regional goods or the mining of energy sources.

[349] Thomas, 2013, p. 683
[350] World Bank, 2014, p. 37
[351] Fong et al., 2014, p. 10: “Depending on the purpose of the inventory, the boundary can align with the administrative boundary of a local government, a ward or borough within a city, a combination of administrative divisions, a metropolitan area, or another geographically identifiable entity.” // CNCA, 2015, p. 38.
[352] See World Bank, 2014, S. 40ff // Hertle et al., 2014, p. 15; *End-energy-based territorial balance*: The whole energy consumption in a specific territory on the level of end-energy (energy, which for example is measured by a domestic metre) is taken into account and allocated to the different consumption sectors. Specific emission factors are then used to calculate CO_2 emissions.“ // CNCA, 2015, S. 39.
[353] See Hoornweg et al., 2011, p. 222ff; Note: This complies with *GHG Protocol Corporate Standard*.
[354] See Fong et al., 2014, p. 11 // CNCA, 2015, p. 38

Experts recommend cities to scrutinise the following sectors within inventory frameworks:[355]

- energy consumption (including emissions emitted by electricity, heating and cooling)
- transport (including aviation and shipping)
- production and use of commodities
- agriculture, forestry and other land use change (AFOLU)
- waste management industry

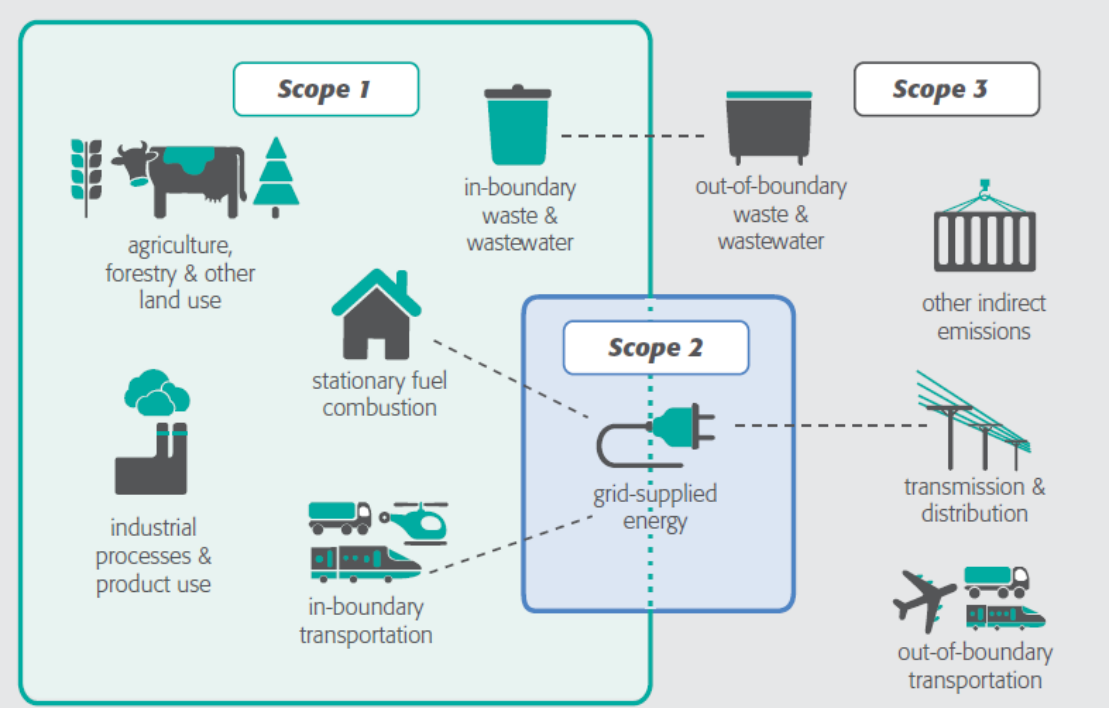
From a city´s perspective, especially cross-border emissions (Scope 3) offer distinct challenges. Likewise, neighbourhood-level analyses of city data generate conceptual problems, which have been reduced in the newly published GPC (see Chapter 6.3.5). Scope 3 emissions should be included in relation to fuel, water management, comestible goods and buildings. Apart from a high complexity of inclusion, studies show that the carbon dioxide level of cities hereby increases up to 45 percent.

Most commonly, local inventories use the territorial principle. This means that only those emissions are counted which are caused within a defined boundary. Sometimes, emissions caused outside a given boundary are included in inventories. This approach is based on the so-called activity principle. In this case, these inventories also include emissions caused by energy production and district heating (along with transmission and distribution losses), aviation and shipping (transport of goods and passengers) as well as waste processing.

The main problem of using existing inventories at a city level is that the data gathered in city boundaries may become cross-border data when considered from a district or neighbourhood level. Scope 2 and 3 therefore have a bigger percentual proportion of the inventories and should not be ignored.

The following figure, in compliance with the GPC, illustrates the different emission categories (Scope 1, 2 and 3) for cities. Further challenges arise from the condition that the guidelines presented in the following sections do not identically cover individual categories. The choice of Scopes varies widely throughout guidelines and emission sources, which may further exacerbate limitations to the extent of comparability.

Figure 10: Exemplary presentation of Scope 1, 2 und 3 emissions for cities



Source: Fong et al., 2014 // boundary: limit of the system

[355] Hoornweg et al., 2011, p. 223ff // Fong et al., 2014, p. 10

The recommended gradations, according to the GPC, differentiate between certain "levels" of reporting. The BASIC level only includes data of Scope 1 and Scope 2 as well as the waste component of Scope 3. By expanding analytical depth, the BASIC+ level assures consistency with IPCC requirements.[356]

6.3 Guidelines for greenhouse gas inventories

6.3.1 Introductory remarks

The following chapter outlines the institutional evolution of greenhouse gas inventories. The balancing of GHG emissions is essentially not subject to any legal regulations so far, apart from the existing basis for the trading of emission rights, or the preparation of *National Inventory Reports*, within the framework provided for the UNFCCC member states.[357] On the one hand, the focus lies on top-down guidelines defined by international agreements (IPCC and EU) and, on the other hand, on bottom-up guidelines, which are specifically issued for cities by independent initiatives. While these premises are based on the IPCC, new endeavours aim to standardise calculations as well as to solve problems concerning the collection and comparability of data. The methodical reconditioning on a city level was primarily ensured by the listed initiatives as well as by standardisations (DIN, CBN, I.S.O). Especially the *Global Protocol for Community-Scale GHG Emissions*[358] has the potential to become the leading framework for urban GHG-emission inventories.[359]

The *United Nations Framework Convention of Climate Change,* which was held in Rio de Janeiro, declared the preparation of national greenhouse gas inventories to be compulsory for its signatories.[360] On the basis of the UNFCCC guideline, other inventories have been published, which especially include data voluntarily provided by local authorities and enterprises.[361] With increasing awareness of the negative outcomes of climate change, requirements for inventories have been gradually raised, especially for public institutions and enterprises.

The European Union has already established a new mechanism in 2013 and 2014, which affects both the reporting and the monitoring of greenhouse gases, with the explicit goal of enabling more precise and regular derivation and documentation.[362]

Through the *Greenhouse Gas Monitoring System*, EU members are committed to establish national inventories in order to enable the calculation and reduction of emissions. Each single year, the member nations are required to communicate individual emission values for the seven greenhouse gases[363], as well as information about national strategies and tools, to the Commission. The observation and creation of inventories is based on IPCCC methods[364]. Every spring, the European Commission and the European Environment Agency derive the EU-wide emissions balance based on national inventories.

Focusing on the international commitment on reporting and monitoring in accordance with *The Framework Convention of Climate Change*, one may conclude that signatories are obligated to establish, publish and permanently run programmes to reduce and minimise anthropogenic emissions (according to emission class and source).

Within the last 10 years, several initiatives have published relevant guidelines for greenhouse gas inventories. At the inception, these inventories concentrated activities on the national level[365] while in the course of time, refinement

[356] Fong et al., 2014, p. 12
[357] Mayer et al., 2016, p. 2ff
[358] Note: GPC is regarded as "best practice" by the IPCC, ICLEI, C40 and other well-known institutions // See Chapter 6.3.5
[359] Bienert et al., 2015
[360] Jarvis, 2010, p. 127
[361] Singh, 2014
[362] See original EU regulation 525/2013: Describing the Greenhouse Gas Monitoring Mechanism as well as further clarifications regarding regulation requirements in the area of reporting (EU regulation 749/2014) and inventories (EU regulation 666/2014).
[363] See Chapter 3.1.1
[364] See European Commission, 2016, p.13: For guidelines and goals considering the COP21 conference.
[365] IPCC, 2006

resulted in inventories extending to regional[366] and neighbourhood[367] system boundaries. Despite these encouraging developments, a considerable gap persisted with regarded to elements considered as well as the reporting methods of greenhouse gas inventories.[368] The main difference between both, national and regional, areas can be discerned via the related fields of activity. The preparation and management of directories, i.e. inventories, falls into the accounting framework[369] and outlines the rules and data concerning assessment to ultimately contribute to defined goals. Conversely, reporting frameworks concern themselves with measurement, reporting and verification (MRV). Therefore, they relate to the processes of data collection, distribution and review. Within the presented initiatives, many different MRV systems have been developed, ranging from yearly newsletters to a comprehensive verification of data.

The most important guidelines standardising city level GHG inventories are the following:

- IPCC – Guidelines for National Greenhouse Gas Inventories (2006);
- IPCC – International Standard for Determining GHG Emissions for Cities (2010);
- European Covenant of Mayors[370]– Baseline Emissions Inventory (2010);
- ICLEI – International Local Government GHG Emissions Analysis Protocol (2009);
- GPC - Global Protocol for Community-Scale GHG Emissions (2014).

A full description of the most important initiatives is presented from Chapter 5.2.1 onwards, whereas Chapter 6.3 deals with guidelines that interact conceptually and operationally with the initiatives described in Chapter 5.

The presented guidelines and their techniques exhibit clear similarities. First of all, the IPCC guidelines from 2006 represent the methodical fundament of all others. Secondly, they are based on the territorial principle: Emissions are calculated based on geopolitical boundaries. This procedure creates obstacles for the analysis of cross-border emissions as well as regarding the assessment of emissions in smaller system units. [371] Thirdly, the activity-based calculation method[372] is embedded within every single policy. Hereby, either the emission factors produced by IPCC[373] or other data banks, which include more precise information about countries or even continents, can be used.[374] Lastly, all considered initiatives frame emissions from Scope 1 to Scope 3 as this classification, which is rooted in IPCC Guidelines, has emerged as an operational definition for further guidelines. Similarities exist for Scope 1 and Scope 2, which include city-relevant emission areas such as electricity, burning of fossil energy carriers as well as heating and cooling. The collection of Scope 3 emissions, which includes cross-border emissions of air and maritime traffic, is handled differently.

Despite similarities, such systematisation approaches for inventories differ in terms of calculation methods, determination of geographical boundaries as well as involvement and definition of emission sources . Hence, it is not possible to compare individual inventories when different methodical basics are used.[375]

Existing guidelines, instruments and procedures underpin the importance of specific estimates.[376] Against the backdrop of the plethora of different national and international requirements for GHG emission inventories, they have been scarce at neighbourhood level until the implementation of the GPC in 2004.[377]

[366] e.g. ICLEI Protocol, 2009
[367] Fong et al., 2014
[368] IEA/OECD, 2008, p. 181
[369] Since the UNFCCC in Rio de Janeiro in 1994, it is known as “accounting framework”.
[370] Since 2016 renamed as “Global Covenant of Mayors for Climate & Energy”.
[371] See Chapter 6.2.2
[372] Greenhouse gas emission = activity data X emission factor // See Chapter 6.2.2; NRC, 2010, p.22
[373] http://www.ghgprotocol.org/Third-Party-Databases/IPCC-Emissions-Factor-Database.
[374] e.g. the Emissions Database for Global Atmospheric Research (UN).
[375] Kennedy et al., 2009: Compares methods and approaches of different cities. // Bader et al., 2009: Compares instruments to structure city-level greenhouse gas emissions.
[376] Dhakal, 2010, p. 227
[377] See Kennedy et al., 2009 // Hoornweg et al., 2011, p. 222, for the lack of a common standard for local measuring.

6.3.2 IPCC – Guidelines for National Greenhouse Gas Inventories

The IPCC - Guidelines for National Greenhouse Gas Inventories has been fundamentally important for collecting GHG emissions and to prepare equivalent emission accounts. The guidance was crucial for reporting on a national level and was primarily developed to serve on this level, in addition to other economic sectors. The following table provides a structured overview of the standard´s content:

Table 25: IPCC – Guidelines for National Greenhouse Gas Inventories (2006)

Group	Field of work	Description
General information	*Abstract*	The "Intergovernmental Panel on Climate Change" (IPCC) has been striving to form national greenhouse gas inventories, which are supposed to ensure the comparability of individual country results.[378] The IPCC initially launched its "National Inventory Programme" (1991) and continued to form an entire task force (1999). It was the central objective to define an internationally uniform method to calculate and report net emission values on a national level. These established standards are adopted by UNFCCC-participating countries to ensure consistent and comparable inventories.
	Organisation and website	Intergovernmental Panel on Climate Change (IPCC) http://www.ipcc-nggip.iges.or.jp/public/2006gl/
	Area of use	Global
	Classification	Methodology
	Target group	National inventory + industrial processes
	Mode	Optional objective
	Publications	Last version published in 2006[379]
Specifications	*Primary method*	Preparation and management of greenhouse gas inventories based on the IPCC 2006 GHG Workbook database[380]
	Emission bandwidth	Specified in Kyoto Agreement
	Activities	Direct emissions generated by burning fossil fuels and subareas such as transportation (indirect emissions in Scope 3)
	Methodical principle	Estimates through top-down analysis based on activity data and emission factors
	Border determination	National / territorial
	Baseline	Guidance for computing the predefined author's baseline
	Data requirements	Amount of fossil carriers and electricity used as well as their emission factors; additional data requirements on indirect emissions
	Output	UNFCCC requirements regarding annual reporting

[378] IPCC, 2006
[379] IPCC, 2006
[380] IPCC, 1996

Aspects of information and communication technologies	*Electronic data collection*	No
	Electronic database	Emission factor database http://www.ipcc-nggip.iges.or.jp/EFDB/main.php
	Electronic data processing / presentation	No
	Instruments	IPCC 2006 GHG Workbook[381]

Source: own representation

To meet the aforementioned challenges, the IPCC already published an additional handbook entitled "International Standard for Determining Greenhouse Gas Emissions for Cities" in 2010. In particular, it specifies the application/applicability of IPCC specifications on the city level[382], and is presented in the following table:

Table 26: IPCC – International Standard for Determining Greenhouse Gas Emissions for Cities (2010)

Group	Field of work	Description
General information	*Abstract*	A fixed contract, based on mechanisms of emission collection.
	Organisation and website	UN-EP, UN-Habitat, World Bank und Cities Alliance http://www.unep.org/urban_environment/PDFs/InternationalStd-GHG.pdf
	Area of use	Global
	Classification	Methodical approach
	Target group	Mayor, economic sectors and civil society
	Mode	Solely collection and research purpose
	Publications	Last version published in 2010
Specifications	*Primary method*	Preparation and management of greenhouse gas inventories for cities based on the IPCC 2006 GHG Workbook database[383]
	Emission bandwidth	Specified in Kyoto Protocol
	Activities	Direct and indirect emissions produced by city-related areas such as transport, industry, waste, agriculture and forestry as well as changes in land use
	Methodical principle	Bottom-up analysis based on activity data and emission factors
	Border determination	Operative level
	Baseline	City chooses its own baseline
	Data requirements	Instruments for calculating required data are mentioned in the GHG workbook[384]

[381] *Ibid.*
[382] UN-EP, 2010
[383] IPCC, 1996
[384] *Ibid.* // See Chapter 6-11

	Output	None
Aspects of Information and communication technologies	*Electronic data collection*	No
	Electronic database	No
	Electronic data processing / presentation	No
	Instruments	IPCC 2006 GHG Workbook[385]

Source: own representation

6.3.3 European Covenant of Mayors – Baseline Emissions Inventory

The *European Covenant of Mayors* (see Chapter 5) has developed a Baseline Emissions Inventory (BEI) to measure GHG emissions (expressed in CO_2) within a predefined area, in this case on the city level. As outlined in Chapter 5.3.1.1, two of the world's primary city-led climate change and energy initiatives, the EU Covenant of Mayors and the Compact of Mayors, merged to form the "*Global Covenant of Mayors for Climate and Energy*".

These first-of-its-kind guidelines aimed to contribute to the fundamental comprehension of emission sources and represented a first step towards a Sustainable Energy Action Plan (SEAP). This plan described actions, time periods and responsibilities to achieve defined goals for 2020. The BEI was based on the fundamentals of the IPCC national inventory method from 2010. Nevertheless, for the calculation of CO_2 equivalents, either IPCC default emission factors or specific LCA emission factors were used.

A considerable difference to other initiatives was to be found in the fact that emissions were only recorded in the form of CO_2. It was assumed that the importance of other types of emission is lower. They could have still been included in reporting on an optional basis. Furthermore, the absence of analysis on a neighbourhood level was an additional disadvantage.

Table 27: European Covenant of Mayors – Baseline Emissions Inventory (2010)

Group	Field of work	Description
General information	*Abstract*	Founded in 2008 by the European Commission, it was aimed to be used on a local level (local authorities) and to contribute to the European objective to reduce CO_2 emissions by 20 percent locally. Approximately 7,000 local authorities signed the guidelines, which represents 213m citizens within the EU.[386]
	Organisation and website	EU Initiative http://www.konventderbuergermeister.eu/index_de.html
	Area of use	European Union
	Classification	Methodical approach + platform to exchange know-how and data
	Target group	Authorities and administrative bodies on a local basis
	Mode	Optional objective

[385] IPCC, 1996
[386] Covenant of Mayors, 2016

	Publications	Online version published[387]
Specifications	*Primary method*	- Preparation of a Baseline Emission Inventory (BEI) - Delivery of Sustainable Energy Action Plan[388] - Delivery of Implementation Report
	Emission bandwidth	Specified in Kyoto Protocol
	Activities	Direct and indirect emissions produced by city-related areas such as buildings used by local authorities and residential properties
	Methodical principle	Bottom-up analysis
	Border determination	Operative level
	Baseline	1990 is commonly used as a baseline year, but can be individually chosen
	Data requirements	Calculation methods are provided for certain areas[389]
	Output	Reports, leaflets and proceedings[390]
Aspects of information and communication technologies	*Electronic data collection*	No
	Electronic database	No
	Electronic data processing / presentation	No
	Instruments	No

Source: own representation

6.3.4 ICLEI – International Local Greenhouse Gas Analysis Protocol (IEAP)

The ICLEI - Local Government for Sustainability, originally known as "International Council for Local Environmental Initiatives (ICLEI)" sought to enable local authorities to achieve their GHG emission reduction objectives in a structured form. According to the protocol´s provisions, especially GHG inventories were to be prepared. To use those as a starting position, guidelines and instruments were provided by the "GreenClimateCities Program".[391]

The "International Local Greenhouse Gas Analysis Protocol" was developed in 2009. Therefore, it build upon experience acquired from IPCC Guidelines and the GHG Protocol. It covered all six emission types defined in the first Kyoto Protocol. Further on, it allowed a stringent categorisation i.e. allocation, of emission values. For this purpose, the territorial principle was employed. Only indirect, energy-related emissions, covered by Scope 2, were taken into account. Neighbourhood analyses were only partially taking place within determined industry sectors, such as transportation. The IEAP, as an operative guideline, was replaced by the GPC, which is described in the following chapter.[392]

[387] http://www.covenantofmayors.eu/Brochures-Publications.html
[388] Within one year after the signing of the former Covenant of Mayors.
[389] *Ibid.*// See Chapter 6-11
[390] http://www.ipcc-nggip.iges.or.jp/public/index.html
[391] http://www.iclei.org/activities/agendas/low-carbon-city/gcc.html
[392] See Chapter 6.3.5

Table 28: ICLEI – International Local Greenhouse Gas Analysis Protocol (2009)

Group	Field of work	Description
General information	*Abstract*	The International Local Greenhouse Gas Analysis Protocol was created in 2009 and consisted of guidelines for a systematic collection of emission data up to the neighbourhood level. It served as a network for promoting comparisons and field reports to identify best practice examples.
	Organisation and website	ICLEI- International Council for Local Environmental Initiatives http://archive.iclei.org/index.php?id=ghgprotocol
	Area of use	Global
	Classification	Methodical approach + platform to exchange know-how and data
	Target group	Local
	Mode	Optional objective
	Publications	Last version published in 2009[393]
Specifications	*Primary method*	- Preparation of a Baseline Emission Inventory - National and regional reporting format is specified[394], which allowed participants to produce reports in variable time intervals
	Emission bandwidth	Specified in Kyoto Protocol
	Activities	Direct and indirect emissions produced by city-related areas such as transport, industry, waste, agriculture and forestry as well as changes in land use
	Methodical principle	Bottom-up analysis based on activity data and emission factors
	Border determination	Based on set-up specific or territorial principle
	Baseline	Earliest possible year, which provides sufficient data
	Data requirements	Activity data and emission factors
	Output	None
Aspects of information and communication technologies	*Electronic data collection*	Yes[395]
	Electronic database	No

[393] http://archive.iclei.org/index.php?id=ghgprotocol
[394] ICLEI, 2010, p. 45-49
[395] http://www.ecobudget.org/index.php?id=6956

	Electronic data processing / presentation	No
	Instruments	International Local Government GHG Emissions Analysis Protocol[396], Inventory Software[397]

Source: own representation

6.3.5 Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC)

Since 2001, the *Greenhouse Gas (GHG) Protocol (*GGP) has been one of the most important sources to quantify and manage business-related greenhouse gas emissions. It was jointly developed by WRI, C40, ICLEI, the World Bank as well as the Environment Programme of the United Nations. As a consequence, city-related inventories are made comparable and consistent in the course of time while achieving high quality standards. In this manner, emission reductions can be displayed and the impacts of defined measures and policies be made transparent. Additionally, future scenarios can be mapped.[398] On this basis, more than 1,000 companies and organisations have recorded individual emissions so far.[399] The conceptional framework is built on the territorial concept and hence prevents double counting. In principle, it is suitable for collection and reporting of city-level GHG emissions.

In order to comply with specific requirements of cities, the "Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC)" has been developed to expand on the GHG Protocol. It is based on practical experiences of earlier publications by the IPCC and ICLEI, and is compiled in accordance with the "Memorandum of Understanding" (2011), adopted by a number of initiatives including *ICLEI*, *C40 Cities Climate Leadership Group*, *UNEP*, *UN-Habitat* und *World Resources Institute*. In June 2013, a pilot version was published in the course of a stakeholder dialogue. The last version was eventually published during the UN-COP20 Conference in Lima (Peru) in December 2014.[400]

The GPC present the seven common types of emission (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3), defined in the amended Kyoto Protocol. Technical support for the preparation of inventories is provided by the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* (ICLEI, 2013) and the "*Greenhouse Gas Accounting Tool for Chinese Cities* (WRI, 2013c).[401]

The current version includes findings of 35 pilot cities.[402] Until November 2016, more than 100 cities have adopted the GPC.[403] Unlike other frameworks, this guideline ought to be applied not only on the city level, but also on the neighbourhood level: "(…) although the GPC is primarily designed for cities, the accounting framework can also be used for boroughs or wards within cities, towns, neighbourhoods, counties, prefectures, provinces, and states".[404] Up to now, only anecdotal evidence emerges to exemplify the extent to which it is used on a district- and neighbourhood-level. Especially insight into the collection of activity data (on a neighbourhood level) and specific emission factors (on a city and neighbourhood level) is missing. The continued evolution of Scope 3 emissions aims to enable such insight. The following table summarises the GPC standard in a structured manner.

Table 29: Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC)[405]

Group	Field work	Description

[396] ICLEI, 2009
[397] http://www.ipcc-nggip.iges.or.jp/software/index.html
[398] See World Bank, 2014, p. 48 // Fong et al., 2014, p. 7ff.
[399] GHG-GPC, 2012b
[400] http://www.iclei.org/details/article/lima-hosts-cities-climate-change-meeting-alongside-cop20-1.html.
[401] World Bank, 2014, p. 47
[402] http://www.ghgprotocol.org/city-accounting.
[403] *Ibid.*
[404] Fong et al., 2014, p. 20
[405] See Geoghegan et al., 2014 // GHGP-GPC, 2012b

General information	*Abstract*	Due to prevailing problems with regard to the collection and comparability of data, the GPC was developed in 2012 by C40, ICLEI and the World Resources Institute. Through this merger of competence, the best practice inventory techniques have been jointly combined and thus replace current methodical policies (IEAP, World Bank, UN-Habitat) as a global standard.
	Organisation and website	C40, ICLEI, World Resources Institute http://www.c40.org/gpc
	Area of use	Global
	Classification	Methodical approach
	Target group	Cities and urban districts
	Modus	Optional objective
	Publications	Online version published[406]
Specifications	*Primary method*	- A scenario analysis is carried out, based on available baseline data - According to this analysis, specific goals are set and action plans developed - Variable implementation and collection of progress - Flexible collection formats (Basic / Basic +) are provided for cities, which influence the choice of emission types and sources
	Emission bandwidth	Specified in Kyoto Protocol I + additional emission type specified in Kyoto Protocol II
	Activities	Direct and indirect emissions, including cross-border sources (Scope 1, 2, 3)
	Methodical principle	Bottom-up analysis
	Border determination	Operative level (city level / neighbourhood level)
	Baseline	Dependent on research objective, but 1990 used as a "base year emission goal" scenario
	Data requirements	Dependent on research objective and depth (Basic / Basic +)
	Output	Training sessions und online courses
Aspects of information and communication technologies	*Electronic data collection*	No
	Electronic database	Yes[407]
	Electronic data processing / presentation	Yes[408]

[406] Fong et al., 2014, p. 20
[407] http://www.ghgprotocol.org/Third-Party-Databases
[408] http://www.ghgprotocol.org/Tools_Built_on_GHG_Protocol

	Instruments	Comprehensive tools for inventories and data collection[409], further advancement of current available instruments[410]

Source: own representation

6.4 Summary and comparison

The following table provides an overview of the main reporting guidelines for greenhouse gas inventories, which were presented and discussed more comprehensively in earlier sections. It illustrates the fundamental characteristics of each initiative or guideline, and summarises concise differences:

Table 30: Summary of reporting guidelines (on a national/city level)

Guideline	Release	Publisher	Reporting stage	Application to neighbourhood level	Consistency with IPCC-emission sources	In-Bound measurement	Out-Bound measurement	Number of GHG types
IPCC – Guidelines for National Greenhouse Gas Inventories	2006	IPCC	National level	No	n/a	Yes	Yes	6 GHG
IPCC – International Standard for Determining GHG emissions for Cities	2010	UNEP, UN-HABITAT, World Bank, IPCC	City level	No	Yes	Yes	Yes (only for upward compatible emissions)	6 GHG
ICLEI – International Local Government GHG Emissions Analysis Protocol	2009	ICLEI	City level	No	Yes (except governmental class)	Yes	Yes	6 GHG
European Covenant of Mayors – Baseline Emissions Inventory	2010	EU-COM	City level	No	Limited	Yes	No	CO_2
GPC – Global Protocol for Community-Scale GHG emissions	2014	C40, ICLEI, WRI	City level	Yes	Yes	Yes	Yes	7 GHG

Source: own representation

In the run-up to the COP 21 in Paris, each participating country was requested to submit a quantitative assessment of national GHG reduction policies within the framework of the INDCs.[411] For this purpose, a transmission portal had been set up by the UNFCCC, whereby the information was also made available to the public.[412] The GHG inventories of each country therefore comply with the IPCC guidelines for national greenhouse gas inventories (2006) as well as the revised complementary methods and good practice guidelines of the Kyoto Protocol (2013).[413]

As Table 30 shows, the individual initiatives meet the requirements on the city level to the greatest possible extent.

[409] http://www.ghgprotocol.org/calculation-tools/all-tools
[410] See Fong et al., 2014 // See Chapter 2-3
[411] See decisions 1/CP.19 and 1/CP.20 of the UNFCCC-COP, in FCCC/CP/2013/10/Add.1
[412] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/
[413] Fong et al., 2014, p. 2

Table 31: Similarities/dissimilarities in methodology and data collection

Aspects	IPCC	ISC	ICLEI	COM	GPC
Definition of emissions and thresholds					
Based on and causation principle	X	X	X	X	X
Approval of WRI definitions of Scope 1, 2 and 3		X	X		X
Comprised sectors					
Energy					
Scope 1 + 2	X	X	X	X	X
Scope 1: Industrial processes	X	X	X		X
Scope 2 : Electricity transmission and distribution	X	X	(X)		X
Handling of life cycle emissions					
Inclusion of upstream emissions via material and fuel consumption		X	X	X	X
Acceptance of inventories, which are based on a life cycle approach				X	(X)
Calculation method and data collection					
Requires an emission factor-based collection method	X	X	X	X	X
Permits the use of estimates, which are based on national statistics	X	X			X
Permits the use of IPCC standard emission values	X	X	X		X
Reporting features					
Requires reporting regarding activity data and emission factors used	X	X		X	X
Permits the collection of energy data according to IPCC classifications	X	X	X	X	X
Permits the collection of energy data according to alternative classifications			X	X	X
Requires additional reporting of emissions gathered via government sources		X	X	X	X

Source: own representation

On an urban scale, the "*Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC)*" replaces several previous initiatives.[414] It is supported by leading institutions in the field of sustainable urban development.[415] It is methodologically based on the IPCC Guidelines (2006) as well as the Kyoto Protocol with its amendments (2013) and therefore compatible with national inventories and the GHG Protocol for enterprises.

Currently, already hundreds of cities are taking the GPC Guidelines as a basis for their inventories to record GHG emissions.[416] Therefore, among all alternatives, especially the GPC Guidelines can serve cities as a standard reference for monitoring and reporting of GHG emissions.

[414] Greenhouse Gas Emissions Analysis Protocol (Section: Community), as it was published by ICLEI in 2009, and the International Standard for Determining Greenhouse Gas Emissions for Cities, as it was published by the World Bank and the United Nations Environment Program (UNEP) as well as UN-HABITAT in 2010.
[415] World Resources Institute, C40 Cities Climate Leadership Group and ICLEI – Local Governments for Sustainability (ICLEI)
[416] A complete listing of cities, which apply GPC, is available at: http://www.ghgprotocol.org/GPC_cities_list

7. Reporting systems for recording and monitoring GHG emissions

7.1 Requirements for reporting systems

For the purpose of implementing greenhouse gas emission inventories, a plethora of approaches with corresponding guidelines (see Chapter 6) exists, whereby the GPC is the most recent and appraised approach worldwide. Pursuant to such a guideline or a protocol, an inventory must be effectively implemented. To that end, various reporting systems exist that utilise related software. Requirements for these solutions exist and include, but are not limited to, the following aspects: transparency, clear process management and the possibility to simulate scenarios.

The measurement itself should be implemented in a structured process. This includes the support by systems that do not only consist of the collection, storage and retrieval of computed data (such as emission factors or activity data), but in addition support the calculations themselves and furthermore assist in reporting. A GHG reporting system providing frequent, precise, consistent as well as complete and transparent information is an elementary component for municipalities on the track towards decarbonisation. Smart solutions in this area also help to implement and track strategies for targeted emission reduction.[417]

Such a reporting system can also play a supporting role in fulfilling reporting obligations – both for voluntary agreements (such as the former *Covenant of Mayors Sustainable Energy Action Plan*, *cCR / Mexico City Pact* or the *Earth Hour City Challenge*) as well as for legally binding guidelines (such as the *São Paulo City Climate Law* and the *UNFCCC Kyoto Protocol*)[418]. Particularly in the case of the initiatives presented by the IPCC and the Covenant of Mayors, the primary objective of the reporting system is to record compliance with legal requirements[419] and to uncover problems. Without this control and evaluation entity, achieved reductions could not be independently recorded or verified.

Table 32 summarises the methodological requirement criteria from a municipality's perspective:

Table 32: Requirements of GHG-reporting systems from the municipal perspective

Compliance with guidelines	Reporting system must essentially meet the requirements of the GPC
General requirements of recording	• Flexible boundary definition • Clear emission definition • Structured recording of emissions by sectors • Including life cycle emissions (upstream/downstream) • Defined method of calculation • Precision of data collection / MRV
Objective	• Evaluation of status quo • Flexible baseline (esp. 1990) • Possibility of simulations and scenario analysis • Clear progress monitoring
Technical requirements	• Web-based application with databases • Possibility of integrating different users, companies etc. with different authorisations

Source: own representation

The influence of the municipal policy on the collection and on the reduction of GHG emissions is very heterogeneous. While, for example, land use or waste management can be addressed more directly, there are often only indirect connections to consumed goods or emissions from companies. This underlines the fact that both the choice of instruments and the success of recording depends on the cooperation of various stakeholders.

[417] Salinas et al., 2010, p. 4ff
[418] See Chapter 7.5 for a summary of the different methods to achieve this target.
[419] Kyoto Protocol for IPCC and EU reduction targets for the Global Covenant of Mayors

This cooperation includes the exchange of information, analysis, critical discussion as well as the inquiry of other experts and serves the purpose of considering results at different levels (in the sense of strategic, tactical and operative reporting). The utilisation of appropriate information technology is the fundament for an efficient implementation of data collection. In China, the integration of companies in the reporting process is already well advanced from a technical perspective.

In the area of software, databases and reporting systems, there is currently a remarkable range of tools for measuring and monitoring GHG emissions. They range from simple and inexpensive options (such as a hotel management tools for calculating the ecological footprint of hotel rooms[420]) to complex, comprehensive, national measurement systems used by countries around the world.[421]

In addition, an increasing number of cities do not only use the reporting systems presented in the following, but also platforms, such as the *Carbon Disclosure Project* or the *carbonn Cities Climate Registry*, to provide the public with collected and processed information.

7.2 Platform of the European Union

As already discussed in Chapter 6, regional and international initiatives and reporting systems help countries to create a methodological basis for the management of GHG emissions. Many of these approaches are voluntary and are based on self-imposed targets. However, member states of the European Union are committed to report their GHG emissions as well as their strategies for mitigating climate change and progress towards the achievement of the targets[422]. Since 2004, the EU has committed itself to develop a mechanism contributing to the implementation of the Kyoto Protocol[423]. The *EU Greenhouse Gas Monitoring Mechanism Regulation*[424] *(MMR),* however, does not contain explicit requirements concerning cities.

Table 33: Reporting platform of the European Union

Group	Field	Description
General information	Organisation and website	European Union http://rod.eionet.europa.eu/instruments/652
	Application area	EU (member states)
	Classification	Measuring + reporting + screening
	Target group	National ministries of the EU member states
	Mode	Binding objectives
	Type	Inventory + strategies
Technical details	Emission bandwidth	Greenhouses gases included in the Kyoto Protocol
	Emission allocation	Polluter
	Activities	Energy, industrial processes, land utilisation & change in utilisation, and forestry (LULUCF), waste management and agriculture
	Methodical principle	Top-down

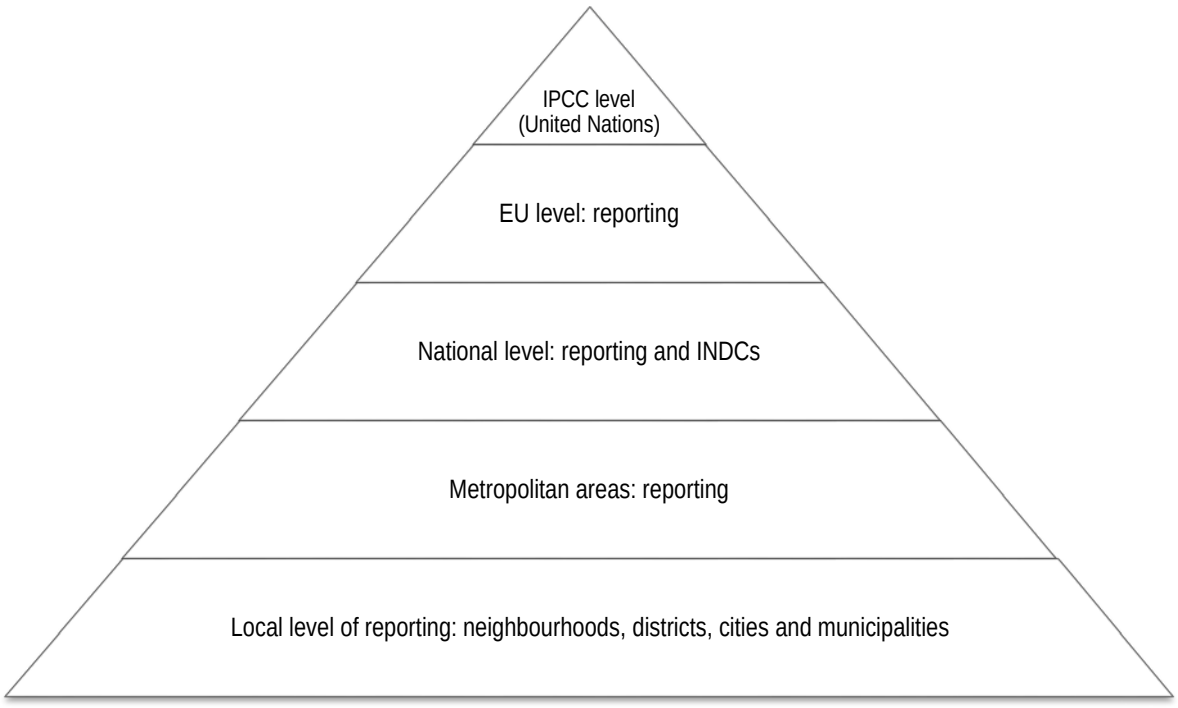
[420] Hotel CO_2, 2016
[421] See Chapter 7.3
[422] European Union, 2013, p. 1: via the *EU Greenhouse Gas Monitoring Mechanism*.
[423] European Union, 2013b, Article 1
[424] European Union, 2014

	Emission categories	Direct + indirect
	Limit determination	National
	Global Warming Potential data used	2nd IPCC Report (1995)
	Consistency with international standards	IPCC
Aspects of communication and information technology	Electronic data collection	Collected data of all EU states Web platform (connected to *Reportnet* data repository)
	Electronic data processing or presentation	None, official reports only
	Languages	All official EU languages

Source: own representation

Nevertheless, ***the choice of an instrument for the derivation of urban greenhouse gas inventories should be congruent with the methodological principles of the MMR*** since data are collected to meet the reporting requirements of the European Union, which are derived from the international guidelines of the UNFCCC Secretariat[425] and are influenced by the European climate guidelines.[426] The following graphic illustrates the horizontal and vertical aggregation of inventory results.

Figure 11: Horizontal and vertical aggregation of inventory results



Source: own representation, based on Deng-Beck et al., 2015, p. 5.

[425] European Union (2013_a:1) and Bodle (2015) for an analysis of the connections in reporting prerequisite between UNFCCC and EU climate targets.
[426] See also Deng-Beck et al., 2015, p. 5

7.3 Presentation of particular reporting systems for cities

7.3.1 "ECO2Region" (Europe, esp. Germany, IT and CH)

Commercially developed, ECO2Region offers a relatively economical reporting tool, particularly for cities that are already connected to the Climate Alliance. Moreover, interested cities can apply for subsidies from the (German) Federal Ministry of Environment for its acquisition and use. The tool itself, on the one hand, is relatively flexible in terms of regional definition (so there is a community solution for differentiating one's own report regions), but on the other hand various complexity levels (and costs) are possible depending on the scope of the functions selected. The web-based software initially creates a top-down opening balance, which can then be further adapted or updated bottom-up, for example by input from the city administration. The provider, based in Switzerland, in principle addresses all European cities, although the tool is practically applied mainly in Germany, Italy and Switzerland: it is available in English, German, French and Italian.

Table 34: "ECO2Region" by Ecospeed Climate Software Solutions

Group	Field	Description
General information	Organisation and website	Ecospeed AG, Zurich/Switzerland https://www.ecospeed.ch/region/de
	Application area	• Primarily Europe (since 2005), so far CH, IT, Germany • "Community" solution for flexible merger of cities and municipalities
	Classification	Measuring + strategy
	Target group	Esp. municipal authorities
	Mode	Open targets
	Type	Inventory + scenarios
Technical details	Emission bandwidth	Only CO_2 in basic version
	Emission allocation	Polluter
	Activities	Energy, households, companies, traffic, LULUCF, waste
	Methodical principle	Bottom-up (use of databases as well as city inputs), initial balance is top-down
	Emission categories	Direct + indirect
	Limit determination	National + regional + individual
	Global Warming Potential data used	2nd IPCC Report (1995)
	Consistency with international standards	• GHG Protocol • "Accounting according to all recognised standards"
Aspects of communication and information technology	Electronic data collection	• Separation into miscellaneous sectors, energy sources or vehicle categories • Web-based software

	Electronic data processing or presentation	• Certain scenarios of measures • Formulation of an initial balance as well as additional local data collection
	Languages	English, German, French, Italian
	Limitations	The ECO2Regionsmart software only allows CO_2, enhanced versions account for all Kyoto greenhouse gases.
	Expenses	Members of the Climate Alliance (see Chapter 5): 350 EUR for ECO2Regionsmart. For non-members, the price depends on the population size (up to 6,500 EUR). The same applies to ECO2Regionpro and ECO2Regionpremium. German cities can receive subsidies from the Ministry of Environment.

Source: Advisory Council

7.3.2 GRIP (UK and 14 additional countries)

Table 35: GRIP by Tyndall Centre and UK Environment Agency

Group	Field	Description
General information	Organisation and website	Carbon Captured Ltd http://www.carboncaptured.com/software-tools/
	Application area	In principle, worldwide strong focus on the UK
	Classification	Measuring + strategy
	Target Group	Research, economy, city administration
	Mode	Open targets
	Type	Inventory + scenarios
Technical details	Emission bandwidth	Greenhouse gases included in the Kyoto Protocol
	Emission allocation	Consumer
	Activities	Energy, industrial processes, waste management, agriculture, land-use change
	Methodical principle	Bottom-up
	Emission categories	Direct + indirect
	Limit determination	Regional + local
	Global Warming Potential data used	2nd IPCC Report (1995)
	Consistency with international standards	IPCC

Aspects of communication and information technology	Electronic data collection	Online Interface Tool
	Electronic data processing or presentation	Energy Emissions scenario
	Languages	English
	Limitations	Negatively, the tool does not allow direct integration of reports to higher, i.e. regional or national level. Furthermore, emission factors are missing.
	Expenses	Software is free, training units are not. Unfortunately, the prices are not transparent.

Source: Advisory Council

The *Greenhouse Gas Regional Inventory Protocol (GRIP)* is an instrument used since 2006 by various European (including London, Bologna, Stockholm, North West England) as well as American (Sacramento, Washington DC), Chinese and Latin American cities and regions. The software was designed to measure the GHG emissions of metropolitan regions. In addition, it also fulfils the task of recording emissions which are outside the region, but contribute to the power supply of cities (similar to GPC Scope 2). It covers the six greenhouse gas sources of the Kyoto Protocol and is largely consistent with the *IPCC Guidelines*. The only significant difference is the fact that the *GRIP* allocates the emissions of electricity generation to the place of consumption, whereas the *IPCC Guidelines* calculate these emissions in relation to the place of production. Emission factors have to be uploaded, allowing cities to enter user-defined data or, alternatively, to fall back on predefined benchmarks. Otherwise, there is no direct connection to the *IPCC EF database*, so users must enter values independently. Negatively, the tool does not allow a direct integration of reports to higher, i.e. regional or national levels.

7.3.3 Bilan Carbone Territory (France)

The *Bilan Carbone*® is, in principle, both a directive and an instrument for accounting GHG emissions. The *Bilan Carbone* was developed by the *Agence de l'Environnement et de la Maîtrise de l'Energie – ADEME*, consisting of three modules: companies, municipalities and territories. The software can be used for the measurement of emissions by regional authorities (module *"patrimoine & services"*) as well as for emissions from all activities of a particular territory (module *"territoire"*). Thus, the *Communauté Urbaine du Grand Lyon* used the instrument to balance and monitor the GHG emissions of the municipality. The *Bilan Carbone* was developed specifically for the needs of French municipalities and includes all six areas of the Kyoto Protocol. In addition, it also takes other directly emitted greenhouse gases (such as CFC / fluorinated hydrocarbons) into account. Against the background of the need to allocate each issue to a specific activity, the software also measures indirect emissions. They include international aviation and water transport related to the local territory. The offer provides preset emission factors for French cities, but they can also be independently adjusted by the user. A negative aspect of the use is the complex and costly training that is required.

Table 36: Bilan Carbone Territory

Group	Field	Description
General information	Organisation and website	*Agence de l'Environnement et de la Maîtrise de l'Energie* http://www.carboncaptured.com/software-tools/
	Application area	In theory worldwide (actually only France)
	Classification	Measuring + strategy
	Target group	Research + municipalities

	Mode	Open targets
	Type	Inventory + scenarios + reporting
Technical details	Emission bandwidth	Greenhouse gases included in the Kyoto Protocol
	Emission allocation	Producer + consumer
	Activities	Industry, residential areas, agriculture, transportation
	Methodical principle	Bottom-up
	Emission categories	Direct + indirect
	Limit determination	Regional
	Global Warming Potential data used	4th IPCC Report (2007)
	Consistency with international standards	ISO 14001
Aspects of communication and information technology	Electronic data collection	Spreadsheet tool for the recording of emissions
	Electronic data processing and presentation	Spreadsheet tool and Energy Emission scenario Instrument
	Languages	French
	Limitations	Fee required for training
	Expenses	1,750 EUR for training as well as licensing and implementation costs.

Source: Advisory Council

7.3.4 CO_2 calculator (Denmark)

The software was developed in 2008 by the *Danish National Environmental Research Institute (NERI)* in cooperation with a private consulting company *(COWI).* The main objective of the application is to enable Danish municipalities to monitor their GHG emissions. Additionally, the intention is to ensure that municipalities can evaluate the effectiveness of their regional emission reduction measures. Up to now, 60 Danish municipalities use the CO_2 calculator of the *Environment Portal*.

The City of Copenhagen is also among the users and is using the portal with a few adaptations aimed at integrating renewable energies. In addition, the city publishes an annual report, explicitly describing emissions and calculation methods. The calculation methods for Danish municipalities are based on the requirements for national emissions reporting by the EU and the UN. The measurements were developed in accordance with the guidelines of the *Danish National Inventory*.

Table 37: CO_2calculator of the Danish National Environmental Research Institute (COWI)

Group	Field	Description
General information	Organisation and website	*Danish National Environmental Research Institute (NERI)* http://www.forskningsdatabasen.dk/en/catalog/2185795591
	Application area	Denmark
	Classification	Measuring
	Target group	Municipalities and Research
	Mode	Open targets
	Type	Inventory
Technical details	Emission bandwidth	Only CO_2, methane and nitrogen oxide
	Emission allocation	Producer + consumer
	Activities	Industry, residential areas, agriculture, transportation, waste management, LULUCF
	Methodical principle	Bottom-up
	Emission categories	Direct + indirect
	Limit determination	Regional
	Global Warming Potential data used	3rd IPCC Report (2001)
	Consistency with international standards	IPCC
Aspects of communication and information technology	Electronic data collection	Comprehensive inventory tool
	Electronic data processing and presentation	No
	Languages	Danish
	Limitations	No visualisation or planning instruments, inventory tool only.
	Expenses	None

Source: Advisory Council

7.3.5 Project 2 Degrees (USA and worldwide)

The *Project 2°* is a joint venture of the *Clinton Climate Initiative*, *ICLEI* and Microsoft. First, a software based on the *ICLEI HEAT* tool (see Chapter 5) was developed in 2009 and was tested in the cities that are part of the *C40*. The application includes the six GHGs of the 1st Kyoto Protocol and is consistent with the 2006 *IPCC Guidelines*. The collected data can be modified and structured as required. Accordingly, formats such as the ISO 14064, *the International Local Government GHG Emissions Analysis Protocol (ICLEI)* or the *GRI Protocol Standard for Communities of the WRI (GPC)* can also be created. Due to the possibility of creating different protocol and reporting formats, the results of the analyses of *Project 2°* are also suitable for international comparison.

Table 38: CO_2 calculator Project 2 Degrees by ICLEI, Clinton Climate Initiative

Group	Field	Description
General information	Organisation and website	Clinton Climate Initiative, ICLEI, Microsoft https://www.clintonfoundation.org/our-work/clinton-climate-initiative
	Application area	Worldwide (USA)
	Classification	Measuring + strategy
	Target group	City administration
	Mode	Open targets
	Type	Inventory + visualisation + reporting
Technical details	Emission bandwidth	Greenhouse gases included in the Kyoto protocol
	Emission allocation	Producer + consumer
	Activities	Fuel- and electricity consumption, traffic, waste management, industrial processes, aviation and seafaring
	Methodical principle	Bottom-up
	Emission categories	Direct + indirect
	Limit determination	Operational
	Global Warming Potential data used	2nd, 3rd and 4th IPCC Report (1995, 2001 and 2007)
	Consistency with international standards	IPCC, GHG Protocol, ISO 14064, ICLEI
Aspects of communication and information technology	Electronic data collection	Emission tracker, which allows different coefficients of activity data and emission factors.
	Electronic data processing or presentation	Processing the data on graphics and tables with the possibility of analysing individual sectors.
	Languages	English
	Limitations	Only available in English; complex inventory process
	Expenses	None

Source: Advisory Council

7.3.6 "CO_2 Grobbilanz/EMSIG" (Austria)

EMSIG (emission simulation in municipalities) was developed in 2002 by the Energy Agency of the Regions in Austria. Subsequently, a simplified version of the software, called CO_2 Gross Balance was published in 2006. As part of the further development of the application, there was a cooperation with the Austrian Climate Alliance. In principle, the software consists of two modules: the standard version used by approximately 70 municipalities and the expert version used by approximately 35 municipalities.

Methodically, the system reverts to data and emission factors that refer to Austria as a whole. For this reason, the City of Vienna decided to introduce its own reporting system that only takes the emissions of the City of Vienna into account. The *CO_2 Grobbilanz* incorporates three gases: CO_2, methane and dinitrogen oxide, whereas *EMSIG* considers all six types of emissions of the Kyoto Protocol and also other gases such as CFC / fluorinated hydrocarbons. The solutions are organised regionally according to the principle of the respective scope of application, whereby *EMSIG* can also show emissions over the entire life cycle. Both instruments are in accordance with the *IPCC Guidelines*. A significant disadvantage of the *CO_2 Grobbilanz*, however, is the fact that the application does not include industrial processes, the use of solvents and land use. Accordingly, comparisons with cities using other measurement methods and tools are limited.

Table 39: "CO2 Grobbilanz/EMSIG" of the Climate Alliance Austria, Energy Agency of the Regions

Group	Field	Description
General information	Organisation and website	Energy Agency of the Regions http://www.umweltgemeinde.at/co2-grobbilanz, http://www.klimabilanz.at
	Application area	Austria (worldwide)
	Classification	Measuring + strategy
	Target group	Environmental officers of the municipalities
	Mode	Open targets
	Type	Inventory
Technical details	Emission bandwidth	Only CO_2, methane and nitrogen oxide
	Emission allocation	Consumer
	Activities	Energy, fuel, cooling/heating, municipal level, traffic, agriculture, waste management
	Methodical principle	Bottom-up
	Emission categories	Direct
	Limit determination	Operational
	Global Warming Potential data used	3rd IPCC Report (2001)
	Consistency with international standards	IPCC
Aspects of communication and information technology	Electronic data collection	Simple virtual instrument for data collection
	Electronic data processing and presentation	Creates inventory and mitigation options
		Online Interface: simple estimates, detailed annual summaries and measurement and reporting at the production site, area or activity level
	Languages	German

	Limitations	The methodology neglects industrial processes and land use. The CO_2 footprint as a result of the calculations is of limited use only, as comparative measures are missing and no recommendations for optimisations can be derived.
	Expenses	1,650 EUR for Climate Alliance municipalities, 2,150 EUR for non-Climate Alliance municipalities, each plus value added tax

Source: Advisory Council

7.4 Superordinate platforms with city reference

7.4.1 carbonn Climate Registry Platform (cCR)

The *carbonn Climate Registry (cCR)* has been a common and public storage space of the *Compact of Mayors* (see Chapter 5) since 2010. In addition to the basic reporting templates, the platform also provides assistance in the context of the publication of GHG emissions in accordance with the requirements of the *GPC*. However, binding to the *GPC* does not play a decisive role, since the platform also supports the publication of emissions outside the GPC framework. Currently, the *cCR* covers about 600 cities and regions from 62 nations which report their emissions with the support of this platform.[427]

This makes the *cCR the world's leading reporting platform for local and regional climate protection efforts*. From the point of view of the representatives of *cCR,* it is, however, unclear to what extent the reported results of the individual cities have also been considered in the respective national INDCs.[428] Here, there still seems to be a substantial need for action with regard to vertical integration. Efforts are made by the *cCR* to improve reporting; for example, measures have been taken to avoid double counting, and almost a third of the registered inventories have also been examined by a third party.[429]

Technically, the *cCR* offers the possibility of presenting the commitment to climate protection (reduction of CO_2 or CO_2e emissions as well as improvement of the carbon intensity) or to energy consumption (increased share of renewable energies or improvement of the energy efficiency) of the municipal institutions. Regional administrations can demonstrate their efforts in the development towards a climate-neutral city in various sectors. Currently, around 80 percent of the exposures disclosed relate to medium-term targets until 2020. 38 percent of the municipalities aim at reducing GHG emissions of more than one percent *per annum*, thus exceeding the target values of the Kyoto Protocol.

The reporting of the emissions is based on the guidelines of the *International Local Government GHG Emissions Analysis Protocol (IEAP)* and the *Global Protocol for Community Scale GHG Emissions (GPC, see Chapter 6).*

Table 40: carbonn Climate Registry (cCR)

Group	Field	Description
General information	Organisation and website	Compact of Mayor and ICLEI and supported by Urban LEDS and R20 (and approx. 12 additional initiatives) http://carbonn.org
	Application area	Worldwide

[427] Deng-Beck et al., 2015, p. 14
[428] Deng-Beck et al., 2015, p. 5
[429] Deng-Beck et al., 2015, p. 21

	Classification	• "Commitments" (climate protection goals) • "Performance" (GHG inventory) • "Action" (measures)
	Target group	Local and national administrations
	Mode	Open targets
	Type	Inventory + visualisation + reporting
Technical details	Emission bandwidth	Greenhouse gases included in the Kyoto Protocol
	Emission allocation	Producer + consumer
	Activities	Energy, industry, buildings, waste management, transportation, AFOLU (agriculture and forestry/other land usage)
	Methodical principle	Bottom-up
	Emission categories	Direct + indirect
	Limit determination	Operational
	Global Warming Potential data used	3rd IPCC Report (2001)
	Consistency with international standards	IPCC, GHG Protocol, GPC
Aspects of communication and information technology	Electronic data collection	Online instrument for reduction detection and -targeting
	Electronic data processing and presentation	Online interface with various options for the visualisation of emissions and sources. Additionally, adaptation and mitigation options, implementation status and reporting templates.
	Languages	English
	Limitations	Complicated interface
	Expenses	None

Source: Advisory Council

7.4.2 Carbon Disclosure Project for Cities

Since 2000, the *Carbon Disclosure Project (CDP)* has been providing a platform for the disclosure of the respective carbon dioxide management of companies as well as cities and other actors. It is the world's largest reporting platform. The funding is provided by foundations, governments and companies. Therefore, it is now not only possible to achieve the initial goal of CO_2 capturing, but also to support the broader aim for the holistic development of sustainable cities and the collection of a broad range of indicators.[430]

[430] https://www.cdp.net/en/research

The CDP city programme was developed by the participants in *C40* and the *Clinton Climate Initiative* and is used by more than 5,600 organisations in 76 states and regions.[431] Here, environmental data, GHG emissions, climate- and water risks and the concomitant economic chances are published.

The CDP is used as the official reporting platform of the *C40*, the *Compact of Mayors* and the *Compact States and Regions*.[432] Even though the *Global Protocol for Community-Scale Greenhouse Gases* (see Chapter 6.3.5) was developed as the first global standard, in 2015 92 percent of all cities within this network carried out reporting using the Carbon Disclosure Project methodology.[433] Over the past five years, the *CDP* helped over 300 cities to handle over 1.67 billion tonnes of greenhouse gases. In total, cities were able to document more than 4,800 activities aimed at mitigating and adapting to climate change through self-responsible initiatives and individual measures.[434] The *CDP* is also based on reporting according to the *GPC* guidelines.[435]

Table 41: Carbon Disclosure Project

Group	Field	Description
General information	Organisation and website	CDP, ICLEI https://www.cdp.net/cities
	Application area	Worldwide
	Classification	Inventory + strategy
	Target group	Local administrations
	Mode	Open targets, official reporting platform of *C40*, the *Compact of Mayors* and the *Compact States and Regions* used.
	Type	Inventory + visualisation + reporting
Technical details	Emission bandwidth	Greenhouse gases included in the Kyoto Protocol
	Emission allocation	Producer
	Activities	Buildings and miscellaneous elements: water release, traffic and street lights, harbours and airports, vehicle and transit fleet, electricity production facilities, waste recycling and wastewater treatment facilities and additional processes.
	Methodical principle	Bottom-up
	Emission categories	Direct + indirect
	Limit determination	Operational
	Global Warming Potential data used	3rd IPCC Report (2001)
	Consistency with international standards	IPCC, GHG Protocol, GPC

[431] See CDP, 2016, p. 3
[432] http://www.c40.org/blog_posts/expert-voices-kerem-yilmaz-c40-director-of-research-projects
[433] http://www.c40.org/networks/reporting
[434] See SSG, 2016, p. 1
[435] See Fong et al., 2014, Chapter 1.5

Aspects of communication and information technology	Electronic data collection	Open data portal, containing information on the following topics: CDP results, participating cities, climate change and risks, forestry, GHG emissions and targets.
	Electronic data processing and presentation	Online interface with various options for the visualisation of emissions and sources; portal for the disclosure of the respective carbon dioxide management of companies as well as cities and other players.
	Languages	English

Source: Advisory Council

7.5 Summary and comparison

The reporting systems presented some similarities for the recording and reporting share, on the one hand, but on the other hand, there are still differences. For municipal decision-makers, choosing the right instrument is also dependent on the targets influenced by initiatives[436] and guidelines[437] as well as the regional context and – last but not least – the individual initial situation. Considering these objectives – above all the legally-binding guidelines within the UNFCCC and the European Union – local emission measurements must become a general practice in European cities and regions. The following quotation summarises the meaning of inventories very well: "Planning for climate action begins by developing a GHG inventory".[438]

In principle, a large number of alternative and expedient solutions already exist. Nonetheless, the efforts are not infrequently undertaken in parallel and isolated from each other. Approaches, methods, software and concrete derived actions often differ widely. The lack of coherence, which has already become apparent within the directives and sectoral integration, thus continues in relation to recording instruments and in reporting. The fact that the *GPC* is enforced as a guideline and *cCR* and *CDP* are established as essential reporting platforms shows clear harmonisation tendencies.

[436] See Chapter 5
[437] See Chapter 6
[438] See Fong et al., p. 9

The following table summarises the essential similarities and differences of the recoding and monitoring instruments.

Table 42: Summary of recoding and monitoring instruments

Aspects	E2R	GRI	BCA	C2R	P2D	C2G	cCr	CDP	GPC
Boundaries and emission definitions									
Based on territorial and polluter pays principle	(X)	X	X		X		X	X	X
Approval of World Resources Institute definitions on Scope 1, 2 and 3 emissions	X			X		X			
Global Warming Potential: 2nd or 3rd IPCC Report	X	X		X	X	X	X	X	
Global Warming Potential: 4th IPCC Report			X		X				X
Polluter as source of emission	X		X	X	X		X	X	X
Consumer as source of emission	X	X	X	X	X	X	X		X
Included sectors									
Follows sector division in Scope 1, 2 and 3	X	X	X	X	X	X	X	X	X
Integration of direct emissions	X	X	X	X	X	X	X	X	X
Integration of indirect emissions	X	X	X	X	X		X	X	X
Sectors									
Energy	X	X	X	X	X	X	X	X	X
Industrial processes		X	X	X	X		X	X	X
Households	X		X	X		X	X	X	X
Companies	X	X			X	X	(X)		X
Transport (excl. aviation and shipping)	X	X	X	X	X	X	X	X	X
Waste		X		X	X	X	X	X	X
Land use, land-use changes and forestry				X	X	(X)			X
Calculation method									
Requires an emission factor-based registration method	X	X	X	X	X	X	X	X	X
Allows use of international activity data + emission factors	X	X	X	X	X	X	X	X	X
Provides specific aktivity data + emission data	X		X	X	X				X
Allows recording of energy (in accordance with IPCC divisions)		X		X	X			X	X
Allows recording of energy (in accordance with alternative divisions)	X		X		X	X	X	X	X
Accuracy of data collection									
Requirement: national activity data + emission factors	X	X	X	X	X	X	X	X	X
Requirement: local activity data + emission factors	X	(X)	X	X	X		X	X	X
Electronic data collection and data processing									
Inventory tool	X	X	X	X	X	X	X	X	X
Data analysis and representation	X	X	X				X	X	X
Provision of reporting templates							X	X	X
Konsistency of rules and standards									
IPCC	X	X		X	X	X	X	X	X
ISO			X		X				X
GHG Protocol					X		X	X	X

Source: own representation

8. Methodical approaches for evaluating cities

Chapter 8 deals with the methodical approach for analysing low-carbon initiatives in selected cities (see Chapter 9). Based on sample cases, it highlights the political implementation, conflicts and barriers as well as its actual structure.

8.1 Explanation of the PESTLE approach

A homogenous analytical approach is essential. It needs to be structured, well established and consistent throughout the different urban areas, so as to ensure an equitable assessment of the respective initiatives. A solely quantitative assessment of heterogeneous cities cannot work on its own. Therefore, a holistic measurement needs to be included that examines all facts of the multilayered relationships and effects. Accordingly, cities or neighbourhoods are analysed in a structured manner, following the requirements of the PESTLE framework. The PESTLE analysis provides a broad and comprehensive assessment via the integration of **p**olitical, **e**conomic, **s**ocial, **t**echnological, **l**egal and **e**nvironmental aspects.[439] Thus, a holistic picture emerges, which helps us to understand barriers and restrictions, which can be counteracted by suitable measures.[440] The PESTLE analysis is used especially for the evaluation of CO_2 reduction aims and the associated initiatives or strategies, as it covers all relevant aspects within a city. This is particularly important, because cities in general run several initiatives and sets of measures for achieving CO_2 reduction targets. The resulting assessment matrix is characterised by the following aspects:

- action level “political“
- action level “economic“ (incentive mechanisms and behavioural change)
- action level “social“ (participative/cooperative approaches)
- action level “technological“ (information systems, databases, innovations)
- action level “legal“ (legal frameworks and regulatory interventions)
- action level “environmental“ (environmental effects)

Theoretical aspects which have already been mentioned in previous parts of this study are now expanded in terms of local conditions. Therefore, it is possible to assess each city, or its measures and initiatives, on its own. Additionally, the key questions and interviews serve to refine the assessment matrix.

Each part of the PESTLE analysis is taken into account for the final assessment. This enables to give a comprehensive overview, even though certain aspects affect several topic areas. Positive case studies lead to particularly advantageous assessments in certain areas and can be specifically identified as best-practice initiatives.

The PESTLE analysis was extended even beyond the descriptive results in the process of characterising each PESTLE action level. This assessment has no statistical significance[441], but visualises the most important potentials and barriers for each city on its way to CO_2 neutrality. It is based on a 5-point Likert scale, which assesses the degree of integrity, robustness and reliability, from low (0) to high (4). The scale was established to enable a simple comparison between different countries and cities. Nevertheless, it is clear that the respective results should only be discussed within a particular comparative group. On the basis of diverging challenges, e.g. Hangzhou and Amsterdam, it is not meaningful to make direct comparisons at this point. In the following section, the individual action levels are briefly described and specific questions for each area introduced. Initially, the contribution of each city to the global climate protection goals as well as the strategic background, is considered.

[439] Franz et al., 2009, p. 215
[440] FME, 2013
[441] Šuklev et al., 2012

8.2 Action level "political"

The common assumption for policy and public sector institutions is that those they experience difficulties in dealing with changes and adjustments to social and ecological conditions. Relating political requirements and a positive attitude regarding decarbonisation are essential conditions for the initiation of specific measures for reducing GHG emissions. Additionally, the governance structure is paramount for the success and the realisation of measures, initiatives and laws. Especially Anglo-American management literature has criticised political institutions for a long time and described their environment as bureaucratic, change-resistant and backward- oriented, instead of being proactive.

Public sector organisations, such as local authorities, central or regional governments, parliaments or organisations of the voluntary sector use appropriate strategies to position stakeholders within their network, in order to permanently maintain their legitimacy and reputation, to secure financing sources and to preserve the balance of power between different parties. The strategic management of organisations has become more important within the context of complex social, ecological and political environmental factors.

Owing to the need of implementing national climate protection plans (INDCs), long-term strategies for emission reduction are necessary in order to achieve climate neutrality. Therefore, national plans have to guarantee consistent strategies for decarbonisation. Additionally, those plans must provide effective incentives to actively integrate stakeholders into this process.

The assessment of the design and structure of the process of political opinion formation and government structures can be particularly differentiated, particularly with regard to centrally controlled structures that substantially work with top-down-approaches and decentralised systems with high local degrees of freedom.

For decentralised approaches, the state usually determines vague performance parameters, usually via several target figures. (Local) institutions, however, develop their own plans for efficiency enhancement and decide independently how to achieve their objectives.

Key questions for assessment

- What role does the municipal government play (at the provincial- or city level) in achieving nationally proposed CO_2 reduction targets?
- What role do neighbourhood-based approaches play in comparison to sector-based initiatives?
- What are the most relevant sector-based initiatives (buildings/construction, industry and mobility), and how are they developed?
- With which initiatives does the public sector take a lead role with regard to behaviour and investment?

8.3 Action level "economic" (incentive mechanisms and behavioural change)

On this action level, the economic aspects of incentives are assessed. Topics like incentive systems, the pricing of financial consequences from traffic congestion or the promotion of electric mobility as well as funding programmes for the energetic restoration of the building stock, are discussed.

The economic aspects of initiatives for the reduction of greenhouse gases are concerned about with costs and the efficient use of CO2. Urban initiatives can either be implemented at the household or the industrial level, in the commercial and in the transport sector. Additionally, existing solutions such as emission trading are presented.

Key questions for assessment

- Which financing programmes are used to implement CO_2 reduction goals at the city level?
- Are subsidies available for fostering the use of sustainable energy?
- What additional market-based solutions are available?

8.4 Action level "social" (participative/cooperative approaches)

On this action level, participative and cooperative approaches und behavioural changes are assessed, such as public transportation, cycle routes, car sharing, the UK UNLOC project and general approaches on to "shared space".

Educational work and targeted interaction are essential for achieving the CO2 reduction targets. In this way, political measures and proposals can be effectively implemented.

Nevertheless, the information policy of such approaches is often improvable.[442] If the information base is not sufficient, risks and uncertainty occur that may ultimately threaten the implementation of CO_2 projects.

Key questions for assessment

- How are cooperation efforts between authorities and other organisations designed with respect to measures and initiatives?
- Are there any efforts to minimise the energy consumption per citizen – e.g. by fostering the use of vehicles with alternative drivetrain options or public transportation?
- What efforts can be allocated to local or city governments with regard to the social commitment of citizens to CO2 emissions?

8.5 Action level "technological" (information systems, databases, innovations)

On this action level, the technical solutions of each city to for reducing carbon intensity are assessed. Fundamental examples are alternative fuels, the recycling infrastructure, restructuring of the CBD, smart grids and regenerative energy supply. Furthermore, (technical) approaches for specific inventories are examined.

Key questions for assessment

- How does a city measure its achievements regarding the CO_2 reduction?
- Is there a uniform reporting system or reporting platform?
- How does a particular city manage its databases with respect to inventory, energy consumption and CO_2 emissions?
- What are relevant aspects of data protection and comparability, and are there conditions enabling this data to be accessed for the calculation of emission inventories?

8.6 Action level "legal" (legal frameworks and regulatory interventions)

On this action level, regulatory interventions are evaluated. Relevant examples in this context include legally binding regulations, planning requirements as well as city-specific energy regulations, fiscal instruments, redevelopment areas and the use of urban voids.

Key questions for assessment

- What regulations were used for implementing municipal CO_2 reduction goals?
- Are there any specific local or supraregional conventions for energy-intensive sectors or industries?
- Are there official maximum emission levels that may not be exceeded?

[442] Gouldson et al., 2012

8.7 Action level "environmental" (environmental effects)

On this action level, environmental aspects of initiatives, or the status quo of environmental quality, are assessed. Urban gardening, roof greening and the expansion of parks and green belts are essential aspects in this area and constitute possible solutions. One of the issues covered in this section is the progressive urbanisation process in metropolitan areas. Particular solution concepts in this context are therefore discussed.

Key questions for assessment

- How will authorities deal with growing urbanism tendencies and the related growth in the energy demand?
- What are the biggest urban challenges that local authorities will have to cope with if they wish to achieve carbon neutrality?

9. Analytical part – measures in selected cities

9.1 Hangzhou

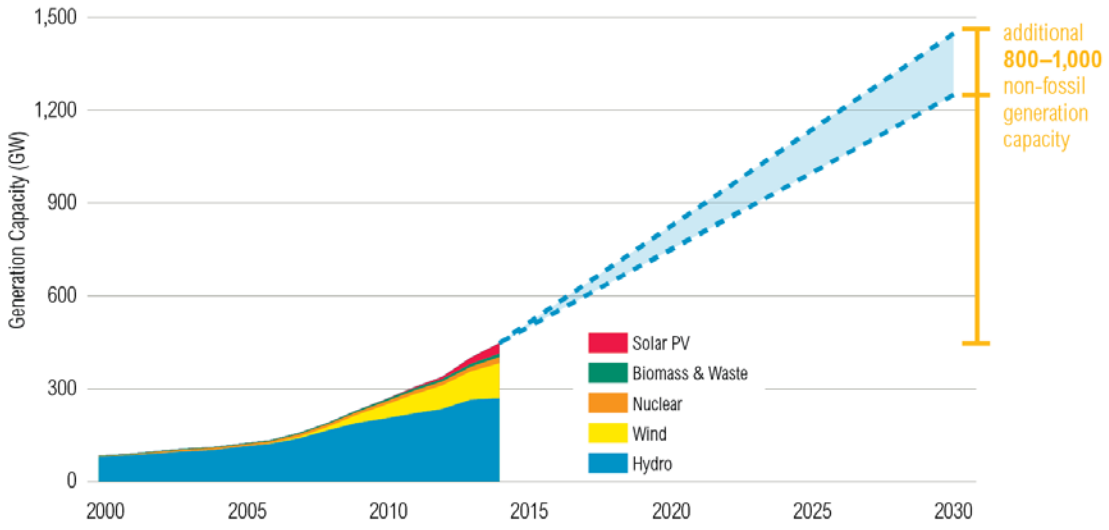
9.1.1 China's contribution to the World Climate Agreement

In 2015, China emitted a total of 9,154 million tonnes of CO_2; this corresponds to a fourfold increase of the 1992 level and a share of around 27.3 percent of global carbon dioxide emissions[443] - making China the world's largest emitter of greenhouse gases.

The country's INDCs[444] have already been published in June 2015 and as a central goal include that the greenhouse gas emissions in 2030 should exceed their peak. By the same date, the share of energy from non-fossil sources should be at 20 percent. This means an increase in capacity of up to 1,000 gigawatts. Specifically, further elements of the INDCs include:

- to extend the trade of emission certificates,
- inventory improvements [445],
- to increase the use of renewable energy from wind and sun,
- to monitor emissions in industrial sectors with particularly high emissions,
- to consider emissions in the sectors of buildings and transportation more intensively.

Figure 12: Increase of non-fossil energy sources in China until 2030



Source: World Resources Institute, Bloomberg New Energy Finance, White House.

The figure summarises the fundamental problem appropriately: As the world's largest issuer, China is currently not willing to undertake an absolute reduction in GHG emissions. Similarly to the argumentation of many low- and medium-income economies, the country wants to continue to increase the prosperity of broad population strata in the previous way. As a result, consumption and resultant emissions rise. There are still potentials for improvement in the area of concrete forecasts of the emissions development by 2030. In addition, certain sectors, such as seafaring, should be included.

[443] BP Statistical Review of World Energy, June 2016 // Population Reference Bureau (PRB), 2016, p. 9
[444] Department of Climate Change, National Development & Reform Commission of China, 30.06.2015
[445] Zhou et al., 2012

By 2030, however, the **carbon intensity** per unit of value-added (CO_2 emissions per unit of GDP) should be reduced by 60 to 65 percent (40 to 45 percent by 2020). 2005 has been chosen as the base year. However, different organisations also claim that this goal is not very ambitious and therefore only a minimum requirement.

The reforestation programme of the People's Republic can be described as ambitious and corresponds to 4.5 billion cubic metres. China has already achieved an expansion of its forest area of 49 million hectares between 2005 and 2010.[446]

Hangzhou is the capital of the Zhejiang province and the eponymous Hangzhou metropolitan region. Due to the growth in industrial - and production facilities, coupled with rapid population growth, Hangzhou is in many respects an exemplary instance of the many rapidly growing megacities of the PRC. Intensive city extensions with large industrial zones are characteristic. The city has about 8.7 million inhabitants; the 2013 per capita GDP was at approx. 68,000 RMB and the share of the industrial, manufacturing sector of the present value-added is 47 percent along with an urbanisation rate of 73 percent.[447]

9.1.2 Strategic principles

The aim of Hangzhou to *reduce the carbon intensity by 50 percent by 2020, compared to 2005,* goes beyond national targets. In 2009, the city government passed a resolution to implement a ***low-carbon city***. Various initiatives to implement these targets[448] make the city one of China's model cities in this area.

So far, there have already been clear guidelines for Hangzhou by the central government. Between 2010 and 2015, the carbon intensity per EUR value-added had to be reduced by 19.5 percent.

Key facts of strategy

- Achieving more ambitious decarbonisation targets (compared to the overall Chinese INDCs)
- Strong increase in public transportation and reduction of motorised individual traffic
- Model "low-carbon-city".
- Intensifying the efforts in data management for greenhouse gas inventory

9.1.3 PESTLE analysis

Political

What role does the municipal government play (at the provincial or city level) in achieving nationally proposed CO_2 reduction targets?

China's 12th five-year plan contains clear national targets for the "Low Carbon Development (LCD)", according to the aforementioned plans in compliance with the INDCs.[449] A clear goal is to improve the local strategies for decarbonisation ("Improving Regional Strategies on Climate Change").[450] These targets are further broken down into provinces and cities. In contrast to other countries, there is a centrally controlled allocation of the necessary emission reductions to individual cities in China.

A major challenge for China is the various types of city, which does not allow a deterministic or uniform approach. *Each city must develop strategies and individual goals to achieve the national targets for decarbonisation on-site*.These objectives have not always been fully implemented in practice, which can partly be explained by *competing objectives*. It has been common so far for the mayors and

446 Fransen et al., 02.07.2015
447 Hong et al., 2013, p. 651
448 Goetze et al., 2012
449 Department of Climate Change, National Development & Reform Commission of China, 30.06.2015, p. 3
450 Department of Climate Change, National Development & Reform Commission of China, 30.06.2015, p. 6

representatives of provincial governments to *have higher chances of promotion, especially when they have a significant increase in the value added* (measured by local GDP and its increase)[451]

Compared with western countries, *cities in China have a relatively high autonomy*, which may be surprising in the light of the generally highly centralized perception of China. Cities are not only responsible for providing adequate infrastructure and services, but also for job creation and local economic performance. This partly leads to high competition between the individual cities and provinces. The cities have hitherto defined the main transformation steps of the country over the past three decades.[452] Against this backdrop, of course, the city governments are again measured by the rapid implementation of the current 12th five-year plan. This also contains clear targets for decarbonisation.

The central government has hitherto been a stronger driver of decarbonisation than most cities. According to the INDCs, greenhouse gas emissions should be strictly controlled in urban areas. Cities are to be transformed from the classic industrial orientation to low-carbon urban areas. Progressive urbanisation is to be slowed down and smaller cities will be supported with regard to planning instruments and the realisation of construction projects.

Another challenge is that overall governance follows a hierarchical structure, starting with the Central Committee, the provincial government and finally the urban level. *Typically, mayors and decision-makers are deployed by the central government. There is no influence by the local population.*[453]

The *central government reviews and releases both the urban master plans for large cities*, relevant investment measures and also the reallocation of agricultural land to urban areas.[454]

The *National Development Reform Commission (NDRC)* is China's central planning authority for the formulation and implementation of national guidelines for economic and social development. In 2010, this agency launched a *pilot programme for low-carbon cities and provinces* in which five provinces and eight cities (*including Hangzhou*) participated. The programme did not impose strict requirements for implementation, but the cities themselves were called upon to develop their own plans as to how the targets could be achieved. This included not only superordinate goals but also the transformation steps for the industry, the implementation of sufficient capacities for the monitoring of the realisation of success, change to spatial planning, etc. Moreover, guidelines on how the social component of the change in behaviour and consumption styles can be achieved should be developed. In another project, so-called eco-cities were supported in a pilot project. In 2011, 133 participants in the programme already have the goal of becoming a low-carbon city.

The local governance of the process is extensive (see below).

What role do neighbourhood-based approaches play in comparison to sector-based initiatives?

Neighbourhood-based approaches do not play a specific role. Sector-related measures dominate. It is worth mentioning the high share of district heating in China, which has currently been largely fuelled by fossil fuels. Approx. 50 percent of cities have such facilities. The reformation of heating systems ("Heat Reform Guidelines") also intensively addresses the potential for the conversion of these systems to renewable energy sources.

Within the framework of INDCs it was emphasised that other forms of urban development should be promoted in the future. In this respect, it remains to be seen whether smaller and ultimately quarter-projects will increase in the future.

[451] Liu et al., 2012, p. 99
[452] Baeumler et al., 2012, p. XI // Chen, 2012
[453] WBGU, 2016, p. 272
[454] Liu et al., 2012, p. 99

What are the most relevant sector-based initiatives (buildings/construction, industry and mobility), and how are they developed?

In the pilot regions, up to *76 different set of measures are implemented in 10 areas*[455] to achieve decarbonisation. In the sectors of buildings, transportation, change in the composition of net consumption and renewable energies, most activities are registered. The measures cover the entire internationally-known spectrum of possible approaches. This also includes:

- on-site training,
- establishing think tanks,
- providing web-based CO_2 calculators to influence consumer behaviour,
- changing public procurement processes (green procurement),
- increasing the energy efficiency of the building stock (retrofits and new construction),
- converting district heating to renewable energy sources,
- expanding renewable energy sources (including solar, PV, biogas, geothermal energy).

In China, *50 to 60 percent of all trips in the cities are still on foot or by bicycle*. However, there is now a strong negative shift in practically all megacities, and a stronger orientation towards motorised individual traffic is clearly evident. Cities are encouraged to actively counter this trend with appropriate alternatives. [456]

The *"Hangzhou Public Bicycle Sharing System" was the first in China* and today has over 70,000 cycles and 2,700 stations. This makes it *one of the largest of its kind in the world*. Further expansion is planned. An access card must be purchased once.[457] The city has spent more than 300 million RMB on these measures.

To further contain the motorised individual traffic, the metro system was extended by 278 km. The share of bus traffic should be 50 percent, half of which should be particularly energy-efficient.

In China, it is now common in all major cities that *electric cars can immediately receive a license plate* at no great cost, whereas new vehicles powered by fossil fuels have to purchase a license plate by auction. This can cost up to $10,000 and usually takes several months. The scheme has now been in force for some years and had triggered the purchase of a larger number of cars ahead of its introduction.

Electric scooters are also part of the distinctive cityscape in practically all major Chinese cities and an international *best-practice example of electric mobility*. Within the last 10 years, they have been implemented and have now created certain problems. The scooters are often driven on their own, separated tracks. Since the vehicles are very quiet, there are more accidents. Chargers are spread all over the city. The scooters can now be purchased at a favourable price and have ranges of 40 to 50 km, which is quite sufficient in cities for a typical route to work and back. The advantages clearly predominate.

There are *recycling solutions for the used batteries* and the scooters can be operated with sustainably generated electricity (if it exists). Particularly in developing countries, the motorised individual traffic can be reduced to the necessary minimum, and car trips - in which often only one person sits in the car - can be avoided. In addition, persons from poorer sections of the population can also afford this type of transport.

[455] Note: education, information, consumer behaviour, industry production, energy, transportation, waste management, buildings, recycling economy, urban planning, local ecology, etc.
[456] Baeumler et al., 2012, p. lix
[457] Shaheen et al., 2011 // Press, 2013

In Hangzhou, companies such as *Wanxiang Electric Vehicle* or *BYD Company Ltd*. sell electric vehicles. In 2014, the city bought 2,000 electric buses and 1,000 electric taxis.

40 percent of the 2030 building stock of China are still to be built. China was one of the first non-OECD countries to *introduce standards in the construction sector that focus on energy efficiency* (Building Energy Efficiency Codes (BEECs)). In addition, building materials are subject to a labelling requirement. So far, only limited progress has been made in the area of energetic renovation. In this segment, more (financial) incentives should encourage the population to get involved.[458] Screenings have shown that in the housing sector of large cities about 80 percent (as of 2008) of the new buildings correspond to the energy standards for climate protection. This represents a significant progress in comparison with previous years. Compared with the EPBD in Europe, the energy requirements in China are more moderate. However, cities are required to define further requirements that go beyond national minimum standards.[459] Since 2008, there are also *clear requirements for the energy efficiency of public buildings.*[460] Further measures in the field of energy requirements for the building stock are contained in the 12th five-year plan as well as in the INDCs. The share of green buildings in new construction areas is to rise to 50 percent by 2020. Hangzhou has further defined the requirements at the local level, and has introduced the "12th FYP for low-carbon city development" and the "12th FYP for building energy conservation", in addition to other supporting regulations for the improvement of the energy efficiency of buildings.

A central problem is that there are *few incentives for housing tenants to behave in a climate-friendly manner*, since the heating costs are often billed by rental space and only rarely according to the consumption-based billing.[461] Also, energy prices are partly subsidised - irrespective of the source of energy - which also supports increased consumption.

The dense population of Chinese cities is a positive, in the sense of decarbonisation, when compared with European metropolises. The challenge is therefore to *increase the proportion of green space* in the area.

Economic

Which financing programmes are used to implement CO_2 reduction goals at the city level?

The financing of transformation will be a key challenge for China. *At present, cities are financed in particular by the conversion of agricultural land into building land*. This has led to an intensified urban sprawl, low densities and the designation of building land, which in part clearly exceeds the actual demand.[462] As a result, the theoretically clear and rigorous urban planning processes are difficult to be implemented in practice. Stronger controls and the participation of the population are essential here.[463]

China's Ministry of Finance is massively promoting the purchase of electric cars. The target size is p.a. 700,000 new cars p.a. in this segment.

Direct financial aid is often limited to transfer payments from the central government to the provinces or cities.[464] In the 11th five-year plan, the requirement to make *150 million m² of the building space more energy-efficient in the colder regions* was exemplary. The targets were broken down into the individual provinces and linked with the related subsidies.[465]

[458] Baeumler et al., 2012, p. lvii
[459] Draugelis et al., 2012, p. 181
[460] Draugelis et al., 2012, p. 183
[461] Draugelis et al., 2012, p. 180
[462] Liu et al., 2012, p. 97: "Land concessions form an important source of off-budget revenues."
[463] Liu et al., 2012, p. 108
[464] Liu et al., 2012, p. 99
[465] Draugelis et al., 2012, p. 197

The World Bank is intensively promoting certain decarbonisation projects in China through the *Global Environment Facility (GEF)*. This is supported, for example, by the so-called *"Heat Reform and Building Energy Efficiency Project (HRBEE)"*.

The International Finance Corporation of the World Bank Group also offers interesting instruments in China. The *IFC CHUEE ("China Utility-Based Energy Efficiency Finance Program")* supports the implementation of ***projects in the areas of energy efficiency and renewable energies***. IFC effects risk-sharing with Chinese banks by ***covering certain shares of potential loss***. The specific focus is on small and medium-sized enterprises. CHUEE works with the city government in Hangzhou to implement the instruments with local banks, too.

According to the INDCs, it is the declared objective of the national government to further expand these areas of green financing instruments.[466]

However, it is important to note that a reconstruction of the local income components is essential. Budget parts from the area of the conversion of agricultural land should be replaced by property tax and taxation of dedication profits. [467]

Are subsidies available for fostering the use of sustainable energy?

Financial support is less common in China than it is in Germany. Initiatives exist, for example, in the promotion of PV plants or the promotion of companies using a high proportion of recycled materials. There are subsidies for electric cars and other measures.

The use of public transport is heavily subsidised in China.

The city of Hangzhou has also launched a five billion RMB fund to realise the transformation.

What additional market-based solutions are available?

In many cities, there is clear ***feed-in tariff*** for feeding in regenerative generated energy into the electricity grid. It is made up of a mixed subsidised prize sponsored by the state and the respective city. Experts estimated a ***payback within about six years***.

The city of Hangzhou has also introduced a product label to promote low-carbon products according to ISO 14064 and PAS 2050.

Stronger pricing systems to avoid negative external effects (see billing of heating costs) are still highly expandable.

Hangzhou has launched one of the pilot projects in China to ***trade with emission rights (certificates trading)***. This requires major efforts to gather relevant information from statistical data. Various authorities are involved in the implementation. The auction and any interregional trade to be considered are important here. The limit of inclusion is companies that emit more than 10,000 tonnes (p.a.).

Social

How are cooperation efforts between authorities and other organisations designed with respect to measures and initiatives?

China's spatial planning policy over the past decades was characterised by the realisation of ***uniform satellite cities, high-rise residential buildings and industrial zones***. Old town centres or historic buildings[468], however, had to give way regularly. This has resulted in an underlying problem for the decarbonisation process. ***People feel only conditionally connected with "their city"***, which makes a

[466] Department of Climate Change, National Development & Reform Commission of China, 30.06.2015, p. 14
[467] Liu et al., 2012, p. 103
[468] WBGU, 2016, p. 276: "Loss of historical authenticity."

necessary change in behaviour and participation of the population in efforts to decarbonize significantly more difficult.

Participation of citizens was clearly underdeveloped in China. In recent years, progress has been made in this area through increased information and involvement of the population at various levels. There are several "think tanks" on urban as well as provincial levels, which deal intensively with questions of climate change and include NGOs as well as the target population. ***According to some experts, however, inequalities and a lack of participation are still increasing at the local level***.[469] Nevertheless, it has also been stated that the growing middle class is increasingly successful in demanding participation.[470]

Chinese cities regularly use surveys for local public transport and try to implement the results of the evaluations quickly and effectively.

Are there any efforts to minimise the energy consumption per citizen – e.g. by fostering the use of vehicles with alternative drivetrain options or public transportation?

There are extensive initiatives in Hangzhou (see above).

What efforts can be allocated to local or city governments with regard to the social commitment of citizens to CO_2 emissions?

Various initiatives to influence the behaviour have been initiated in the pilot regions. They include the globally known instruments, from training to web-based information platforms.

In addition to regulation, Hangzhou is also intensively focusing on the voluntary change in the consumption patterns of the population.

In Hangzhou, the world's first ***"Low Carbon Science & Technology Museum"*** was launched in 2006.[471] The instrument is also an example of best practice, as this is a relatively simple way to create awareness among more parts of the population. In particular, school classes use the terrain intensively.

Technological

How does a city measure its achievements regarding the CO_2 reduction? Is there a uniform reporting system or reporting platform?

China relies heavily on monitoring the targets and controlling, which is why ***11 large indicator systems control the realisation of low-carbon cities and green cities***.[472] Hangzhou measures its achievement as part of decarbonisation on the basis of the following parameters:[473]

- carbon intensity (CO_2 per unit GDP)
- share of the high-tech industry in the total value added
- share of the service sector in the total value added
- share of the cultural sector in the total value added
- proportion of public transportation in the total transportation
- buses per 10,000 inhabitants
- share of electric buses

[469] Chen, 2012, p. 137ff
[470] Zhu, 2013, p. 257ff
[471] http://www.dtkjg.org.cn/cn/en/Venues-47.html
[472] Hong et al., 2013, p. 653
[473] Hong et al., 2013, p. 654

- increase in the number of public bicycles
- existing forest (in percent)
- per capita green space
- length of metro lines

These are less than 50 percent of the total known sizes within the "low-carbon-city-initiative". The building sector, for example, is only inadequately addressed.

Hangzhou is one of the seven pilots for the GHG inventory. The inventory is carried out on three levels and includes the province, 11 cities and 90 municipalities. The ***Hangzhou region Xiacheng district uses the GPC-Beta version***. The city will collect the total of six GHG emissions[474] in the urban area in five sectors (energy, industry, agriculture, changing land usage, forestry and waste management). Cross-border transports as well as waste disposal are also taken into account. The data is recorded simultaneously bottom-up and top-down. The transport, building and industry sectors are particularly intensively considered. In addition to the results in the form of the *Global Protocol for Community Scale Greenhouse Gas Emissions (GPC)*, the required national data are generated from this as well. The data is selected according to the ***principle "Measurable, Reportable and Verifiable (MRV)"***. That means, the city wants to ensure that the addressed areas are also measurable in practice and can be subject to an examination / validation.

As in other cities, ***data generation and quality is a key challenge***. A deficit in terms of transparency is accompanied by deficits in the integration of the population. Interestingly, however, the actual data available to the administrative authorities is very large, which offers potential for targeted decarbonisation efforts. As a result, ***participation in reporting becomes a requirement for companies according to certain limits***. The support includes education, training, quality control, etc. In the case of the individual requirements for emission reductions by large polluters, the city government works less with penalties than with awards for companies that perform best-in-class. Data is collected and exchanged via a common platform.

Various local NGOs or government-supported organisations, such as *WIR China* or *The Global Environmental Institute*[475], offer trainings for city administration representatives and low-carbon development toolkits. In addition to the inventory itself, they to some extent include instruments for forecasting and for scenario observations. They also include macro drivers that update local economic performance, population development and other relevant areas.

The city governments also make clear cost-benefit analyses for alternative policy instruments for decarbonisation. For microanalyses, an average of 30 areas of action can be selected and prioritised from a set of up to 100 in six sectors for concrete implementation in a municipality.

How does a particular city manage its databases with respect to inventory, energy consumption and CO_2 emissions?

Central databases are provided (see above).

What are relevant aspects of data protection and comparability; and are there conditions to enable this data to be accessed for the calculation of emission inventories?

[474] Note: These include CO_2, CH4, N2O, HFCs, PFCs and SF6.

[475] Note: Together with the National Development and Reform Commission (NDRC) the China Academy of Science Institute for Policy Management (CAS/IPM) and the Center for Climate Strategies (CCS) as well as Global Environment Institute (GEI).

There is no information on this in China. Due to the political system, these aspects are presumably less addressed and effective access to third party data is not a major challenge. For example, companies (see above) are obliged to supply data.

Legal

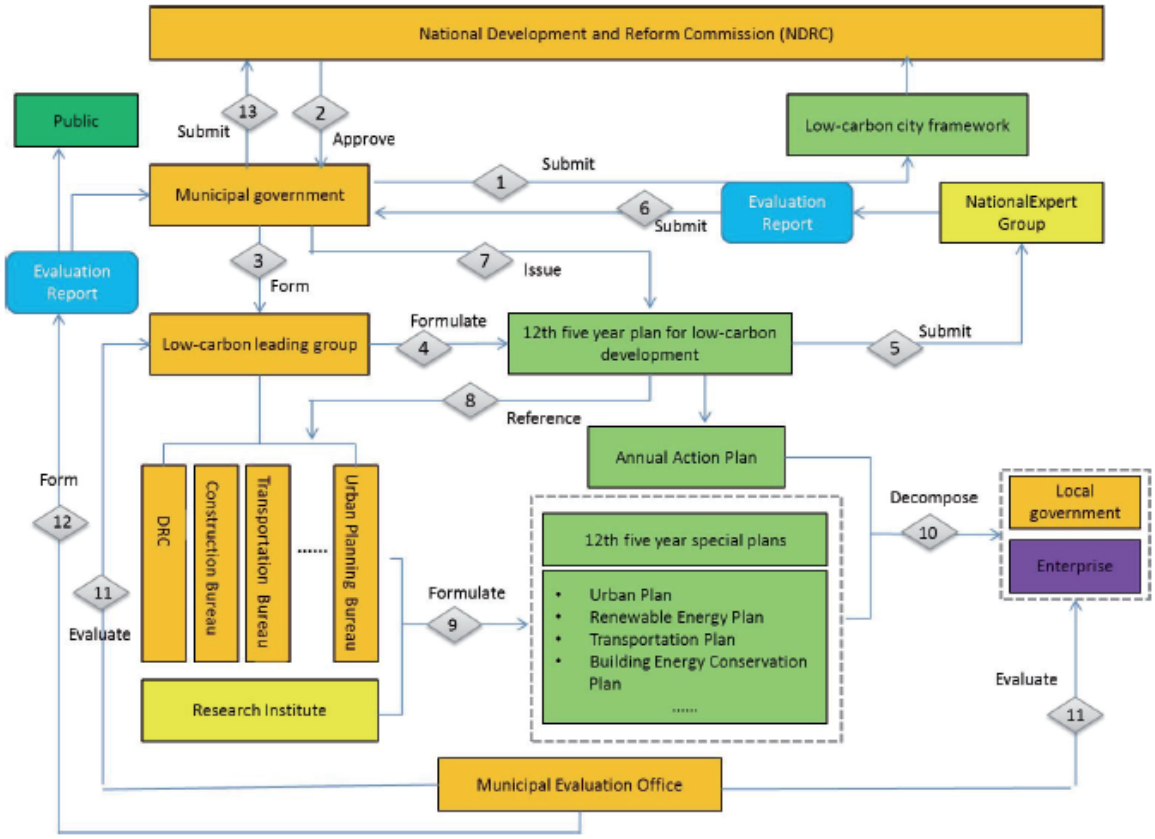
What regulations were used for implementing municipal CO_2 reduction goals?

Intensive national and local regulations - and in particular the so-called 12th five-year plan - have already been outlined. In addition, Hangzhou has introduced restrictions on the deforestation and extends the limitation of "old" industries with high pollution.

Many interlocutors stated on-site that there should be much more legal regulations on environmental protection and focused decarbonisation than currently available. For example, it is possible to introduce more stringent requirements at the local level for the energy efficiency of the building stock.

The governance elements in Hangzhou are fundamentally comprehensive and comprise clear guidelines with regard to the structure and process organisation of the implementation of necessary transformation steps. On this occasion, advisory groups, all involved authorities and the public are involved as well. *Hangzhou has defined a clear planning and implementation framework for the introduction of the transformation steps to a low-carbon city*. This also provides the municipal development of the plans against the background of the objective as well as, for example, the corresponding approval steps by the NDRC. Once the whole plan has been approved, the individual local authorities involved are asked to translate the targets into concrete packages of measures. Annual targets are also broken down to smaller units, up to (large) companies. The implementation is reviewed by a separate department, and corresponding progress reports are referred to the local government. It should be emphasised that these reports are also published and thus accessible to the population.

Figure 13: Structure- and process organisation of the Hangzhou planning steps for decarbonisation



Source: Hong et al, 2013, p. 658

Are there any specific local or supraregional conventions for energy-intensive sectors or industries?

The corresponding industries are separately monitored and have their own targets. However, the fundamental change in value chains is slow.

Carbon leakage, meaning the resettlement of companies with high emissions in other regions, is still a widespread instrument,[476] as greenhouse gases are thus only shifted and not removed.

Are there official maximum emission levels that may not be exceeded?

Large companies are obligated to participate in the city's greenhouse gas inventory and receive their own emission targets. However, the short-term economic performance of the local economy - and thus the increase in production (and emissions) - continues to negatively impact the clearly defined long-term objectives of decarbonisation.[477]

Environmental

How will authorities deal with growing urbanism tendencies and the related growth in the energy demand?

In the case of China, the entire urbanisation process is steered by political elites. The urbanisation is driven exclusively by the migration (rural exodus). Since the end of the 1990s, the central government has been trying to strengthen the regions affected by the migration more intensively - so far with only limited success.

In general, there are currently too few incentives and price signals to effectively stop the progressive degradation of environmental goods in the People's Republic. In recent years, however,

[476] Fenga et al., 2013, p. 11654ff
[477] Liu et al., 2012, p. 99

the environmental awareness of the population has risen significantly, particularly due to the high levels of air pollution in the megacities. Against this background, the central government is intensively addressing climate and environmental protection.

Besides the above-named NDRC pilot projects on "Low-Carbon Province and City Development", there are other projects in China that aim to protect the environment. The MoHURD (Ministry of Housing and Urban-Rural Development) has declared several cities as *"National Eco-Garden Cities" - including Hangzhou*.

It has already been shown in detail that the government is already supporting many initiatives: the expansion of non-fossil fuels, the conversion of district heating networks, the creation of energy-efficient buildings and the efforts made in some cities to use methane gas from waste to meet rising energy requirements resulting from the progressive urbanisation in combination with rising prosperity and consumption. Despite the extensive decisions and measures, they are not sufficient. This statement is true for China as a whole, but unfortunately also for Hangzhou, although the city is supposed to have a flagship status with regard to decarbonisation. *The air in Hangzhou continues to be so bad that on the occasion of the G20 summit in September 2016, factories were temporarily switched off by the authorities*, in order to have better environmental conditions during the meeting of the international government representatives. If one considers that the targets for climate protection in Hangzhou are already much more ambitious than in China as a whole, this status quo is sobering and worrying.

Waste is another problem area, which is increasingly aggravated by the increasing consumption. Although there are initiatives for increased recycling, the challenges are massive. Guiyu, for example, was still a small village, which was primarily geared to rice cultivation until a few decades ago, but then turned into the largest zone for the recycling of electronic scrap in the 1990s. The environmental damage is devastating. For example, the local water is no longer drinkable.[478]

What are the biggest urban challenges that local authorities will have to cope with if they wish to achieve carbon neutrality?

The local challenges are clearly isolatable and include:

- incorrect incentives for government representatives (GDP growth instead of sustainability KPIs are rewarded),
- inadequate financial resources and sources of funding that tend to promote further urban sprawl,
- conflicts of objectives with regard to the increase in the material prosperity (and consumption) of the (poor) population and environmental protection,
- up to now, limited (citizen) participation and underdeveloped environmental awareness of broad segments of the population,
- ongoing urbanisation and population growth in cities are counteracting success in the field of environmental protection.

9.1.4 Comprehensive assessment

Action level "political"

Plans for decarbonisation, which exist in almost all cities, still in part have the status of declarations of intent and lag behind economic objectives. Hangzhou is a best practice example, since more ambitious goals apply than at the level of the People's Republic as a whole. The structure and process organization of the entire decarbonization process is also clearly defined. The public is involved. The problem, however, is that – similarly to the INDCs – only improvements in carbon intensity but not absolute reductions are aspired, until 2030. Prerequisites within a strong national state and strengthened local structure allow for

[478] Pellow, 2006, p. 226ff

targeted governance. There are also good instruments and software tools to control these processes in detail and specifically. However, there still exists a strikingly high level of air pollution and the steady rise in GHG emissions also clearly shows that the priority remains clearly on an expansion of the economic output (and therefore negative external effects). False incentives for local mayors, and – despite improvements – lack of population participation and improvable supraregional controls represent further optimisation potential.

Action level "economic" (incentive mechanisms and behavioural change)

A crucial trade-off in China continues to be the high level of industrial pollution. Since, as a rule, short-term job losses at least are accompanied by a massive increase in efficiency standards, policy is cautious with drastic measures. Furthermore, as at times of the G20 summit, for example, large polluters are switched off only temporarily. Carbon leakage is still a major problem in China. A reduction of emissions will only be possible through reduced economic performance in the short term[479] and requires an ambitious conversion of the value chains. The green economy is becoming increasingly clear in some sectors, such as mobility. The expansion of regenerative energy sources is massively pushed.

Incentives are also set by trade with emission certificates. However, there is still insufficient information about the costs of environmental pollution and an insufficient causal allocation of costs. The conversion of the tax systems, the comprehensive consumption-dependent charging of heating costs, in addition to the expansion of financing instruments for sustainable investments, are to be pushed forward as examples.

Action level "social" (participative/cooperative approaches)

The change in China, towards the stronger participation of citizens, is noticeable. In particular, the information and behavioural influence on the population in order to promote the environmental awareness is advancing. However, due to the state form, effective progress is still limited.

Opportunities that are common in other countries, such as the voluntary purchase of "green energy" with corresponding additional costs, for example, are not possible in China.

Action level "technological" (information systems, databases, innovations)

China is already well-advanced in the implementation of technical solutions, which are proclaimed as best practice in individual regions worldwide. The software-based support of the inventory as well the apps for the bicycle stations, etc. are examples. This development is supported, for example, by "China's Science and Technology Actions on Climate Change".[480] The scaling up and further dissemination of these solutions, however, will be the central challenge, in combination with the possibility of financing.[481]

Action level "Legal" (regulatory interventions)

Up to now, China is using intensive regulatory interventions to heal market failures. Nevertheless, the (extensive) specifications and regulations on environmental protection and the limitation of climate change are classified as unambitious and highly expandable by experts.

Market-based approaches are only partially present so far (pilot projects for certificate trading, financial incentives, product awards, etc.). In this case, more effective causation pricing for pollution would be important. However, this also requires increased sensitivity and a more pronounced environmental awareness among the population.

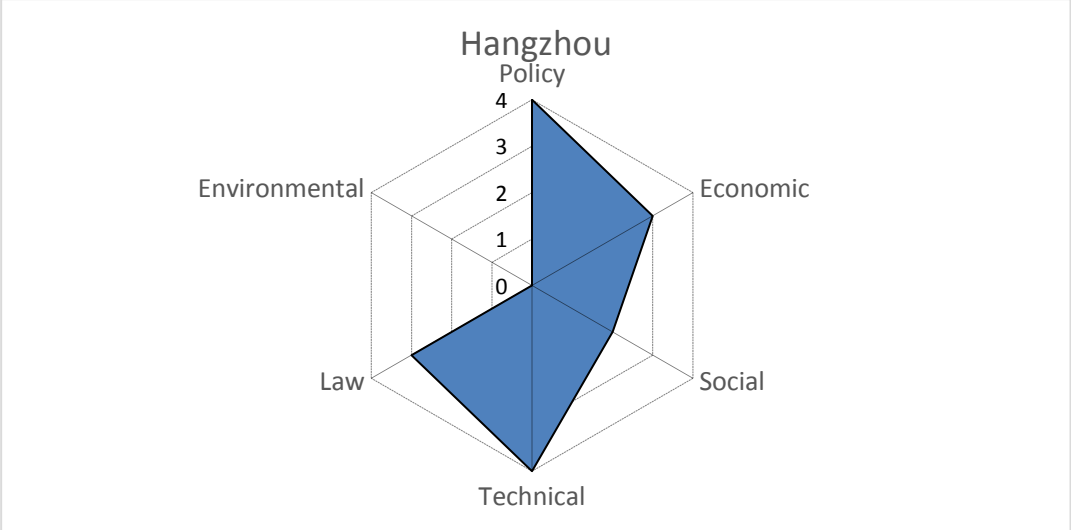
[479] Xiangyang et al., 2011, p. 3ff
[480] Department of Climate Change, National Development & Reform Commission of China, 30.06.2015, p. 4
[481] Huang et al., 2016

China needs to manage its transformation from an economy that is built on maximising supply and demand towards an economy with low growth and intelligent handling of emissions.

Action level "environmental" (environmental effects)

It is characteristic that so far, in the competition for industrial settlements and economic performance, life and environmental quality as a decision-making parameter and "structured and coordinated planning" has taken a back seat.[482] Due to these massive problems, particularly as a result of air pollution, a change is taking place. The biggest challenge in China remains the very high volume of motorized individual traffic. Significant progress has been made in the field of electric mobility (especially scooters).

Figure 14: Evaluation of Hangzhou



Source: Advisory Council

9.2 Amsterdam

9.2.1 Netherlands' contribution to the World Climate Agreement

As part of a broader initiative and in cooperation with other member states of the European Union, the Netherlands submitted their letter of intent (Intended Nationally Determined Contribution, INDC) on May 6th, 2015. Within the letter, the authors suggest a reduction of the per-capita-emissions by 41 percent by 2030 compared with 2010.[483] With a target value of 7.5 tons of CO_2 equivalents per capita/year, the Netherlands range around the European average and take the 52nd place within a global plan data ranking regarding its 2030 goals (2010: 37th place, about 11 tons of CO_2 equivalents).[484]

9.2.2 Strategic principles

In 2015, the City of Amsterdam defined its current strategic principles regarding the reduction of emissions. The "Agenda Sustainable Amsterdam"[485] focused on the following points:

- renewable energy
- air quality
- recycling economy
- climate resilience (adaptation)

[482] WBGU, 2016, p. 273
[483] EU INDC, 2015
[484] The University of Melbourne, Australian-German Climate and Energy College, 2015
[485] The document is the basic source of the following chapter. Other sources, however, are marked as such.

- city administration optimisation

The City also released strategic aims for certain sectors such as energy supply within the Paper "2040 Energy Strategy".

Due to economic as well as (moderate) population growth, the emissions rose by 30 percent between 1990 and 2015. After a recent turnaround, the emission goals were further tightened. Within the next five years, the 2015 agenda suggests a CO_2 reduction by 40 percent as an internal target value.

According to the Triple-Bottom-Line, **"sustainability" is not only a matter of environment protection, but should also develop itself as a „societal engine" and „economic driver".** The initial starting point for energy cost reductions were their absolute value of 1.8 billion EUR. Thus, each percentage point reduction results in an 18 million EUR increase in funds for consumption, pension schemes or other investments.[486]

Regarding the five above-mentioned areas, also known as transition paths, the following aspects are essential:

1. Renewable energy:
   The basic target states an increase of 20 percent in renewable energies compared to 2013. The core technologies are wind and solar energy. In addition, the per capita energy consumption will be reduced by 20 percent compared with the 2013 consumption. The energy-efficient refurbishment of private as well as public buildings has been identified as the central strategy to cut emissions. Additionally, a "climate-neutral" standard for new constructions has been effective since 2015.

2. Air quality:
   (Supra-)national standards are no longer the relevant benchmark for air quality. In fact, the overfulfilment of these standards is the goal.[487] In the process, not only air-related metrics are relevant, but also specific health-related goals concerning the population. Accordingly, the introduction of "green zones" including the replacement of vehicles was started as a voluntary project. However, in the medium and long term, these limitations are set to become compulsory. Thus, the City plans to provide 4.000 public charging stations for electric vehicles.

3. Recycling economy:
   The key aspect of the City's underlying concept, which is planned to be implemented, is the "raw material instead of waste" guideline. By 2020, 65 percent of private waste are supposed to be reused (also known as "cradle to cradle", according to which the life cycle of a product starts at its origin/"cradle", but does not end at its disposal. Instead, the rest of the disposed products are seen as the origin of yet another product, representing a new "cradle"). To do so, broad measures have to be taken by the population and in the context of the waste management.

4. Climate adaptation:
   Since climate change is a politically and meteorologically noted process, a certain level of it will have to be accepted. Accordingly, the City of Amsterdam has adapted to it by addressing the areas of water supply during dry periods in addition to flood protection. Tangible actions, however, are expected following the next local elections.

5. City administration optimisation:
   The city administration of Amsterdam is aiming at a reduction of 45 percent of their own CO_2 emissions by 2025. Within the procurement budget of 1.5 billion EUR per annum, the main goal is to promote

[486] City of Amsterdam, 2016
[487] Additionally, for sectors such as the soot emissions, own standards shall be developed, if no National or European requirements exist.

sustainable production and delivery chains. Furthermore, the city administration is determined to set an example by increasing the percentage of its own waste separation from 40 percent to 75 percent by 2025.

The City of Amsterdam *underlines the principle that the project financing is mainly covered by 3rd parties, namely market participants*. Within the City's budget plan, funds worth 170 million EUR are allocated for activities which are expected to remain uncovered by private investment activity. These activities mainly include improvements in air quality, refurbishment of public schools, adaptation measures as well as the efficient use of (rain)water supply and the energy labelling of public residential buildings.

According to the framework paper, the *"Energy Fund" is the only and also dominant source of financing by the City to support the private sector*. Earlier vehicles such as the "Amsterdam Investment Fund" were merged into a common structure: The "Amsterdams Klimaat en Energiefonds" (AKEF) does not provide subsidised financing but funds at market conditions. The only measures exceeding market conditions moderately are securities by the City and tax incentives.

Subsidies for the Euro6-Standards (alternative fuels) are derived from and financed by the corresponding national programmes.

Key facts of strategy

- Financial drivers are taken from the market: subsidies are reduced to a minimum and public funds are invested mainly in measures for the public sector.
- Regarding mobility, specific improvements within the motor traffic are essential.
- Resource protection through a recycling economy: Reuse according to the "cradle-to-cradle" principle leads to positive financial and ecological effects. However, the society has to adapt, for example by stringent waste separation.
- Reduction of energy costs by refurbishment: The old building stock does not only release emissions, but also minimises the tenants' financial scope.

9.2.3 PESTLE analysis

Political

What role does the municipal government play (at the provincial or city level) in achieving nationally proposed CO_2 reduction targets?

Similarly to Denmark, the Netherlands is highly dependent on measures on the city level, in order to achieve the proposed CO_2 reduction goals, due to the country's high urbanization level of 90 percent with a further increase of 1.0 percent[488] per annum. The City of Amsterdam underlines the fact that national standards regarding emission-related air quality does not represent a sufficient target. Accordingly, the City takes a leading role by overfulfilling national standards, and setting its own. Additionally, the municipal government has passed the target of reducing the city's CO_2 emissions by 40 percent within five years. So far, a postcode-related approach regarding tax incentives for local energy production is active within the Netherlands. However, it is expected that municipal differentiation will be removed to a nationwide extent.

[488] CIA, 2016: "In comparison, urbanisation rates in Denmark range at 0.6%, and Germany around 0.2%."

What role do neighbourhood-based approaches play in comparison to sector-based initiatives?

Until 2015, several quarter-related subsidy schemes were active, according to which financing was targeted at local level and specific areas (such as Central, West, North) or regions. However, these schemes do no longer exist. A matter of interpretation remains the issue as to whether or not the City's planned recycling economy can be seen as a quarter- or sector-related measure. Hence, waste management is targeted; nonetheless, realisation requires the support of the population within the districts. Accordingly, each district appears to be targeted equally, yet the starting point differs from neighbourhood to neighbourhood. The same pattern also applies to the goals for air quality. Precisely formulated, a threshold value of 30 micrograms NO_2 per m^3 for the "heaviest hit parts of the city" is set to be ensured. The current thresholds are mandatory for each area since 2015. Regarding the aspect of climate resilience, the neighbourhood level appears to be feasible. Unfortunately, specific measures are expected after the imminent election. The vulnerability of a city regarding climate change can definitely be observed on the neighbourhood level, especially due to Amsterdam's low geographic location and its neighbourhoods, which are located close to rivers. These neighbourhoods are specifically endangered by rising sea levels. Additionally, the implementation of wind energy can be useful especially for neighbourhoods located around the harbour and the NDSM shipyard as well as Noorder Ijplas. Besides, the district heating system will be extended to 87.000 connections in 2018 and 102.000 in 2020.

What are the most relevant sector-based initiatives (buildings/construction, industry and mobility), and how are they developed?

The strategy "Sustainable Amsterdam" presents a comprehensive and mandatory implementation scheme with precise time limits to keep track of. Within the energy sector, the city plans a call for tender regarding a public solar park for 2016, in which a total of 160 megawatts of electricity will be generated by 2020. The real estate and construction sectors do not only show a significant impact by implementing new energy-related standards on the local level (up to zero-energy pilot projects), but also by refurbishing and optimizing public buildings energy-efficiently. The traditionally important Dutch public housing construction sector is supposed to reach an average new building standard "B" by 2020. In line with the basic concept of the recycling economy, construction materials are supposed to become part of reuse cycles. With regard to the mobility sector, the City plans to provide 4.000 charging stations for electric vehicles. The call for tender was made in Q1/2016, with a set time frame for realisation by 2018.

Economy

Which financing programmes are used to implement CO_2 reduction goals at the city level?

The City of Amsterdam aims at providing a market-oriented approach by the conservative provision of public financing as well as usage of subordinate programmes. The dominant financing component is the national budget for improvements in air quality (NSL), which was directed towards the City by the province of Noord-Holland. Another relevant point is a **mobility fund for improvement measures in the mobility sector, which is mainly financed by parking fees.** Furthermore, funds worth 170 million EUR have been budgeted for measures in the next few years. Regardless of that, the city participates in funding programmes for electric mobility and the expansion of the related infrastructure.

Are subsidies available for fostering the use of sustainable energy?

The transaction of funds for sustainable energy projects is limited to the "Klimaat en Energie" Fund, which provides loans and securities. The City of Amsterdam underlines the fact that no subsidies are paid, but *support at market conditions is given.* However, it is worth mentioning that indirect subsidies for renewable energies may exist. These subsidies include specific tax deductions for the part of the investment which is directly associated with renewable energy. Nevertheless, a transparent explanation of

how far these possibilities differ from ordinary tax deductions is not provided by the fund and thus is subject to local tax advisers. Typically, the fund provides support for projects within the range of 500.000 EUR to 5.000.000 EUR with amortization duration of 15 years and a minimum return of 7 percent. Regardless of these criteria, a portion of funds provided by ordinary banks is still a necessity.

Social

How are cooperation efforts between authorities and other organisations designed with respect to measures and initiatives?

The cooperation between authorities and public service organizations (such as the local transport provider GVB) is already outlined within the strategy paper. Additionally, planned research projects (e.g. "Fuel Poverty", and poverty risks due to energy costs) have already been addressed to potential cooperation partners and collaborators (for example the Economic Development Office). The cooperation was instituted for example by building a network of 1,000 charging stations, which was funded by a foundation of local, national and international members. The strategy paper names the cooperation beyond administration and sector borders as a clear success factor in the acceleration and realisation of the project. The paper names knowledge and funds as well as politics, converters, companies, education and citizens as the relevant stakeholders which need to cooperate. The introduction of connections within the municipal administration is explicitly named.[489]

Are there any efforts to minimise the energy consumption per citizen – e.g. by fostering the use of vehicles with alternative drivetrain options or public transportation?

Electric mobility has already been targeted by the City. Within the field, a "track record" for electric bicycles exists. Regarding public transportation, the only measure that has been named is the introduction of emission-free public bus services (GVB) by 2026. However, for public ferries, the only effort is an examination to evaluate the possibilities of decarbonisation.

What efforts can be allocated to local or city governments with regard to the social commitment of citizens to CO_2 emissions?

The inclusion of citizens and initiatives is essential for certain sections of the sustainability concept. This especially applies to the recycling economy sector, which aims at the reuse of waste (including construction material), resource protection and the prevention of repeated production emissions. Therefore, citizens will participate by obeying a strict and friction-free waste separation scheme. At this point, citizens are explicitly responsible for achieving the sustainability goals of the City.

Apart from that, the described measures are generally designed to reduce the emissions per capita to 7.5 tons of CO_2 equivalents until 2025.

Technological

How does a city measure its achievements regarding the CO_2 reduction? Is there a uniform reporting system or reporting platform?

The City of Amsterdam follows a ***yearly reporting- and monitoring cycle regarding its CO_2 emissions***. Within the process, the monitoring is limited within the administrative borders of the local government (local authority). Additionally, a **periodic sustainability report** is published, that displays current data of the

[489] Further platforms are "Amsterdam Smart City", "Amsterdam's Economic Development Office", and sustainability networks such as "Wij Krijgen Kippen", "Zuidas Green Business Club", "DORA (for business creation)", "ZO! Duurzaam" (as regional initiative for south-eastern quarters of the city) as well as "Green IT Amsterdam Region Foundation".

locally developed "Sustainability Index"[490]. However, the yearly reporting by itself does not appear to be the only valuation basis regarding the success of CO_2 emissions. In its latest CDP data set, the City of Amsterdam notes, that its emissions have been cut. Nonetheless, the precise calculation of emissions will be provided later. The 2014 *data are validated by an external auditor (CE Delft).*

Amsterdam transfers data by using the CDP cities platform. Accordingly, the data set for 2016 has only been set up, whereas the report for 2015 has been submitted. The platform requires a registration. The City of Amsterdam does not report in the carbon Climate Registry.

How does a particular city manage its databases with respect to inventory, energy consumption and CO_2 emissions?

The granularity of the database and its underlying structures show potential for improvement. By means of that, the inventory for gas and electricity consumptions bases on data of the energy provider *Liander*, whereas heat supply data is taken from the company *Nuon*. ***However, both the data processing and the inventory of the emissions remain non-transparent***. Significantly, no chapter has been dedicated neither to the reporting nor the monitoring issue within the latest CDP report or the strategy paper. Hence, neither a definition regarding the composition of emissions nor an inventory pattern is reported. Accordingly, major simplifications are expected. Instead, the strategy paper reveals the calculation of the sustainability index, for example by including aspects such as a life quality index.

Legal

What regulations were used for implementing municipal CO_2 reduction goals?

According to local construction regulations (Verordening Huisvestingsvoorzieningen), each primary school, built after January 1st 2015, has to be constructed in accordance with the regulations for clean schools, namely *van Eisen Programms* (PvE). The same regulations are also planned for newly built secondary schools, whereas corresponding building requests are yet to be submitted in 2017. Furthermore, the City of Amsterdam has applied for the status of an innovation project within the crisis and reconstruction law (Crisis- en Herstelwet) to run tests on innovative solutions more easily. These solutions focus on the introduction of a recycling economy. Moreover, various regulations regarding solar panels as the central instrument within the planning process (Welstandsnota) have been abolished. Subsequently, an assessment process regarding the installation of solar panels without building request and permit has been started. Additionally, the following regulations for municipal realisation are relevant:

- electricity law, "SDE+" as well as the executive order for airport zones – regulating conditions for the generation of renewable electricity
- environment management law / building law
- waste regulations as regulations for utilisation

Are there any local or supraregional conventions for energy-intensive sectors or industries?

No. The reason for that is the fact that there is no heavy industry in Amsterdam. 90 percent of the economic activity are small- or medium-sized enterprises.

Are there official maximum emission levels that may not be exceeded?

[490] The „Sustainability Index" contains CO_2 emissions per capita and N2O-emissions as two out of ten indicators.

No. Exemptions are only made regarding the goals for the air quality.

Environmental

How will authorities deal with growing urbanism tendencies and the related growth in the energy demand?

Even though the Netherlands are already a highly urbanized country, data shows a high on-going urbanisation rate. The latest CDP report shows, that ***population growth and emissions have decoupled*.** A detailed description of a possible decoupling of consumption and emissions was not provided. A major step against further resource consumption was identified by introducing a recycling economy in order to compensate for the inflow of citizens. A detailed reconditioning, however, was not provided by the City's reports.

What are the biggest urban challenges that local authorities will have to cope with if they wish to achieve carbon neutrality?

Due to the high proportion of public housing, the building stock represents a major challenge in order to reach emission goals. The reason for that is the fact, that only a few municipal pilot projects were carried out regarding public housing (first attempts were performed in other and more rural areas). Accordingly, the City faces the issue of finding a partner to launch a pilot project to develop 1.000 housing units on the zero-energy level. The second challenge is the introduction of a recycling economy. In order to introduce such an economy, the main challenge is to communicate the importance and necessity to the population in order to reach the emission goals.

9.2.4 Comprehensive assessment

Action level "political"

The basic decision towards a "sustainable Amsterdam" is characterised by the political will to overfulfil national standards and acceleration in attainment. It becomes apparent that Amsterdam is one of only a few cities to force the introduction of a stringent recycling economy, including matching time metrics. That also incorporates a higher valuation of quarter-based initiatives and measures. The established political-strategic basis can be seen as a sophisticated implementation plan, providing a foundation to verify the degree of performance.

Action level "economic" (incentive mechanisms and behavioural change)

Unfortunately, the City of Amsterdam uses financial resources almost exclusively for own municipal measures. Incentives for private households and enterprises shall arise from cost reductions (e.g. due to energy consumption reductions in buildings). The budget of 170 million EUR appears to be reasonable regarding these limitations. The existing subsidy schemes are based upon market conditions and provide moderate incentives – further impulses were desirable. No necessary incentive mechanisms have been introduced for the waste management industry.

Action level "social" (participative/cooperative approaches)

Even though precise constellations between authorities and organizations have been established, only vague declarations of intention regarding the participation of citizens and stakeholders have been outlined. Basically, the implementation topic itself appears to be on track. Against the background of the goals for 2020, questions arise in how far civil participation should have been done earlier and to a larger extent.

Action level "technological" (information systems, databases, innovations)

The derivation of green house inventories and the resulting reduction goals appear to be non-transparent. It is comprehensible, that certain data is provided by external energy suppliers. Thus, presumptions about simplified inventory approaches by using emission factors arise. Even though an external audit about 2014 figures was performed, no conclusions can be made about the underlying information systems or data processing by accessing Carbon Disclosure Projects (CDP). The information depth does not differ from the city level.

The transparency and data quality of the inventory are more important than participation within a publication platform.

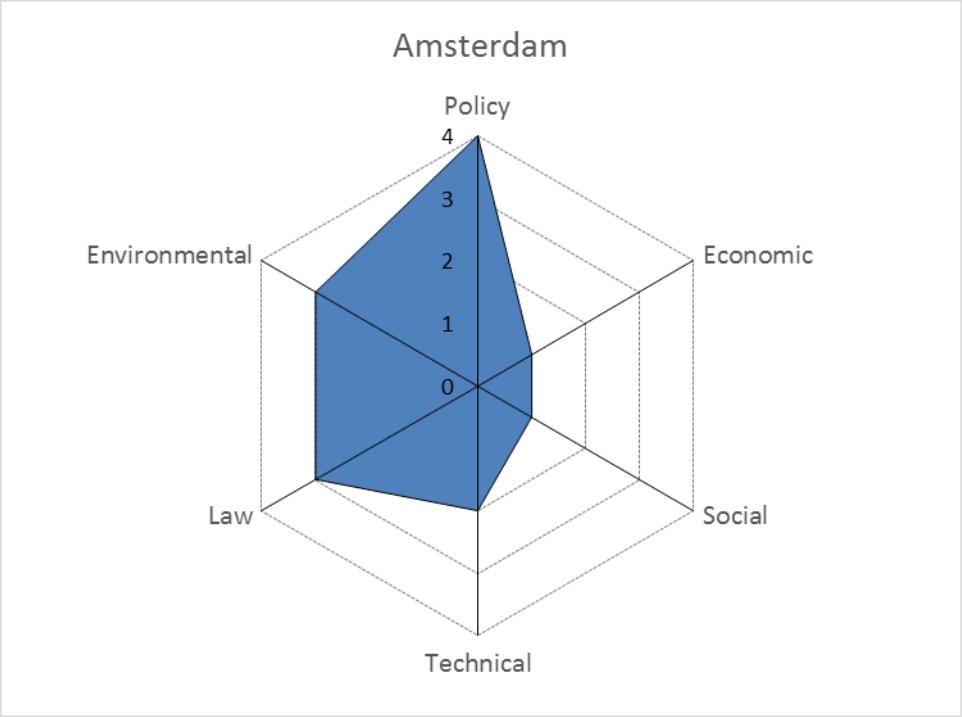
Action level "legal" (legal frameworks and regulatory interventions)

Apart from certain air quality metrics, no precise emission caps exist. However, regulations aim at forcing behaviours towards the zero-energy standard within the city. Regarding self-regulation, the City has defined comprehensive standards. Accordingly, barriers for a faster diffusion of solar energy have been abolished. Regulatory interventions appear to be reasonable.

Action level "environmental" (environmental effects)

Although the City has not explicitly addressed the issue of environmental impact within its strategy paper against the background of an increasing population, ecological considerations and a holistic approach regarding a healthy living environment play a central role. Thus, the air quality issue has been one of the main drivers of the sustainability concept.

Figure 15: Assessment of Amsterdam



Source: own representation

9.3 São Paulo

9.3.1 Brazil's contribution to the World Climate Agreement

On September 28th, Brazil transmitted their INDCs.[491] They contain greenhouse gas reduction goals on an absolute basis (including land use, change of land use and forestry (LULUCF)) with a share of 37 percent by 2025 and 43 percent by 2030.[492] The corresponding baseline year, though, is 2005 (instead of 1990). The mitigation strategy includes a bunch of single measures referring to an increase in efficiency as well as to an increase of the share of renewable energy up to 45 percent in 2030. Major urban areas like São Paolo and Rio de Janeiro contribute essentially to the successful implementation of these goals. INDCs do not specify the role of cities at all. With 11 million inhabitants living in the city centre and 20.2 million residing in the outskirts, São Paolo is the leading metropolitan region in South America, making up 20 percent of the national GDP.[493] Apart from respective laws on the state level[494], both cities have already formulated clear goals to reduce greenhouse gas emissions and launched appropriate measures, regulations and other initiatives.

Waste production and energy consumption are main drivers of emissions. Previous progress in greenhouse gas reduction is considerable: From 2004 to 2012, the nation increased its GDP by 32 percent while simultaneously reducing greenhouse gas emissions by 52 percent (GWP-100; IPCC AR5); at the same time 23 million people could be saved from poverty.[495] Efforts of municipal governments in the main metropolitan areas of São Paolo and Rio de Janeiro were not sufficient to limit the absolute increase of greenhouse gas emissions. From 2005 to 2012, emissions in both cities have almost doubled. These self-reported statistics neglect the depletion of the rainforest (Amazonas) as well as the significant economic recession during the reported period. Although Brazil could reduce emissions caused by deforestation by about 76 percent from 2005 to 2010, according to WRI, changes in land use and deforestation still remain major causes for emissions.

São Paulo has seen tremendous growth in the 1940s and 1980s. Firstly driven by coffee cultivation, the city became an important industrial hotspot thereafter (first in the textile sector, subsequently in automotive manufacturing, chemistry and metal processing). Due to historical migration São Paulo is now a multicultural city. The past decade has shown a stronger orientation towards the service sector.[496] Currently, Brazil has to deal with a political and economic crisis.[497] São Paulo in particular has seen massive increases in real estate prices in 2014, whose downward adjustments intensify the current crisis.[498] In an emerging country with rapid urbanisation processes and substantial population growth it is a major challenge to implement reduction goals on an absolute basis while ensuring the GDP growth per capita at the same time. From 2005 to 2010, before the crisis, the middle class has seen economic growth resulting in 21 percent higher emission levels. In the light of continuing urbanisation the challenge is likely to persist. In this context, Brazil will intensify regulation efforts ("stringent modality of contribution"). Currently Brazil causes 3 percent of worldwide anthropogenic greenhouse gas emissions.[499]

The basic legal framework to mitigate climate change was already implemented in 2009.[500] The first *National Climate Change Plan* was adopted in 2007.[501]

[491] Federative Republic of Brazil, 2015
[492] Here: Centennial Global Warming Potential (GWP-100), based on IPCC AR5.
[493] WRI Brazil: http://wribrasil.org.br/en
[494] National Policy on Climate Change (Law 12,187/2009) // Law on the Protection of Native Forests (Law 12,651/2012) // Law on the National System of Conservation Units (Law 9,985/2000)
[495] Data for emission reduction: MCTI (op.cit.) // Data for GDP: Ipeadata (op.cit.) // Data regarding poverty: MDS (op.cit.). // Lucon, 2015, p. 13: "The author points out a reduction of 36 percent."
[496] WBGU, 2016, p. 308
[497] Glüsing, 2016
[498] Trade online, 2015
[499] Lucon et al., 2015, p. 6 // Centro Clima, 2013
[500] WBGU, 2016, p. 318
[501] http://www.mma.gov.br/estruturas/208/_arquivos/national_plan_208.pdf

In this context, Brazil has published a comprehensive *National Adaptation Plan* (NAP)[502] which further elaborates on the goals. The NAP was created bottom-up and intensively discussed among various stakeholder groups. The implementation steps to achieve the mid-term goals by 2019 were introduced in 2016, involving 11 industry sectors. Major INDC goals are the following:

- increase the share of biofuels in the national energy mix to 18 percent until 2030 (using ethanol and new biofuels („second generation biofuels")),
- increase the share of renewable energy to 45 percent until 2030,
- improve the electrical energy efficiency by 10 percent,
- rise the energy efficiency in the transport sector and expanding the local public transport,
- set mitigation criteria for city development and construction regulations,
- extend green belts and create compact cities,
- duty to report and document achievements once every five years.

9.3.2 Strategic principles

São Paulo is one of the first cities among its peers to develop a distinct action plan to mitigate climate change.

Key facts of strategy

- Significant reduction of greenhouse gases, also on the municipal level and broad political initiatives
- Defined sector-based approaches placing low importance to quarter-related considerations
- Necessity to balance goals of environmental policies and the requirement for participation and growth
- Intensive inventory and monitoring, supported by the WRI
- Mixture between regulation and market-based instruments
- The relation between growing prosperity of an evolving middle class and increasing emissions has to be interrupted.
- Emission reduction of private transport in cities

9.3.3 PESTLE analysis

Political

What role does the municipal government play (at the provincial or city level) in achieving nationally proposed CO_2 reduction targets?

INDCs do not discuss specific regulations for cities. Though, distinct requirements for urban areas can be deducted from national climate protection laws. Almost 85 percent of the population in Brazil is living in cities. Surprisingly, urban areas do not play a major role within the national climate protection strategy.[503]

In general, on the municipal level in São Paulo a broad range of laws and regulations has been adopted which ensure far-reaching discretionary competence and which actively address emission mitigation. The municipal government decided to pass LEI No. 14.933 already in June 2009, which was to reduce greenhouse gas emissions by 2012 relative to 2005 levels by 30 percent.[504] In addition, respective organisational units were created (*Comite de Mudanca do Clima e Ecoeconomia*), being in fact subject to the environmental department (*Secretaria do Verde e do Meio Ambiente*), but company representatives and citizens are also represented in these organisations. In June 2010, São Paulo adopted

[502] Plano Nacional de Adaptação à Mudança do Clima, 11.05.2016
[503] Kahn et al., 2015, p. 3
[504] Note: 20 percent in Rio de Janeiro by 2020 as well as in Belo Horizonte by 2030 (baseline year 2005).

Decree No. 55947 implementing the ambitious *"Climate Change Policy Law" (LEI No. 13798 of 2009; "Política Estadual de Mudanças Climáticas")*. This climate protection law requires revolving inventory activities every five years.[505] Its measure catalogue (Program of Goals of the City of São Paulo from 2013 to 2016) specifies more than 120 individual goals in 20 sectors. While doing so, spatial priorities with regard to city planning and development have been set.

These regulations have provided certain institutions with extended authorities with respect to decarbonisation. The *Climate Change Policy Management Committee* is to prepare major decisions. The *Climate Change Program* ("ProClima"), subordinate to the municipal environmental agency (*CETESB*), prepares action plans for the construction, manufacturing, energy, transport, waste management and agricultural sectors. Here, public interests will be heavily involved.

Problems regarding the implementation and governance in general especially become apparent when it comes to approaches going beyond city limits where diverging interests of surrounding communes result in subsequent failure. In 2015, *Estatuto da Metropole* has been adopted, which specifies guidelines for greater urban areas and which will result in superior metropolitan goals dominating local interests.[506] The *São Paulo metropolitan area will be perceived as one planning district (see also Paulista).* Relevant approaches have not made their way into reality yet.

In general, we see only little continuity, i.e. stability, in the municipal policy which, analogous to the situation on the national level, limits the efficiency of agreed measures.

What role do neighbourhood-based approaches play in comparison to sector-based initiatives?

São Paulo is dominated by sector-based approaches (see following aspect).

City centre revitalisation has been promoted by public efforts. Revitalisation of the former in-town industrial areas should be achieved using the city planning instrument „Operacao Urbana Centro".

What are the most relevant sector-based (buildings/construction, industry and mobility) initiatives and how are they developed?

Action corridors, based on the ambitious, municipal climate protection regulation, involve transport, renewable energy, waste management as well as construction and land use. Particularly, the following aspects have been agreed upon:

1. Mobility:
    - reduced use of fossil fuels for public transport by 10 percent p.a. as well as modification of the entire municipal fleet with respect to renewable energy by 2017,
    - implementation of management systems which contribute to a reduction of private transport and to a strengthening of public transport,
    - official route sections for car pools and busses, support of car sharing concepts and improvement of cycling infrastructure,
    - implementation of limited greenhouse gas emissions („GHG emissions standards") for all vehicles throughout the metropolitan area.
2. Energy:
    - abolishment of financial grants for fossil fuels; promotion of local energy production,
    - implementation of efficiency standards for construction, industry and transport sectors,
    - implementation of LED lights and efficient municipal systems.

[505] WBGU, 2016, p. 318
[506] WBGU, 2016, p. 320

3. Waste management:
    - waste reduction and promotion of recycling efforts,
    - requirement for all newly constructed (big) buildings to implement waste management plans,
    - reduction of emissions caused by the use of methane on municipal garbage dumps,
    - ban on the use of plastic bags.
4. Construction:
    - implementation of efficiency standards for new constructions and for real estate stock in order to receive official permits of building use,
    - need to meet specific sustainability requirements for newly constructed buildings of public authorities,
    - use of certified wood in buildings of public authorities.
5. Land use:
    - optimised land use planning to increase density (especially in areas with a high level of employment in order to reduce traffic),
    - expansion of park areas,
    - increase of number of trees throughout the city.

Traffic, or more precisely the traffic chaos*, is still one of the major challenges of São Paulo*.[507] The extent of the environmental pollution becomes visible in daily traffic jams throughout the whole metropolitan area, as public transport is neither readily available nor safe. A major share of CO_2 emissions of the city comes from private transport. Among 38.3 million rides per day, 29 percent are caused by motorized private transport, yet already 36 percent by the use of public transport. *In 2011, seven million vehicles were registered in the city, which accounts for 23 % of all greenhouse gas emissions in the São Paulo region.* The city undergoes great efforts to promote public transport.[508]

In mid-September 2016, *WRI Brasil Sustainable Cities* and the *Institute for Transportation and Development Policy* (ITDP Brasil) published a study which outlines the fact that only about 23 percent of the population of São Paulo lives near public transport facilities („people near transit (PNT)"). The survey concludes that this share can be increased to 70 percent by 2025, in case further efforts will be made. This fact implies the ongoing big need for action.

In the metropolitan area *several million people live in a total of about 1.600 slums (favelas)*.[509] According to public authorities, this can be translated into a deficit of additional 800.000 residential units. The government in charge has put **extensive housing programmes**[510] into place which, apart from promoting the construction of additional housing for low income groups, follow increasingly ecological goals (ecological measures undertaken in slums, energetically optimized buildings, water protection etc.).[511] The urban housing policy is oriented towards the *Plano Municipal de Habitacao* (PMH) which has been renewed the last time in 2009 for another five years. Referring to practical implementation, the action plan lacks sufficient financial means and a good governance structure. Simultaneously, *a lot of trophy assets in "gated communities" constructed by private builders remain vacant due to the ongoing real estate crisis*. The risky safety situation and increasing isolation tendencies of middle and upper

[507] Bell et al., 2006
[508] C40 Blog, http://www.c40.org/blog_posts/sao-paulo-to-introduce-electric-bus-fleet-add-300km-of-priority-bus-lines-english-portuguese: "São Paulo introduces electrical buses and increases its "Priority" lanes by another 300 kilometres."
[509] Serpone Bueno, 2011
[510] Kahn et al., 2015, p. 8
[511] WBGU, 2016, p. 315

class[512] intensify social conflicts and prevent both exchange of ideas and the achievement of intended goals.

Energy saving is addressed in the construction sector, but not with comparable effort to Europe. All newly constructed buildings need to generate at least 40 percent of the energy used for hot water using solar panels.[513] According to the new standards (Brazilian Labelling Program), new buildings should achieve energy savings of 50 percent compared to the average energy consumption of today's building stock. Refurbishments should save up to 30 percent.[514] The *Minha Casa Minha Vida Program* (MCMVP) is the national programme for social housing. The programme was initiated in 2009 and targets the construction of 3.4 million housing units. Law 7.746/2012, adopted in 2012, lays down that sustainability criteria should additionally be considered in public sector- initiated tenders. The *Cingapura programme* is in existence since 1990 in order to transfer families living in informal estates (Favelas) to social housing.

The climate-related committees put in place have also worked out proposals for urban planning („new Urban Planning Regulation (PDU)"). More specifically, a "Transport Oriented Development" will be implemented which is expressed in the new spatial planning concepts and the São Paulo master plan created in 2014.[515]

In Brazil, national law ensures the collection and disposal of waste by municipalities. Recycling is left to private entrepreneurs. In 2010, ***laws for waste separation*** have been initiated (Politica Nacional de Residuos Solidos, RNRS). An increase of the share of recycled waste and waste separation shall result in a sharp decline in deposited garbage. The so-far rather informally organised sector of waste collectors will be actively involved. In 2013, 30 of 39 independent municipalities of the greater São Paulo area already carried out separate waste collection, whereas only ***less than 5 percent of the waste arising*** was separated. At least 28 municipalities collaborated with local collectors of recycling material.[516]

In the decade to come, investments of around 500 billion US dollar in the Brazilian energy sector are anticipated. In this context, it remains essential to avoid investments into sectors which are expected to cause greenhouse gas emissions on a persistently high level.[517]

Economic

Which financing programmes are used to implement CO_2 reduction goals at the city level?

The city administration has fixed the establishment of a ***"Special Environment and Sustainable Development Fund"*** in its laws. In addition, further incentives can be created (e.g. if private households use the funds of the "Private Natural Heritage Reserve" in São Paulo to finance refurbishments).

In general, ***municipal financial means are insufficient, especially when compared with the scale of challenges faced.***

Several international organisations, such as the World Bank, KfW and the Inter-American Development Bank (IADB) support local decarbonisation projects.

As an example, the WRI, in cooperation with *Brazil's Ministry of Cities,* has worked on guidelines for Brazil's federal bank (*Caixa Econômica Federal*)[518] which resulted in investments of USD 4 billions in 63 urban mobility projects in 56 cities. Likewise, for the extension of line 4 in São Paulo, apart from USD 1.6

[512] WBGU, 2016, p. 313: "Already more than 35 percent of Gated Communities."
[513] Law Nº 14,459, 03.07.2007 // Decree Nº 49,148, 21.01.2008 // http://www3.prefeitura.sp.gov.br
[514] Kahn et al., 2015, p. 11
[515] Law 13.430 / 02 // adjusted Law 16.050, 31.07.2014
[516] Besen et al., 2014, p. 266
[517] Lucon et al., 2015, p. 1
[518] Kahn et al., 2015, p. 8: "In total, the state-owned *Caixa Econômica Federal* Bank should spend 1.6 billion dollars in the upcoming years."

billion of public funding, an additional contribution of 246 million US dollars could be raised by private investors.

Selo Casa Azul is a financing programme of *Caixa Economica Federal* which benefits social housing and sustainability. *Caixa Economica Federal* has also recently released an assessment tool for related projects.[519]

The World Bank, using the example of Brazil, stresses that ***LCCDP-accredited projects in cities lead to the opening up of new financing solutions***. Potential (external) investors are assured by review processes that the use of financial means and the efficiency of admitted projects meet international requirements. Besides, "carbon credits" can be generated which lead to cash inflows in the event that they are sold.

Are subsidies available for fostering the use of sustainable energy?

Analogous to subsidised financing, comparable instruments are hardly available.

What additional market-based solutions are available?

São Paulo trades air pollution rights as part of a pilot project. At the end of April 2010, the environmental authority CETESB, the exchange BOVESPA, the industry association FIESP and the São Paulo investment agency signed a corresponding agreement. It is legally based on Act No. 52469 adopted in 2007, an attachment to the São Paulo Law of Pollution Control ("*Sobre Controle de Poluição do Meio Ambiente*") already being in effect since 1976. The region is thereby subdivided into "air quality control regions" and "subregions". For seven emission categories the region's output level is differentiated into (1) saturated, (2) almost saturated, (3) not saturated. For sectors with high pollution levels CETESB has to implement a programme for emission reduction ("*Programa de Redução de Emissões Atmosféricas*") which may include the use of tradeable pollution rights.

São Paulo ***reduced burdens for admission of firms and projects which give reason to expect a positive or neutral environmental impact***. The Environmental Ministry Resolution No. SMA-056, among others, subsumes facilities to produce biofuels or water processing etc.

Social

How are cooperation efforts between authorities and other organisations designed with respect to measures and initiatives?

Civic activism developed mainly as a consequence of the national city reform movement which influenced political guidelines successfully. The *Center for Sustainability Studies* of the *Getulio Vargas Foundation*, the *WRI* and further NGOs, like e.g. the *Climate Observatory,* play a major role in the decarbonisation process of São Paulo.

The municipal climate protection laws have led to the establishment of a group of consultants, the so-called „***State Climate Change Council***" ("*Conselho Estadual de Mudanças Climáticas*") and the „***Municipal Climate Change Committee***" on the local level. Beside ministers, authority representatives, NGOs, industry representatives as well as other members of the society take part. In the past, the committee actively participated. Nowadays, this is not anymore the case due to the current complicated political situation.

[519] CAIXA, http://downloads.caixa.gov.br/_arquivos/desenvolvimento_urbano/gestao_ambiental/SELO_CASA_AZUL_CAIXA_versaoweb.pdf

Are there any efforts to minimise the energy consumption per citizen – e.g. by fostering the use of vehicles with alternative drivetrain options or public transportation?

There are a lot of alternatives to public transport (see above). The current status quo with respect to air pollution and emission levels caused by private transport is still highly negative. Authorities have already set higher efficiency standards by increasing requirements for granting permits of industrial plants. In officially designated "saturated areas" specific enterprises are no longer allowed to operate as particular emissions – like e.g. CO_2 – are prohibited.[520] The *São Paulo environmental protection agency CETESB can adapt its admission requirements and implement limits for greenhouse gas emissions.* The authority is also able to *integrate compulsory requirements to offset emissions in operating licenses*.

Several laws have been currently adopted which aim at reducing activities that counteract climate protection efforts. As an example, a CETESB guideline pursues reduced sales of diesel cars.[521] *CETESB is therefore authorised to implement environmental standards valid for products sold in the São Paulo region*. They can refer to energy efficiency of heating or cooling systems, illumination or automobiles. Firms offering their products within the territory mentioned are obliged to specify their emission levels.

What efforts can be allocated to local or city governments with regard to the social commitment of citizens to CO_2 emissions?

Apart from the mentioned laws, there is no personal obligation for citizens. Improving the living conditions of the lower class and stabilising the economic development is of higher priority.

The local authority has also adapted procurement requirements based on climate protection goals. In this respect, the city counts on a role model function of the public sector.

Technological

How does a city measure its achievements regarding the CO_2 reduction? Is there a uniform reporting system or reporting platform?

In 2009, São Paulo emitted 15 million tons of CO_2e.[522]

What is positive is that Brazil promotes *GPC* (Global Protocol for Community-Scale Greenhouse Gas Emissions)-standardized greenhouse gas inventories on national, regional and local levels which improve the comparability of results. In order to be able to monitor the goal achievement, a greenhouse gas inventory for a period of at least five years is claimed. In this context, the private sector shall be incentivised to measure greenhouse gases, too. In this respect, São Paulo has seen massive implementation support by the *WRI Program*. Specific emission factors and calculation assistance tools have been developed. WRI, C40 and ICLEI implement the GPC in more than 30 Brazilian cities. The *WRI GHG Protocol* in Brazil in the form of today's *GHG Protocol Brazil Program* has already existed since Mai 2008 as a cooperation between the Brazilian environmental department, the "Brazilian Business Council for Sustainable Development", the "Fundação Getúlio Vargas (FGV)", the "World Business Council on Sustainable Development" and the WRI.

The *LCCDP certification* of the "Low-Carbon City Development Program" granted in June 2012 for Rio de Janeiro (including ISO 14064, ISO 14001 and the GHG Protocol) was a considerable milestone. Similar aspirations exist for São Paulo.

[520] Campetti-Amaral et al., 2016
[521] Campetti-Amaral et al., 2016
[522] Kahn et al., 2015, p. 9

How does a particular city manage its databases with respect to inventory, energy consumption and CO_2 emissions?

Several cities have already initiated „task forces" for the improvement of overall data collection and preparation. In Rio de Janeiro, the ***GHG inventory task force*** already amounts to 50 persons coming from various public amenities. The inclusion of indirect emissions has to be improved, though. As an example, the use of natural materials like wood in the São Paulo construction sector could further accelerate the deforestation of rain forests in the Amazonas area when neglecting this aspect.

Basically, a top-down city-wide inventory is created and the further development of emissions is monitored. It is confronted with the individual mitigation measures of the various action levels on a bottom-up basis. In this context, *Clean Development Mechanism* (CDM) instruments and measures according to the LCCDP play a role, too.[523]

To ensure extensive data on greenhouse gases, the WRI has involved more than 100 Brazilian firms in the measurement.

What are relevant aspects of data protection and comparability and are there conditions making these data accessible for the calculation of emission inventories?

No specific information is available with respect to this question.

Legal

What regulations were used for implementing municipal CO_2 reduction goals?

Various regulations were passed. They were mainly effective. However, their degree of implementation in practice remains insufficient (see above).

According to Art. 182 of the national constitution, all cities are obliged to work out and to implement master plans for urban development. In 2014, the currently valid master plan for São Paulo was passed, under intense civic participation.[524] It stresses the improvement of the environmental quality (protection and extension of park areas), a high urban density, mixed-use (conservation of fragmented structures, involvement of local citizens for planning matters, identification of redevelopment areas) as well as an upgraded traffic sector (development of public transport, car-sharing concepts, extension of pedestrian and bikeways). In order to enforce the stated goals, ***profit absorption measures or a progressive real estate tax would be possible to avoid unexploited downtown plots***.[525]

High growth dynamics rather lead to a planning process catching up on past failures rather than anticipatory planning. Due to the formerly mentioned aspects and a persistently high urbanisation tendency, São Paulo faces massive transformation challenges. Likewise, the city is highly concerned about being increasingly exposed to natural hazards.

Are there any specific local or supraregional conventions for energy-intensive sectors or industries*?*

Regional limitations apply (see above).

Are there official maximum emission levels that may not be exceeded?

Regional limitations apply (see above).

Environmental

How will authorities deal with growing urbanism tendencies and the related growth in the energy demand?

[523] Weltbank, 2014, p. 3ff
[524] Law 16.050 // PMSP (Plano Diretor Estrategico do Municipio de Sao Paulo), 2014
[525] WBGU, 2016, p. 320

Already today, Brazil is one of the countries with the most comprehensive and most successful biofuel programme („Biofuels“). Renewable energy already makes up 40 percent of the total energy demand (75 percent related to electricity). Further extensions are actively fostered (see above).

Decoupling the growing energy demand due to urbanisation and a growing middle class remain unsolved problem areas.

Government authorities of the three regions Espírito Santo, São Paulo and Mato Grosso have announced to recultivate 3.28 million hectares of degraded area.

What are the biggest urban challenges that local authorities will have to cope with if they wish to achieve carbon neutrality?

The rising middle class (with respect to growing consumption patterns), traffic and deforestation are key. When it comes to implementation, aspects like the political stability, prevention of corruption and sufficient financial support are crucial.

Despite lots of legal initiatives, various examples prove a disillusioning status-quo: Indeed, several authors observe an improving water quality due to sharper requirements and controls,[526] although it is not noticeable in practice. Additionally, major river courses overflow almost daily due to foaming caused by introduced detergents. About 30 percent of sewage remains completely untreated. Similarly, authorities have not yet succeeded in addressing the increasing water shortage proactively – a problem that has already been addressed by experts a long time ago. In 2015, empty reservoirs and long-lasting mismanagement by political representatives resulted in a devastating water shortage throughout the city.[527] The situation caused a broad public discussion and culminated in the claim of greater justice and more participation.

9.3.4 Comprehensive assessment

Action level “political”

Support by industry sectors concerned and the accurate allocation of emission reduction goals to individual sectors are major challenges. In general, *São Paulo reveals a high discrepancy between clearly defined, ambitious goals and implementation deficits.* Besides the lack of financial means, corruption, unstable political systems and *generally fragile governance structures* add to the problem. To what extent the fourth biggest metropolitan area is able to take the lead by setting ambitious decarbonisation goals remains to be seen.

Especially due to often corrupt elites and politicians, the high crime rate and thereby destabilised social systems, Brazil has not yet succeeded in starting a significant decarbonisation process in São Paulo. *Positive initiatives, like e.g. basic inventories or the development of public transport, are only achieved by international funding.*

Action level “economic” (incentive mechanisms and behavioural change)

In theory, trading pollution rights and other incentives work. However, these instruments are either not sufficiently implemented in practice or have the status of pilot projects.

Efforts for incentivising a sustainable behaviour in the society or the industry are not comparable to those undertaken in Europe. Setting viable energy efficiency standards for products etc. may be a constructive step.

[526] Jacobi et al., 2015, p. 69
[527] Cohen, 2016, p. 261ff

Lucon et al propose a wide variety of „Low-carbon technology options", based on a substantiated analysis and discuss their implementation as well as their costs and benefits.[528] A more pronounced consideration of these starting points appears to be important.

Action level "social" (participative/cooperative approaches)

Reduction of social disparity and an increasing social segregation[529] **are major challenges** which have been identified. However, no efforts have so far been initiated to tackle these issues. A high degree of informality, corruption, a high share of slum inhabitants and an increasingly fragile security situation disable any efforts. *Decoupling the aspired increase in the quality of life of so far disadvantaged groups and a simultaneously decreasing resource intensity are major tasks*. So far, however, similar to other emerging countries, the rising middle class was responsible for significantly higher emission levels. Participatory approaches are included in all legal initiatives for environmental protection which has to be judged positively.

Action level "technological" (information systems, databases, innovations)

Internationally known solutions are implemented in Brazil, too. Examples range from building inventories according to the GPC with international support to LED-illuminated[530] streets. Financing and the resultant scaling of solutions are the main limitations.

With respect to inventories, great efforts and initial success have been achieved with the help of the WRI. Data-gathering and data quality remain big challenges.

Action level „legal" (legal frameworks and regulatory interventions)

Networks of Brazilian NGOs[531] criticise national goals according to the INDCs to be hardly ambitious (see *Climate Observatory*) and propose an increase of the emission reduction goals to 57 percent. It could be achieved by limiting deforestation and by further developing renewable energy sources like solar energy and wind power. A current WRI report emphasises this point of view and stresses that many instruments with good cost-benefit ratio fulfil current government emission requirements.

Experts also emphasized the fact that current efforts are insufficient to achieve decarbonization. In particular, public transport must be extended. Likewise, the economy requires more incentives to reduce greenhouse gas emissions. The renewable energy sector needs to be developed on a massive scale.[532]

Brazil as a whole and São Paulo in particular show that major problem areas have been identified and a general framework has been set up with the help of legal requirements. *However, when it comes to implementation efforts, major deficits become apparent*. Corruption, varying political majorities, large social differences and the *lack of financial means due to the current economic crisis* hamper a change.

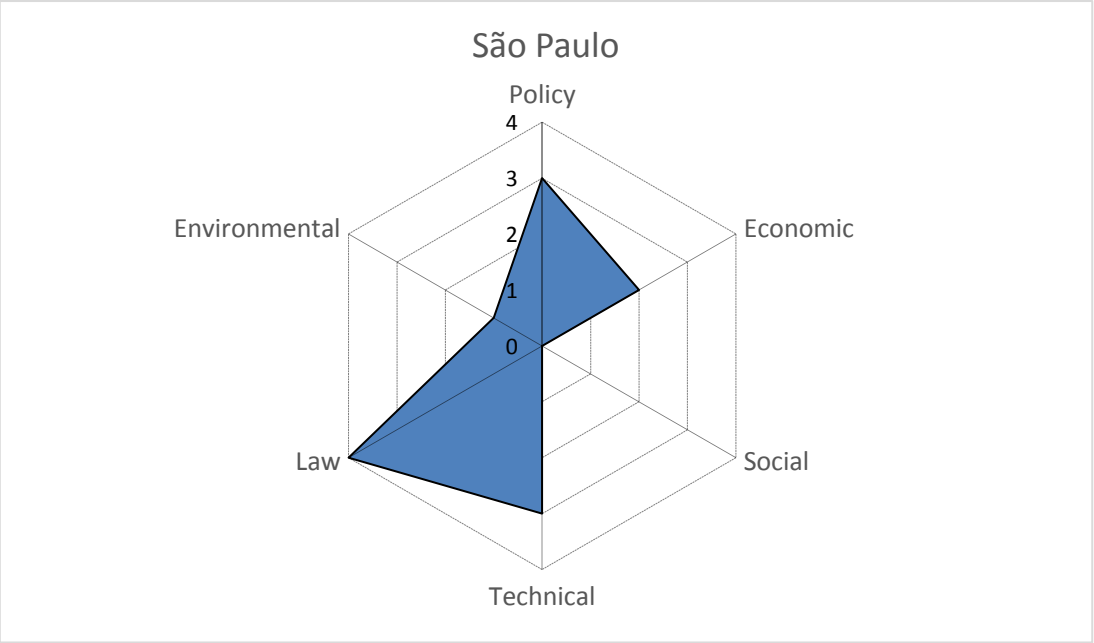
São Paulo also clearly reveals another problem area which is typical of all countries with highly local decision competences: Due to the expansion of megacities beyond city borders, an essential coordination with surrounding municipalities makes few progress owing to *diverging interests*.

[528] Lucon et al., 2015, p. 24
[529] Cohen, 2016, p. 265
[530] Kahn et al., 2015, p. 12
[531] Kahn et al., 2015, p. 13
[532] Lucon, 2015, p. 2ff

Action level „environmental" (environmental effects)

A pronounced disparity can still be seen between the apparent "business-as-usual" mentality going along with a highly negative environmental impact and the ambitious political goals. Existing environmental laws are only partly met due to insufficient enforcement procedures and corruption. From a European perspective, the ongoing traffic chaos, contamination of water, inadequate waste disposal and other areas are in poor condition.

Figure 16: Assessment of São Paulo



Source: own representation

9.4 Singapore

9.4.1 Singapore's contribution to the World Climate Agreement

Singapore's Intended Nationally Determined Contribution (INDC), which was proposed on 3rd July 2015, intends to reduce the emissions intensity by 36 percent from 2005 levels by 2030, and stabilise its emissions with the aim of peaking around 2030.[533] Singapore already proclaimed in 2009 that their emissions will be cut by 7 to 11 percent below the business as usual (BAU) level by 2020. Due to the COP21 agreement, Singapore tightened this objective and planned to reduce its GHG emissions by 2020 by 16 percent below the BAU level. The assumed BAU scenario initially included an increase in the emission intensity, compared to 2005. Changes in the fuel mix during the energy production and the general improvements in the energy efficiency sector already prove a reduction of the emission intensity and let the target for 2030 appear realistically.[534]

9.4.2 Strategic principles

The most recent strategy paper is known as *Sustainable Singapore Blueprint 2015*[535], which includes both the national vision and a fundamental plan for a sustainable development of Singapore. Taking the limited alternatives, due to its geographical location, into account clearly illustrates, that **energy efficiency needs to be seen as a key strategy for reducing CO_2 emissions.** Against this backdrop, the Blueprint 2015 includes several best-practice

[533] INDC Singapore, 2015, p.1
[534] National Environment Agency, 2014 // EMA, 2015
[535] Ministry of the Environment and Water Resources, 2014

examples for energy usage. For additional details please refer to Singapore's *Biennial Update Report (BUR*)[536], which was addressed to the UNFCCC and was published by the *National Climate Change Secretariat*[537] in 2015.

As already mentioned, the geographical location of Singapore makes the city vulnerable for climate change and hence, Singapore concentrates its climate policy not only on mitigation strategies but also on adaptation elements. The former is founded on a political approach, which is based on an increase in the energy efficiency, fuel conversion and the expansion of renewable energy. In this context, it is worth mentioning that Singapore represents one of the biggest central continental hubs for international air and sea transport in the world. Therefore, the GHG emissions linked to those sectors are three times higher than all other emissions produced by its population.[538] Especially those emissions increased drastically over the last decade. Coming from 100 million tons of GHG emissions in 2000, the amount has more than doubled since then and amounted to 205 million tons in 2015.[539] If those emissions, produced by air and sea transport, are considered in the city state inventory, the current mitigation actions would only have little impact on the emission growth of Singapore.[540]

Even though, Singapore is heavily dependent on fossil fuels, it has made early policy choices to reduce its GHG footprint by switching from fuel oil to natural gas. But this strategy has already reached its threshold, because in 2014 more than 95 percent of electricity generation resulted in natural gas.[541] There is no indicator that additional actions are taken to reduce the CO_2 intensity via the energy supply.[542]

Key facts of strategy

- Energy efficiency as a key strategy to reduce CO_2 emissions
- Local public transport consists of trains, buses and bicycles. An expansion of the current services is planned.
- A substantial target is the reduction of the CO_2 intensity by 2030 (not in absolute figures).
- The cooperation of the public and private sector is actively encouraged.
- Smartphone applications are actively used to integrate the new generation of building occupants (GenY).[543]
- Renewable energy sources, such as solar panels, compete for limited space in high density urban areas. The expansion potential is limited.

9.4.3 PESTLE analysis

Political

What role does the municipal government play (at the provincial or city level) in achieving nationally proposed CO_2 reduction targets?

Singapore is a city state of high relevance for the entire region. The political structure allows a quick implementation of new (legal) requirements and strategies. A comprehensive strategy for residing and living is in place, whereby the city level plays an outstanding role for CO_2-neutral initiatives.

What role do neighbourhood-based approaches play in comparison to sector-based initiatives?

In cooperation with leading real estate developers (e.g. CDL)[544] it was possible for the city (Building Authority and National University of Singapore) to develop innovative and focused initiatives, which can

[536] http://unfccc.int/national_reports/non-annex_i_parties/biennial_update_reports/items/9186.php
[537] https://www.nccs.gov.sg
[538] Velasco et al., 2012
[539] BP Statistical Review of World Energy, June 2016
[540] Ministry of the Environment and Water Resources, 2014
[541] EMA, 2015, p. 100
[542] Asia Pacific Energy Research Centre, 2013
[543] National University of Singapore, 2016: "Smart green homes."
[544] CDL, 2014

be seen as neighbourhood-based actions. For instance, Singapore is one of the 45 champion cities with regard to neighbourhood energy.[545] The application of innovative solutions and newly developed technical approaches was visibly promoted.

What are the most relevant sector-based initiatives (building/construction, industry and mobility), and how are those developed?

With its "Sustainable Singapore Blueprint 2015", Singapore has developed comprehensive guidelines, in which sector-based initiatives for the energy, real estate and forestry industry are outlined. The cooling power station can be mentioned as a pilot project in the energy sector. In the context of the project, an underground cooling system for city neighbourhoods, such as the Marina Bay Quarter, where supply from the power station is obligatory for the commercial real estate, was created. The station was built by a private investor, which was a prerequisite for land allocation by the government (*Singapore District Cooling*, SDC).[546] In the building industry, the building authority worked closely with real estate developers to introduce more restrictive legal frameworks for energy efficiency and an improvement of the ***"Green Mark"*** building certification programme.

There is a strong political objective, a sufficient database and a strategic plan as well as the involvement in international initiatives (CDP, C40, ICLEI, Carbonn, GBPN). The INDC lists a significant number of (planned) measures, however, there is no other comparable (operative) action list for the reduction of GHG emissions.

By which initiatives does the public sector take a lead role with regard to behaviour and investments?

From a public sector view, the PSTLES ***(Public Sector taking the Lead in Environmental Sustainability)*** *initiative was implemented in 2006 and is currently revised and improved. In the end, the government is required to publish a sustainable report every three years, which states all institutions and connected initiatives.*

Economy

Which financing programmes are used to implement CO_2 reduction goals at the city level?

There are several mixed financing schemes for different sectors, which are basically implemented by the *National Energy Agency*. For energy saving reasons, measures were taken by a national partnership ("Energy Efficiency National Partnership") and implemented with support of the "Energy Efficiency Improvement Assistance Scheme"[547]. In the waste management industry, funds for projects are available via the co-financing programme "3R Fund"[548]. The programmes are not centrally managed through a conveyor belt, similar to the KfW in Germany. The *One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology (ADAS)* is worth mentioning in this context. It represents a tax incentive system, which is used by companies that replace their old and energy-intensive assets. The government works closely with industrial companies to control investments, which are implemented to increase the energy efficiency.

Are subsidies available for fostering the use of sustainable energy?

In addition to the initiatives mentioned earlier, several other initiatives, like the "Grant for Energy Efficient Technologies", a funding programme for energy-efficient technologies, exist. It is used for newly built and existing industrial buildings, where the focus of investment is allocated to energy-efficient equipment and technologies. The programme is managed by the *National Environment Agency* and the *Economic Development Board* as part of the business development. Overall, a variety of subsidies, financing

[545] UN-EP, 2015b // Singapore Economic Development Board, 2016
[546] Mulchand, 2016
[547] National Environment Agency, 2016a
[548] National Environment Agency, 2016b

programmes and incentives are available, which all focus on improving the energy efficiency. Additionally, the government measures the results of energy-related activities in financial terms.

Social

How are cooperation efforts between authorities and other organisations designed with respect to measures and initiatives?

The government closely works together with relevant stakeholders from different sectors, whereby the focus lies on energy production, buildings and industrial brownfields. A real estate development firm called CDL qualified all their engineers and property manager with the governmental programme "***Singapore Certified Energy Manager*** (SCEM)". Furthermore, the government provides subsidies to independent professionals, if they participate in the previously mentioned scheme.

Are there any efforts to minimise the energy consumption per citizen – e.g. by fostering the use of vehicles with alternative drivetrain options or public transportation?

Many initiatives include the society and general public on their way to CO_2 neutrality. The government has set the target to increase the public transport quota from 64 to 75 percent by 2030.[549] The efforts can be seen in the following two examples: Protected walkways of 200 kilometres towards public transport nodes were built and the trial introduction of autonomous mobility technologies, e.g. driverless buses, was pushed forward.

What are the efforts of local or city governments to improving the social commitment of citizens in terms of CO_2 emissions?

Several initiatives try to improve the social commitment. From a consumer point of view, the "Mandatory Energy Labelling" programme needs to be mentioned, which engages household appliance producers to inform their consumers about the power consumption of their devices. The government has additionally introduced several other instruments that should sharpen the awareness of energy consumption in the residential real estate sector (Green Mark Programme) and improve the energy management in the industrial sector (ISO 500001). Apart from that, different digital media such as apps are used to motivate citizens to actively participate. There is a close collaboration between essential stakeholders of each sector. Likewise, strategic plans exist, which include and address behavioural questions.

Technological

How does a city measure its achievements regarding the CO_2 reduction? Is there a uniform reporting system or reporting platform?

Singapore, as a city state, reports its emissions under the UNFCCC framework. In 2014, Singapore made its third communiqué and the first biennial update report available to the public. All relevant information is accessible via the UNFCCC reporting platform.[550] Additionally, Singapore reports to the CDP cities platform and to the carbonn Climate Registry (cCR).[551] The GPC is not included. What is negative is that the GHG emissions have not already been reported at deeper neighbourhood levels.

How does a particular city manage its databases with respect to inventory, energy consumption and CO_2 emissions?

The relevant information for preparing the UNFCCC reports and GHG inventories are determined by the *National Environment Agency* in cooperation with the National Climate Change Secretariat (NCCS) and other ministries.

[549] Ministry of the Environment and Water Resources, 2014, p.15
[550] http://unfccc.int/di/DetailedByParty/Event.do?event=go
[551] Carbonn.org, 2016

Singapore, as a city state, creates less burdens for reporting depth, because only limited hierarchical levels exist and emission results can simultaneously be reported nationwide. Singapore puts its focus on energy efficiency, whereby energy consumption is intensively monitored. The reporting processes are presented by the *Energy Market Authority.*[552]

What are relevant aspects of data protection and comparability and are there conditions making these data accessible for the calculation of emission inventories?

As in all other cities, fears of data transparency also exist in Singapore. Data are directly collected by the city, e.g. in cooperation with the Building Authority or the Energy Market Authority (an institution, which is subject to the Ministry of Trade and Industry). Due to the city state status, the integration of data is simplified, whereas the National Climate Change Secretariat (NCCS) assumes the whole data reconciliation with other parties, such as the *National Environment Agency*.

Legal

What regulations were used for implementing municipal CO_2 reduction goals?

Several sector-based laws, such as in the building and energy sector, exist. The *Sustainable Singapore Blueprint* represents the leading framework, which served for numerous regulations that became effective. This includes rules for the greening of buildings ("Landscaping of Urban Spaces and High Rises") as well as for the design of sustainable buildings during their planning stage ("Design for Efficiency Scheme") or a general codex on air pollution.

Are there any specific local or supraregional conventions for energy-intensive sectors or industries?

Two remarkable programmes are the "Energy Efficiency National Partnership" (EENP) and the "Energy Efficiency Program Office" (E2PO). The E2PO is a body of several agencies with the aim to improve the energetic efficiency in Singapore. However, the EENP is an initiative, addressing specific industrial companies to support improvements in their sectors. The EENP is a voluntary partnership programme of companies, trying to become more energy efficient to improve their long-term competitiveness as well as their ecological footprint. The EENP is focused on market players in the production and manufacturing industries, which like to implement a specific energy management. The EENP supports companies via a knowledge transfer network, the provision of resources and certificates for public recognition.

The *Carbon Emissions-Based Vehicle Scheme* **(CEVS)** has been revised and is now applicable for all new vehicles, taxis and recently imported vehicles, which were registered before 1st July 2015. Integral part of the programme are vehicles with low emission values (160g CO_2 per kilometres or less), which can be purchased with a reduced *Additional Registration Fee (ARF)*.

Are there official maximum emission levels that may not be exceeded?

The emission standards for vehicles are published by the *Pollution Control Department* (PCD) within the Ministry of Environment. Furthermore, some regulatory frameworks with regard to the quality standard of fuels exist. These frameworks are predominately sector-based. There is an intense collaboration with stakeholders to critically prove and amend those legal principles.

Environmental

How will authorities deal with growing urbanism tendencies and the related growth in the energy demand?

Singapore had 4.03 million inhabitants in 2004, reaching already 5.69 million in 2016. And the city will grow further and further. The "*Sustainable Singapore Blueprint 2015*" forms the guideline for every relevant sector of urbanisation.

[552] https://www.ema.gov.sg

Due to the fact that Singapore, as an island, has limited access to additional land, surrounding islands are integrated for urbanisation. Against this backdrop, additional land consumption will follow. There are innovative legal conditions in Singapore, e.g. the density of construction within city boundaries is increased.

What are the biggest urban challenges that local authorities will have to cope with if they wish to achieve carbon neutrality?

Beyond technological improvements in transportation, the integration of user communities in residential and commercial real estate was mentioned as one challenge for responsible authorities and real estate developers. As another challenge, the development of adequate knowledge in the context of a rapid change – despite regular education and training of professionals – was highlighted. Even in the context of renewable energy, Singapore's urban density, its limited surface area as well as the relatively flat location with its low wind velocity and limited geothermal resources create difficulties for the development of alternative energy options.

Hugh importance is attributed to environmental issues. The majority of grassland has been put under conservation. The urban growth is highly regulated and the urban mobility is a central problem area. Additionally, water and air pollution represent essential challenges. Soil sealing proceeds. Absolute emission values rise.

9.4.4 Comprehensive assessment

Action level "political"

Singapore, as a city state, has the appropriate institutions and conditions to implement CO_2-neutral initiatives. The political structure favours the realisation of such measures. Achievements in the field of neighbourhood-based approaches can be recognised. Even sector-based measures, in areas such as the energy and building sector, have already been implemented. In addition to those successful initiatives, the INDC lists a significant number of planned adaptation measures, whereas the operative implementation is neglected.

Action level "economic" (incentive mechanisms and behavioural change)

Several financing programmes exist, which are mainly realised by the National Energy Agency. Especially the fiscal incentive programme, which enables a one-year accelerated depreciation of energy-efficient technologies, is worth mentioning. For promotion of energy efficiency, additional subsidies for reconstruction measures in newly built and existing buildings are provided.

Action level "social" (participative/cooperative approaches)

Not only stakeholders but also the general public is consequently involved in the path to CO_2 neutrality. As already mentioned earlier, the public transport quota should be increased to 75 percent by 2030 and walkways in excess of 200 kilometres added to the current state. Beside such measures the education campaign for citizens, covering energy consumptions of household appliances or residential building sector information, plays a huge role in achieving CO_2 targets.

Action level "technological" (information systems, databases, innovations)

Singapore has a significant advantage in reporting GHG emissions due to its city state status. Low hierarchical levels simplify the integration of data, which are withdrawable from the UNFCCC. The National Environment Agency, in cooperation with the National Climate Change Secretariat (NCCS), is responsible for the whole data gathering. In this respect, it is negatively noted that there have been some determination problems of neighbourhood-based GHG emissions as well as some serious shortcomings in data transparency.

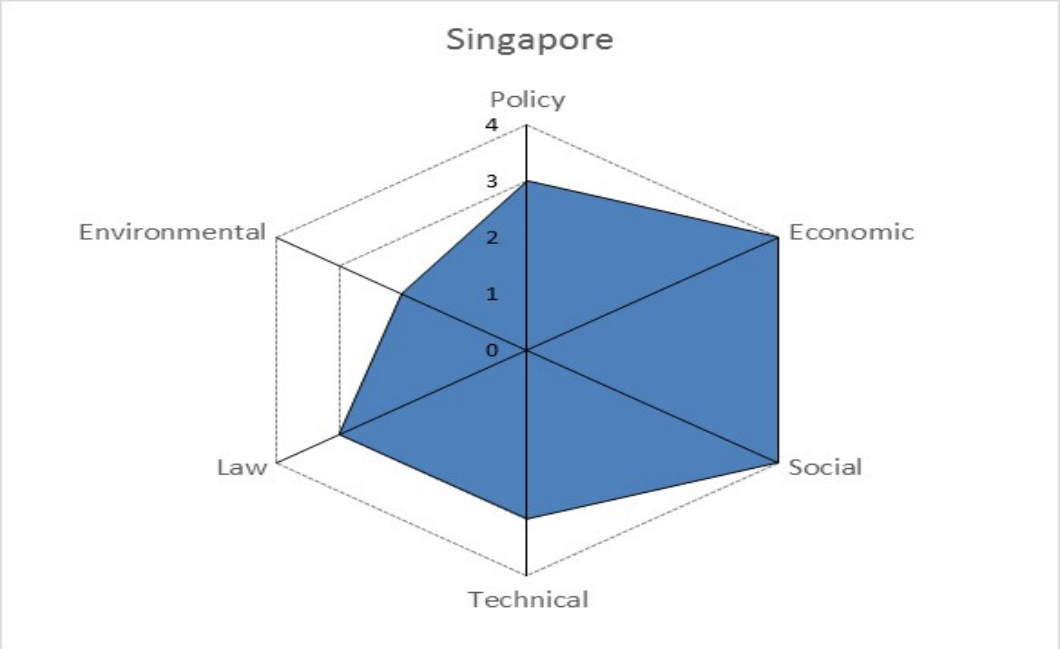
Action level "legal" (legal framework and regulatory interventions)

In the building and energy sector, several sector-based laws exist, which especially address the increase of energy efficiency. The Sustainable Singapore Blueprint programme carries out numerous regulations. Special emphasis lies on the Energy Efficiency National Partnership (EENP), which supports industrial companies of the production and manufacturing industries via a knowledge transfer network and certificates for public recognition.

Action level "environmental" (environmental effects)

With regard to the growing urbanisation, the geographical limitations of Singapore are a massive problem. This problem should be tackled through the connection of the surrounding island. Limited geothermal resources and low wind velocities make the development of alternative energy sources even more difficult. Water and air pollution are central challenges, due to the dense settlement. It is a positive fact, that a big part of the undeveloped land was put under protection.

Figure 17: Assessment of Singapore



Source: own representation

10. Answers to central research questions

10.1 Relevance of the action field "city" in the international context

- What is the significance of the action field "city" in other countries of Europe and the world with regard to the reaching CO_2 reduction targets?

The significance of the city as an actor in the fight against climate change, was, in principle, distinctly recognized by the European Union and documented by the *Leipzig Charta*, in 2007.[553] This central policy document was based on the results of intensive preliminary works, in particular of the Lille Action Program (2000), the Urban Acquis (2004) and the Bristol Agreement (2005). European cities and metropolitan areas, through the signing of the Leipzig Charta, have agreed to the conditions under which extensive plans for the sustainable development can be created, which should be implemented by the city or the municipality. For European cities, there are two political messages that are essential for their further development. Firstly, an integrated urban development should basically be implemented in Europe. For this purpose, the appropriate framework must be obligatorily implemented at national and European levels. However, in the context of the integrated urban development, the focus should be placed on the strengthening of the socially disadvantaged neighbourhoods. Furthermore, with regard to the German role, in the context of the development of a framework on European levels, it is particularly important to establish long-term approaches for integrated urban development politics.[554]

For all of the large European cities analysed here, within this context, there are clear framework conditions and guidelines (see Chapter 9), which facilitate a structured decarbonisation. The future need for action is especially important for the developing and emerging countries (see Chapter 3.4); however, the effective endeavours and, in particular, the target achievement, with regard to the decarbonisation of these cities, are often limited. This can largely be attributed to the frequently centralized structures (such as, for example, in China) and to a performance measurement dedicated so far almost exclusively to the economic development, however, also partially, to an inadequate governance (for example in Sao Paolo) or to an insufficient financial equipping and lack of financial stability (for example in Cairo). The real significance of the major metropolises often goes beyond the available freedom of action. An expansion of the local competencies and an upgrade of the management are necessary.

10.2 Interaction of segments: building, mobility and green areas

- What role do in these cases neighbourhood-related approaches with regard to building, mobility and green areas play either individually or as triad?

While in Germany reduction strategies and greenhouse gases are already extensively considered in the planning requirements and spatial planning concepts of new neighbourhoods nationwide, at international level – specifically in emerging and developing countries – this is not the case. Internationally, the general tendency are flagship projects dominating at neighbourhood levels (see Chapter 11.3), and they cannot experience a profound transformation without further scaling.

The three levels – building, mobility and green areas – will be addressed in practically all of the analysed metropolises, whereby specific green and recreational areas primarily attract intensive attention in developed regions. An important finding of the present study is, among others, that isolated initiatives, which are only directed towards building or mobility, have suboptimal results as a consequence. In the context of the profound transformation of the cities, integrated and cross-sectoral solution approaches are sought. The necessary interdepartmental coordination does not take place in the majority of the analysed cities. Besides, it could be stated

[554] European Urban Knowledge Network, 2007
[555] Federal Ministry of Transport, Building and Urban Development/Federal Institute for Research on Building, Urban Affairs and Spatial Development, 2007, p. 10

that sector-related initiatives, which are often controlled at a central level, clearly still dominate. In addition to Germany, neighbourhood approaches can especially be found in the European neighbouring countries.

10.3 Target-oriented approaches for measuring the CO_2 reduction success

- How do other states and cities measure their CO_2 reduction success at city and neighbourhood levels and which are the challenges that are present for the matter at hand?
- How do other states and cities approach the registration of the building stock, among other things, with regard to the data protection as well as comparability and access requirements to data and balancing concreteness?

The present study has shown that, practically, all analysed metropolises, in the context of metropolitan networks, promote the inventory of greenhouse gases. The depth of recording, the included areas (scopes), the regularity, as well as the verifiability of the results, however, are very different, just as the form of the municipal cooperation and the data and information exchange between responsible and cooperating authorities.

Central challenges include the derivation of local emission factors, the continuous data recording, the migration of data coming from various sources, the usage of international, uniform reference values as well as the personal accoutrements of the corresponding administrative bodies. The integration of data, which is needed by companies or private real estate portfolio holders, is also a central challenge.

The building stock will be derived, based on geographical information systems, land registers or property tax documents. With regard to the surveying of concrete expenditures and the individual energetic efficiency, the EPC datasets will be partially used. Embedding can also be constituted, based on data coming from real estate (marketing) databases as well as information from local utility companies. Data uncertainty and completeness are very high in these areas, which is why the validity and reliability of the information are only of limited use.

As a directive, the GPC is an unstoppable worldwide trend. When it comes to the reporting platforms, the CDP as well as the cCR dominate.

10.4 Contractual conditions and regulations for the implementation of CO_2 reduction targets

- Are there European, international and national comparable contractual conditions and regulations as well as funding programmes for the implementation of the CO_2 reduction targets analogous to the Energy Saving Ordinance (Germ. Energieeinsparverordnung EnEV), the EU energy efficiency directive and the KfW programmes “Energetic urban redevelopment – energy efficient renovation” and “Energetic urban redevelopment – neighbourhood maintenance”?

In various countries, analogous provisions, such as the Energy Saving Ordinance were identified (see Chapter 9). Since within the European context they already present a common root in the form of the Energy Performance of Buildings Directive, they can definitely be considered as comparable – although the national implementations also contain specific requirements (for example with regard to the local building typologies). At any rate, when it comes to the general maturity and the aspiration level, these provisions are, however, similar. Beyond the European borders, the forms of the corresponding provisions with regard to the aspiration level and the focus are, admittedly, not comparable with the German requirements. The present study has revealed that, when it comes to the financing approach, there are already clear differences, with regard to the general approach strategy as well as to the programme composition. Thus, it appears that many programmes similar to the ones of the KfW at local levels, do not offer any significant advantages, with respect to the market conditions. Their acceptance will be even be reduced, with management costs being factored in, which leads to individual programmes not offering any advantages in comparison to the affordable conditions of commercial banks.

When it comes to the comprehensive programmes of the KfW regarding neighbourhood rehabilitation, there is no internationally comparable instrument that can be presented. The scaling of the approach via the GCF seems reasonable.

In many emerging and developing countries, until the present time, the focus has only been on improving the CO_2 intensity and not on the absolute reduction targets. Especially in the mega cities, there is a huge potential for the reduction of greenhouse gases with a clear increase of the ambition level. Individual examples demonstrate that a lot of progress can be made, especially with the help of international partners and a mixture of funds provided by the private sector as well as through development assistance.

11. Recommendations for action and core issues

11.1 Fundamental preliminary remarks regarding the objective

Recommendations for action regarding the decarbonisation of cities must be derived based on the provisions made for the worldwide reduction of greenhouse gases. In order to be able to realize the objective of limiting global warming to 2°C (i.e. 1.5 °C) in comparison to the pre-industrial level (see Chapter 3.5.2), there is a worldwide carbon budget of 750 billion tons available, according to latest estimates. Given the ***current yearly anthropogenic emissions of 33.508 million tons***[555] of carbon dioxide, in 2015, this means massive savings until the complete decarbonisation in 2050. They can be broken down as follows:

Table 43: Residual carbon budget

Current anthropogenic CO_2 emissions worldwide p.a. (2015/2016)	33.5 billion tons
Overall residual budget until the complete decarbonisation	750 billion tons
Reduction to the 2°C target until 2050 (here: constant annual assumption)	on average 22.05 billion tons p.a. maximum
Real percentage of CO_2 emissions for cities (2015/2016)	70% thus circa 23.45 billion tons
Mathematical percentage of CO_2 emissions for cities in 2050 in case of unchanged emission intensity	>85%

Source: own representation and calculation, data: BP Statistical Review of World Energy June 2016, IPCC 2014a, UN-Habitat 2011, UN DESA 2015.

The above-mentioned figures once again illustrate the extent of the necessary decarbonisation efforts that cities have to make – in particular in the context of the progressive urbanisation.

Already in the "The Limits to Growth" Meadows stated that our structures react with the same patterns and approaches, if the very same systems do not function any longer.[556] It is clear that the approach "more of the same" cannot solve the challenges that appear on the path to decarbonisation and which cities have to face. Today, at worldwide level, the free market economy dominates. Often interventions concerning the powers of the free market are negatively judged. However, it seems beyond question, that the current system presents major gaps, because false price signals are sent and, ultimately, negative external effects occur. Against this background, it is absolutely necessary, that the *formative state* anticipatively intervenes in the market processes, in order to facilitate the mitigation and adjustment on the way towards a greenhouse gas-neutral national economy.

Cities can already today effectively limit ***greenhouse gas emissions by using existent, tested and financially advantageous technologies and other solution approaches.*** Estimates start from latent reduction potentials of up to 70 percent. Here, it is important that a ***multitude of the (technical) solutions, in the urban context, lead to positive present values.*** This means that, when it comes to market interest demands, the present value advantages exceed the investment and implementation costs.[557] It is thus possible to realize the economically advantageous development and the reduction of greenhouse gas emission, in cities at the same time.[558]

At the present moment, diverse possible approaches exist for cities with regard to the reduction of carbon dioxide emissions, which, until 2050, could generate savings of cumulative $ 16.6[559] billions and lead to massive reductions

556 BP Statistical Review of World Energy , 2016
557 Club of Rome, 1972
558 Enkvist et al., 2010, p. 8
559 UCLG, 2016, p. 40
560 Gouldson et al., 2015, p. 3ff

of emissions. In order for these decarbonisation objectives to be realized within the estimated timeframe, coordinated efforts by governments, companies, municipalities as well as by individuals will be required. Against this background, cities assume an exposed position regarding the reduction of greenhouse gas emissions, since they are currently responsible for approximately 70 percent of the worldwide greenhouse gas emissions (confer Chapter 4.2).[560]

The present recommendations for action bring together the compiled findings of the study. In doing so, none of the options regarding the reduction of greenhouse gases are prioritized. Instead, the recommendations should provide a selection of practice-oriented and tested alternatives regarding decarbonisation. The central ***long-term transformation of climate-sensitive processes and structures requires a wider mixture of instruments***.

The decarbonisation of cities and neighbourhoods cannot be aspired or achieved separately from other social objectives, such as participation, minimum care etc. Besides, the protection against extreme weather events (especially in coastal regions) is a focal point. The *Sustainable Development Goals (SDG)* and here, in particular, *SDG 11*, specify that ***"cities and settlements"*** must be made ***"inclusive, secure, resilient and sustainable"***.[561]

In the meantime, a ***broad number of globally or regionally focused urbanisation reports*** have been produced. The content always deals with the aspects that are in the centre of attention: vulnerability, fight against poverty, urbanisation challenges such as infrastructure provision, participation, financing of measures and prevention of regionally effective environmental pollution as well as the mitigation of the global climate change. In addition to regionally, sectorally or subsectorally focused reports, differences in the ***accentuation of the proactive solution approaches*** can be found**.**

In addition to bundled technical solutions, such as climate energy efficiency, the governance and integration/participation of the population themes are regularly in the centre of attention.[562]

Proposals for solution approaches are methodically divided into the following approaches:

- technical infrastructural elaborations,
- governance approaches,
- sectoral solutions and neighbourhood-related approaches,
- strengthening actor groups.

The statement that the respective instruments and measures must always be selected, against the background of the individual starting situation of the respective urban area, appears to be essential. It is often stressed, that the real estate is heterogeneous and thus difficult to be compared with one another. This is valid in an exponentiated form for cities, which is why, urban areas are also asked to propose ***individual solutions against the background of specific starting situations.*** It is because of the various initial situations that the recommendations for actions have to be differentiated between developing, emerging and industrialized countries.[563]

The *German Advisory Council on Global Change (Germ. WBGU)* emphasized as well, that a ***"plurality of the transformation pathways"***[564] is required, which are justified with diverse (economic, cultural, climatic) starting situations for the respective cities. Based on the experiences in the context of the surveys belonging to the current study, differences are specifically based on:

- the (type of) political decision-making,
- size and growth perspectives,

561 UN-Habitat, 2011
562 Federal Ministry of Economic Cooperation and Development (Germ. BMZ), 2015
563 German Advisory Council on Global Change (Germ. WBGU) , 2016, p. 131,134
564 World Bank, 2013a
565 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 38

- the general development status,
- the attitude of the general public with regard to environmental protection.

Regardless of the heterogeneous situation, for individual cities, however, three clusters can be identified, to which typical measures for decarbonisation are allocated.[565]

Table 44: Cluster allocation

Cluster	Cluster characterisation	Exemplary measures
Cluster A: *Mature cityscapes, built cities, clear governance and defined infrastructure*	• industrialized countries • high financial opportunities • developed environmental awareness within the general population	• rehabilitation of neighbourhoods • consistent decarbonisation • stringent measurement and monitoring • technical innovations
Cluster B: *New (central) planned cityscapes (China, India etc.)*	• comparatively good governance and political stability • adequate financial basis • growth targets often in focus	• decarbonisation included within construction phase • low-carbon transport • changing the KPI (sustainability)
Cluster C: *Quick and "confused" growing cityscapes in developing countries*	• higher proportion of informal settlements • poor financial basis • barely existent environmental awareness within the general population • fight against poverty as a central challenge • often unstable political conditions	• focus on megacities • international help • implementing governance • low-hanging fruits

Source: own representation

When it comes to the subsequently presented measures, the priority cluster classification will be shown in each case.

11.2 Implementation procedure

After the *measurement of the carbon dioxide emissions*, cities can develop an *individual action plan* by developing and comparing various reduction scenarios. In doing so, technologies and methods that are suitable to the local conditions will be exclusively used.

The existence of a structured implementation plan, even since the early phase of the strategy development, increases the level of clarity among those involved and makes the implementation not only predictable but also controllable.

The *CO_2 inventory* is a critical first step that municipalities have to take for assessing the necessary extent of savings required. The already existent standards and instruments can help cities with this first step (see Chapter 6 and 7). Nonetheless, problems may start with the following step, when tranferring *the inventory data into the foundations for deriving an effective strategy.*

566 Ibid.

A strategy for the reduction of greenhouse gases must not necessarily be limited by size or geographical location. The case studies presented in this study show, for all small as well as for medium and large cities, that a wide range of practical options exists, when it comes to the optimization of the individual CO_2 balance. Each municipality should be able to choose a ***mixture of strategies, action alternatives and concrete measures/actions***, which best satisfy the individual economical, social and ecological framework conditions. However, in the process, there is not a simple basic rule to follow. While some municipalities are in the position of opting, by far, for aggressive approaches towards reducing greenhouse gases, in turn, other should follow a slower, step-by-step approach.

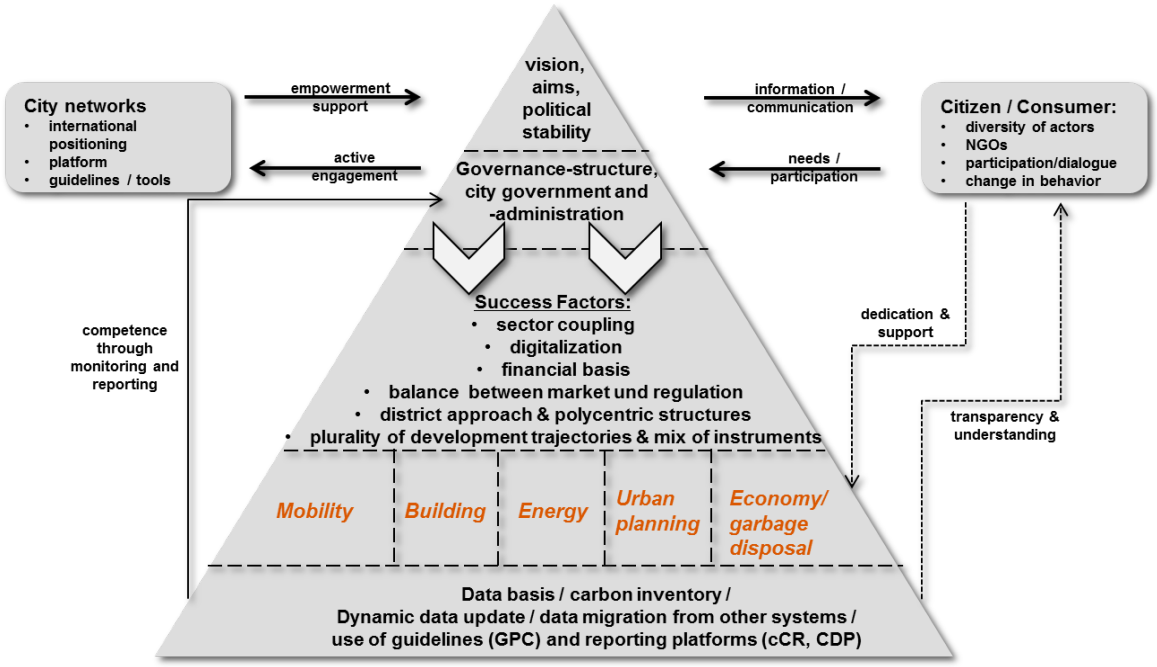
After the ***calculation of the potential target values of the greenhouse gases***, municipalities should be in the position of integrating various ***instruments for the ongoing success control***, for location determination and, ***if the case may be***, ***a revision of the measures***. Furthermore, it should come to the ***comparison of scenarios***, in which a number of reduction strategies are used. This analysis can offer assistance to both municipalities as well as to the stakeholders involved, in order to select precise measures, in a transparent and cost-efficient manner, against the background of specific emission targets.

The proposals outlined here can also be used in combination. They include the areas, which, through the evaluation of cases studies and interviews with experts, can be identified as those that show the biggest potential for the reduction of greenhouse gases (building, land usage, transport, waste as well as energy supply and efficiency) and whose ***feasibility, due to the involvement of relevant stakeholders*** as well as due to ***the fiscal cost-benefit analysis***, seems to be reasonable. Against the background of the multilayered nature of the political processes, a common approach, on several levels, by political decision-makers is necessary, in order to implement the described measures and optimize the results.

In Germany, the present implementation assistance is particularly comprehensive, given that, on the one hand, the Federal Institute for Research on Building, Urban Affairs and Spatial Development (Germ. BBSR) conducts its own research field on “energetic urban regeneration” and, on the other hand, in the federal states as well as at the *German Institute for Urbanism* in the context of the national climate protection initiative, different guidelines are in existence.

The following figure illustrates the essential elements and their relationships in the context of the successful implementation of a decarbonisation strategy.

Figure 18: Essential elements of a decarbonisation strategy



Source: own representation

The "ZECOS – Communal Zero CO_2e Emission Certification System" was, in the period from November 2011 until April 2015, a European project with 11 partners dealing with the operational measurement and reduction of greenhouse gases, among others with the participation of the city of Morbach.[566] With the approach, the usage of local resources was intensified and the improvement with regard to energy efficiency was initiated in various sectors. The local transformation process was thus actively accompanied. The approach consisted of three components:

1) The "Zero Emission Concept" includes three elements: first, as part of the material flow analysis (MFA), the energy balance will be created, on which a potential analysis, concerning energy efficiency and renewable energy, is built. Furthermore, a calculation of diverse scenarios will be undertaken. The objective of the MFA is to summarise all ascertained potentials and ideas into an action plan. The second element is the CO_2 balance, which can be created using diverse methods, for example, based on the GPC directive. The last step for the derivation of a concept regarding CO_2 neutrality is the assessment of the opportunities for financing the planned measures.
2) The second component includes the effective implementation of the activities necessary for the attainment of the previously defined objectives. This also includes the control of indicators, the adjustment of the CO_2e, the creation of the energy balance and assistance for the political processes.
3) The "*Zero Emission Management System" (ZEMS)* is, finally, an integrated approach, in order to make advances in the direction of the CO_2 neutrality. It includes the prerequisites and directives for participating in the ZEMS processes as well as the framework conditions and usage recommendations. Through constant planning, assessing and acting, the degree of target attainment can be measured and, through eventual selective corrections of the measures, also be optimized.

Against the background of the future decarbonisation, at the level of German cities, the approach, in the aforementioned project, offersa reasonable component, i.e. a "blueprint" for the individual decarbonisation strategy as well as the structured data analysis and the monitoring.

567 See Chapter 5.1 // www.zecos.eu

11.3 Recommendations for action for the further implementation of professional framework conditions

11.3.1 Urban planning and control processes regarding transformation

Effective and *workable urban planning and control processes, sensu stricto good urban governance*, are central success factors[567], when it comes to the realization of decarbonisation strategies on local levels. In this context the *municipal city administration and government* is, dependent on and involved in various regional, national and international structures, agreements and provisions. The *scope for action, at the level of local decision-makers, is worldwide very heterogeneous.* While, within the European Union, for example, the *subsidiarity principle*[568] (Art. 5 Par. 3 TEU) as well as the *municipal self-administration*[569] (Art. 4 Par. 2 TEU), are to be ensured at the level of national states, in Asia and Africa, powerful central provisions are often given. Nevertheless, the general *success factors of good urban administration and governmental work* can be characterised on the basis of the analysed examples as follows:

1. high levels of freedom with regard to decisions and competencies in urban issues ("home rule" as well as "decentralization" and "local self-government")[570] as well as dignitaries directly elected by the people,[571]
2. participation of the local population (from pure information to co-decision) as well as public discourse,[572]
3. opportunity regarding the long-term orientation of the political provisions,[573]
4. cross-sectoral integration of climate policy goals[574] and development of independent climate protection plans as well as commitment regarding the adherence to planetary guidelines,[575]
5. clear planning instruments[576] as well as the opportunity for the (quantitative) ongoing progress monitoring,
6. centralized, well networked administrative authorities,
7. level of training as well as selection of employees according to the achievement principle,
8. accountability and transparency for public administrative bodies,
9. financial endowment and adequate salary payment,
10. clear implementation of the defined laws and prosecution of offenders with regard to (environmental) requirements,[577]
11. involvement and interaction with the international network of cities,[578]
12. general principles: sustainability, subsidiarity, justice, efficiency, responsibility, safety & legal security, reaction times, openness, willingness to innovate.

568 German Advisory Council on Global Change, 2016, p. 101ff, p. 114f // UN-Habitat, 2015b, p. 2
569 http://www.europarl.europa.eu/brussels/website/media/Basis/Vertragsartikel/Pdf/Art_5_EUV.pdf
570 http://www.eur-lex.europa.eu/legal-content/DE/ALL/?uri=CELEX:12008M004
571 UN-Habitat, 2015b, p. 2
572 German Advisory Council on Global Change, 2016, p. 104: In relation to the direct election of the mayor, there are, however, also disadvantages.
573 UCLG, 2016c, p. 12 as well as p. 26ff
574 German Advisory Council on Global Change, 2016, p. 132: Criticism regarding the political target objectives often set on a short-term basis, which impede the effective climate protection.
575 German Advisory Council on Global Change, 2016, p. 120 with regard to IPCC.
576 German Advisory Council on Global Change, 2016, p. 142, 145: Development of urban climate protection plans, which support the 2 degrees objective.
577 World Bank, 2013
578 German Advisory Council on Global Change, 2016, p. 221: Often times, such as in the case of India, there are laws indeed, however the offenders will not be adequately prosecuted.
579 UCLG, 2016c, p. 13

Governance is not the same thing as regulatory framework conditions, such as laws or decrees. Nevertheless, they are always part of the political provisions, which can, however, be implemented in different ways. In practice, good governance is always characterised by a well-balance mix of the following alternatives[579]:

- "governing through regulation": decrees, interdictions etc.
- "governing through provision": provision of local public transportation, systems for waste separation, parks etc.
- "governing through enabling": qualification of the general population through training and information as well as financial support.

The extensive competencies of the urban decision-makers are thus essential. The starting situation of individual, large cities is , however, very different. While, Mexico City, for example, is not autonomous, it is maximum in Buenos Aires and exceeds the level of freedom of Berlin, Paris and even London. The *coordinated provisions for a metropolitan region*, are often also impeded by the fact that they consist of many individual municipalities with a different financial endowment and divergent interests (for example, Paris and Los Angeles). Cities with an individual central administration can, however, proceed in an efficient and targeted manner (for example, NY). Here, it is important that the *barriers between municipalities belonging to a metropolitan region* are reduced. A good example is the greater area of Stuttgart, one of the eleven metropolitan regions in Germany, to which, in addition to the city, further municipalities have merged, at their own decision, following common interests and development plans.[580]

Strengthening civil society actors, which also support the urban governance, such as non-governmental organizations (NGOs) and neighbourhood assistance organizations (community-based organizations CBOs), is central. The German Advisory Council on Global Change also justifiably underlines that activities of the civil society, NGOs or companies, contribute to good governance.[581] Singapore has exemplarily managed to intensively integrate companies.

When it comes to environmental protection, *group and community-oriented approaches* promise the best long-term effect.[582] Thus, good governance should also offer a level of freedom, when it for example comes to neighbourhood-related self-regulation and a related effective representation of interests. In Chicago, for this purpose, target-oriented approaches were implemented.

Specific successful pilot or flagship projects offer a *potential for scaling within city networks*. The transfer of knowledge to other cities and between pilot projects moves municipalities in the position of quickly building the necessary know-how.[583] Being a part of the city networks also offers clear advantages with regard to taking over best practice approaches for better governance.

With regard to the above-demanded climate protection plans on local levels, it must be added, that already today they are regularly written down in the form of visions or mission statements for almost each metropolis covering the fields of environmental protection and sustainable growth, participation etc. In this context, it is problematic that these statements rather have a fig leaf function, for example, they provide lip service and they are partially in powerful contrast to the real developments (for example in Sao Paulo). Here, it is important to *introduce, through city networks, intensive and also external controls and sanctioning mechanisms, in order to prevent the "green washing"*.

580 Bulkeley and Kern, 2006, p. 2237-2259
581 Stuttgart Regional Association, 2016
582 German Advisory Council on Global Change, 2016, p. 381
583 Keizer and Schulz, 2013, p. 153-165
584 UN-IDO, 200, p. 4: United Nations Industrial Development Organization.

Table 45: Area planning and control instruments

Cluster	*A, B, C*	CO_2 **impact**	*Indirect, but high*
Implementation effort	*Very high*	**General population acceptance**	*Very high*
Long-term stability	*Questionable*	**Regulation necessary**	*Yes*
Financial effort	*High*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical in terms of success	*Yes*	**Resistances**	*High*

Source: own representation

Good governance is the fertile ground for each of the action alternatives for decarbonisation presented here, which is why it is essential in all three clusters. If needs be, the implementation of a clear top-down approach indeed reduces friction costs, however, it does not help in practice, when it comes to harmonizing the ecological objectives with the economical reality.

The present city networks[584] with powerful governance reference can, with regard to this section, assume a leading role – in particular also with regard to the scaling of good approaches.

11.3.2 Limitation of carbon dioxide-intensive industry production

With regard to the local added value, the ***isolation of expansion and emissions*** is central. The ***improvement of the energy intensity*** thus also plays a serious role, such as the ***turning away from carbon dioxide-intensive industries*** (for example, electricity generation, metal, cement and chemistry). In the sector of municipal planning, concrete approaches should be defined for the reduction of greenhouse gases in the industrial field. It is obvious that this can only be a long-term process, which must take place in an intensive dialogue with the stakeholders – in particular, since, due to the influence on the work market and employment, massive (short-term) conflicting goals can occur.

In particular for cities, there is, however, the problem of the conscious "exports" of emissions of any type, in regions outside the city boundaries. For example, in China[585], industries that often , to a certain extent, contributeto the local air pollution in the urban area, are closed and rebuilt in regions that hitherto present a lower level of pollution (often times, economically underdeveloped). Thereby, no emissions are actually reduced, they are only displaced and the national, or by the transfer over country borders, global greenhouse gas emissions, as a consequence, are not reduced. The ***effects of the so-called carbon leakage are to be avoided***.[586] The measurement of CO_2 emissions, on the basis of Scope 3[587], can thereby contribute to the fact that the least extensive mainstreaming of greenhouse gas emissions takes place.

It is essential to take the regional economic repercussions of the defined measures into account, in order to limit the negative implications of the structural change – such as, for example, the loss of work places – through industrial policy measures. A good example for a successful transformation, from a carbon dioxide-intensive industrial town to a prosperous "green" region is, for example, Essen.[588]

585 UCLG, 2016c, p. 5ff
586 Zhongxiang, 2015 // Feng et al., 2013, p. 11654ff
587 Federal Ministry for the Environment, Natural Conservation and Nuclear Safety (Germ. BMUB), 2016d, p. 8
588 See Chapter 6.2.2
589 http://gruene-hauptstadt.essen.de/essen_2017/erlebe_dein_gruenes_wunder_/Kampagne.de.html

The *sector interconnection*[589] is, in many respects, to be intensified. Industry waste heat can be used as an energy source; properties can be intensively integrated as energy producers or savers. In this context, the sector interconnection platform of the NRW Energy Agency can be mentioned as an example.[590]

Table 46: Area of restriction for the carbon dioxide-intensive industry

Cluster	*In particular B, C*	CO_2 **impact**	*Direct*
Implementation effort	*Very high*	**General population acceptance**	*Partially low due to the loss of work places*
Long-term stability	*Questionable*	**Regulation necessary**	*No*
Financial effort	*Very high*	**Quick wins**	*Possible*
Scalability	*Not specified*	**Pilot projects**	*Possible*
Critical for success	*For cities with high percentage of carbon dioxide-intensive industry: yes*	**Resistances**	*High (industry & lobbyists & concerned employees)*

Source: own representation

11.3.3 Consumption reduction and efficient waste management

Too often, sustainability and "green politics" are still seen as brakes on growth and as leading to the limitation of the personal level of freedom. Ultimately, there are, however, the ***citizens, who, through their engagement and public pressure, can cause the biggest changes***, i.e. facilitate them in the first place.[591] The change and reduction of the individual consumption is thereby a fundamental prerequisite for realizing the decarbonisation objective. For this purpose, ***substitution*** and ***dematerialisation*** are necessary – also the usage of less damaging materials and the reduction of the resource consumption as a whole. The targeted reduction of consumed quantities and general resources , in addition to the impact of behaviour patterns, falls intensively back on a ***professionalisation of the waste management*** – hereby, ***instruments such as the recycling economy, sharing economy and strengthened recycling***, are essential.

The necessary ***change of consumption patterns***[592] can be encouraged and achieved, especially in creative cities, through social innovations. The ***influence of the citizens' behaviour*** must be centrally considered, in the context of decarbonisation solutions, and clearly dominate the possible contribution of pure technical approaches.[593]

In the last few years, sustainable consumption intensively tackled the so-called ***sharing economy*** – i.e. the intensive sharing, swapping and giving away. The development of sharing economy instruments and thus also the powerful combination of classic market economy, social entrepreneurship and participation are critical for success in the context of the extensive decarbonisation.[594] Here, cities can offer support, in particular through the ***reduction of barriers when it comes to the necessary authorizations or through financial incentives***.[595] Seoul, for example, has especially created the "Seoul Innovation Bureau", in order to provide support for a total of 350 companies of the sharing economy until 2018.[596] In addition to rather smaller awareness-raising initiatives, such as reparation cafes, this segment includes *car sharing* projects, which promise to have a potentially bigger impact in

590 Federal Ministry for the Environment, Natural Conservation and Nuclear Safety (Germ. BMUB), 2016d, p. 26f
591 www.energieagentur.nrw/tool/Sektorenkopplung
592 LSE Cities et al., 2013, p. 5: The conclusion, that a more powerful implementation pressure arises itself through citizens.
593 Flade, 2015, p. 211-257
594 UN-EP, 2012a, p. 50: „Human behaviours… play a critical role." // Enkvist et al., 2010, p. 7
595 Rifkin, 2014, p. 50
596 German Advisory Council on Climate Change (Germ. WBGU), 2016, p. 350
597 Seoul Metropolitan Government, 2015, p. 1ff

the context of decarbonisation. The *sharing and swapping economy principally* can also be understood as a protest, i.e. countermovement, when it comes to a pure market economy consumption orientation.

Climate change, from the point of view of the people involved – or rather, more precisely, the people who are currently in the position of still preventing the worst effects of the global climate damage through their actions – is a complex and, in particular, phenomenon which is difficult to understand. Individual actions and the impact fall apart, spatially and temporally, and the chain of effects for individuals "disguises" the (negative) effects of its present consumption behaviour. This problematic area analogously applies for industrialized and developing countries, however, it is significantly more pronounced in a few developed regions. Therefore, initially, before diverse measures, it is essential to establish 1. *enlightenment and transparency* and *2. to practice low-threshold communication***.** As an example, the household waste, in large areas of Asia (for example, Indonesia and Thailand) is thrown directly in front of one's own door and "at best", periodically, burned on-site. This has come about because, in these regions, historically, packaging and waste have primarily consisted of organic substances, which rot easily (for example food products were often packed in banana leaves). With the increased purchase power, a situation arose, in which the products allowed for human consumption, were, for example, packed in plastic or, for example, in case of batteries, contained chemical substances. Nevertheless, these things, due to the lack of knowledge and experience, were discarded analogously to the "traditional" way – with related catastrophic consequences for the people and the environment.

Based on cities, the following problem areas are central:

- electronic waste including smartphones, TVs and various household appliances[597],
- plastic waste and plastic materials in general,
- waste with chemical substances.

The *product cycles* have, in the past few years, reduced more and more, due to the high requirements of consumers, always with regard to new "features"/solutions as well as the high competitive pressure. And, thus, a stronger *focus on durable everyday objects* must also be promoted.

The approaches for a short-term solution regarding existent challenges are primarily to be searched in regulatory approaches:

1. legal requirements regarding production, durability and disposal requirements[598] (for example, through the EU Eco-design Directive as well as the EU Directive for Electrical and Electronic Equipments),
2. procurement requirements of public authorities,
3. labelling of devices with higher durability,
4. supporting the change of behaviour (for example by establishing reparation cafes etc.),
5. influence by rules/bans regarding the waste volume (for example banning disposable packaging, plastic bags etc.),
6. "high" waste collection charges for residual waste.

It must also be avoided that *electronic waste leads to negative external effects* and (as before, on a large scale) that it will be "*disposed of cost-effectively*" in developing countries, across borders. Strengthening[599] the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal*[600] is an essential step here. The internalization of real and, in particular, correct disposal costs will be also parallely reduced through the rising costs of consumption. *Electronic waste, however, also represents a source of income*, which is why

598 Baldé at al., 2015 // WGBU, 2016, p. 349: Frequently, electronic waste will be exported in developing countries (partially illegal). This partial, inappropriate recycling and the landfilling endanger local livelihoods and the health.
599 Huisman et al., 2015: Only 35% of the electronic waste in Europe was correctly disposed of in 2012.
600 EUR-LEX, 2006
601 „Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal" from 22.03.1989, Decree EG No. 1013/2006, EUR-LEX, 1989 // see hereto German Advisory Council on Global Change (Germ. WBGU) Recommendations 2016, p. 197

projects regarding the health-compatible recycling of such waste, involving local actors, can lead to important contributions towards development and reduce environmental risks.[601] Related projects can be easily realized by municipalities in collaboration with NGOs or local initiatives.

With regard to the waste disposal, ***recycling and refill systems*** must be ***significantly strengthened***. Until now, approximately 2/3 of the municipal waste were not disposed of in such a way.[602] There are also high potentials in developing and industrialized countries. The strengthened ***focus on recycling, reutilisation and cycles*** has multiple advantages:

- reduction of municipal expenses,
- strengthening of the shared economy,
- creation of employment opportunities,
- reduction of local environmental impacts,
- reduction of plastic materials being thrown into oceans,
- reduction of the "private" waste incineration (common in Asia),
- reduction of greenhouse gas emissions from landfills.[603]

The waste material and recycling approaches, which are present in industrialized countries, must be further developed for the ***complete recycling economy*** in a targeted manner. ***Cradle-to-cradle approaches*** are instruments, which support the recycling economy.[604] However, they have until now been in the state of pilot projects and limited to industrialized nations. The coverage, if possible, of all citizens (waste collection coverage in % of the city population) as well as the rate of the professional waste disposal (controlled disposal in % of the collected and properly managed waste) in almost all industrialized countries amounts to almost 100 percent, however, the maximum recycling quota amounts to approx. 50 percent (recycling rate in % of the total waste generated).[605] Against this background, there is still a very high potential for optimization in the countries concerned. In developing or emerging countries, first of all recording the total catchment area must be ensured – the rates are partially still under 50 percent. As a second step, the controlled disposal must be optimized. Only then, one can actively work on the aspects of the recycling economy. There are the biggest potentials, since recycling quota of only 8 percent are reported, in less developed metropolises, such as, for example, Buenos Aires or Guadalajara. Emerging countries offer starting points for the creation of incomes as well as for the targeted promotion of the recycling economy. This should be followed by clearly provided development plans, since the current situation of the informal waste management is regularly characterised by working conditions that are dangerous for one's health, high leaks of chemical products as well as the selective usage of useable waste. In this way, it is possible, for example, in Cairo, to integrate the informal sector on a contractual basis.[606]

Cycles should, however, not only be referred to consumer goods or food packages in an isolated way. As an example, in **Tel Aviv,** ***up to 100 percent of the water resources have already been recycled***.[607] The development of the water and sewage infrastructure, within existent urban structures, is, however, extremely cost-intensive and barely feasible. As an example, it is noted that, **in the majority of the emerging megacities, an insufficient sewage infrastructure** has been quoted. Frequently, 90 percent of the waste water, from industry and private households, reaches rivers unfiltered.[608] The development and operation of a corresponding infrastructure is, despite the concomitant resource consumption and emissions, urgently necessary. Due to the broadly cultivated

602 Buchert et al., 2016
603 ISWA, 2012, p. 5
604 Explanatory note: these have contributed, according to IPCC, in 2010, to approx. 3% of the total anthropogenic GHGs, cf. IPCC, 2014c, p. 385
605 Toxopeus, et al., 2015, p. 384ff
606 Population Reference Bureau (PRB), 2016, p. 6: San Francisco, 48% as well as Adelaide, 54%.
607 Kingsley, 2014
608 Schellnhuber, 2015, p. 638
609 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 82, 147

surfaces, the "subsequent" implementation of the two-chamber sewer system is often, barely feasible (as the long-standing successful projects of the KfW in LaPaz/Bolivia prove).[609] Further measures include instruments for managing the water demand as well as for closing leaks. On a medium-term basis, the conservation and treatment of the resource "water" can also substantially contribute to the reduction of greenhouse gas emissions.

The *prevention of plastic waste* can be ensured with relatively simple instruments. Positive is the *banning of plastic bags*[610] (for example, in India or Kigali/Africa), but alternatives must also be seriously considered, e.g. the (consumption) economy (in particular the big food product chains) as well as NGOs. For PET bottles, the solution is more complex, since, as a general rule, for *glass or other plastic bottles*, the solution takes *the form of returnable systems*. It should also be considered that plastic waste represents a significant source of income for the informal waste management in many emerging and developing countries, which is why the integration of these groups is elementary, when it comes to the introduction of new systems.

In almost all countries, there were campaigns in schools, companies etc. with regard to the sustainable consumption behaviour. Here, a *more powerful consolidation of awareness building* is essential, *by clearly establishing related activities in school curricula*. The projects that cannot present a scalable solution, but, however, are going straight in the impact direction, are, for example, reparation cafes and urban gardens. *Urban gardening*[611] has developed in metropolises, such as New York, London, Tokyo and Berlin, since the beginning of this millennium and has spread all over the world. More important than the opportunity contained in the result, of providing substantial contributions to the city maintenance with the generated food products[612] is the fact that such kind of projects catalyse and promote innovation, community spirit, urban self-administration and initiatives regarding climate protection.[613] A similar approach is followed by *reparation cafes*, which, in the context of awareness raising with regard to the necessity of long-lasting consumer products, can play a growing role.[614]

Specifically in emerging and developing countries, the current *waste volume* is one of the central challenges. Thus, the quantity of urban waste has increased tenfold in the last decade.[615] In many *developed national economies, the so-called "peak waste" has already been reached*, whereas in the rest of the world the per-head consumption continues to increase.[616] Actual studies prove that, in particular, the *occurrence has increased with the growing per-head rise*,[617] which is why, from the perspective of urban areas, specifically in case of improvement of participation and of the incomes of poorer social groups of population, the *isolation of this development and of waste generation must be more strongly considered*.

The technical prerequisites for efficient handling (i.e. the prevention) of waste are available. Solutions represent win-win situations and can also be easily implemented. Municipalities should see the incidental waste strengthened as a resource. In addition to the above-mentioned improvement of recycling systems, this can also be ensured by extracting energy from waste, for example, by using methane gas at landfill sites.

To sum up, the *implementation of waste management systems for emission reduction* represents *a cost-efficient instrument for the reduction of greenhouse gases*.[618] Waste reduction, through the implementation of

610 Germany Trade and Invest, 2015
611 Earth Policy Institute, 2016: World map of countries and municipalities, which have taken regulatory measures regarding plastic bags.
612 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 343
613 Grewal, 2011, p. 1-11
614 Hopkins, 2008
615 Muraca, 2016
616 Hoornweg et al., 2012
617 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 84
618 Population Reference Bureau (PRB), 2016, p. 6: „Global municipal waste data show that per capita volumes tend to rise with average income levels but negative impacts lessens as wealthier cities improve waste processing systems".
619 A comparison financed by the *Federation of Canadian Municipalities*, between projects, has shown, that waste projects were, in general, the most cost-efficient with regard to the reduction of greenhouse gases. // See Federation of Canadian Municipalities FCM, 2009

the "3Rs" – meaning reduction, reuse and recycling, consequently is a basic prerequisite for reducing greenhouse gas emissions in the urban area.

Table 47: Area of waste and consumption reduction

Cluster	*A, B, C in diverse gradations*	**CO_2 impact**	*Direct reduction, in particular with regard to the Scope 3 emissions*
Implementation effort	*According to each measure, low to very high*	**General population acceptance**	*Very high*
Long-term stability	*High*	**Regulation necessary**	*Yes partial*
Financial effort	*According to each measure, low to very high*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*Low with good governance*

Source: own representation

11.3.4 Energetic efficiency of buildings (new or existing buildings)

At present, buildings account for approx. 1/3 of the worldwide energy demand, (cf. also Chapter 4.3)[619], however estimates relating to possible efficiency enhancements could reduce the demand by up to 46 percent until 2050.[620]

The *decarbonisation of the building stock* – in the construction and in operation phase(!) – will be especially essential in the fast-growing urban areas. Analogous to the population development, approx. *85 percent of the new constructions will* take place *in emergent national economies*, more than half being executed in China.[621]

In the field of construction and real estate industries, there are already technologies for the realization of green, sustainable buildings, which ensure a significant reduction of emissions in the field of building management. Technical solutions in particular include the following:

1. energetic optimization with complete heat insulation (thus reduction of the primary energy consumption and of the total CO_2 balance),
2. larger usage of renewable raw materials (for example wooden structures),
3. optimized illumination (for example through daylight architecture and LED use),
4. life-cycle approach regarding construction ecology (for example with LCC and LCA tools),
5. cooling with natural cooling agents and waste heat recovery (for example by separating climate areas in retail buildings, using natural ventilation),
6. avoidance of leaks within cooling systems (for example more intense verifications, certificates such as TÜV),
7. integration of regenerative power generation (for example PV systems or solar systems etc.).

Through the reduction of energy consumption, the increased usage of solar energy as well as through the reduction of waste heat sources, it was possible to create buildings in Germany which are very close to the concept of CO_2 neutrality.[622]

In the majority of the countries the *usage of these technologies will be* implemented *based on legal requirements* (in particular for new buildings). This can, for example, be observed in Singapore (cf. Chapter 9),

620 Lucon et al., 2014, p. 671-738
621 Ürge-Vorsatz et al., 2012, p. 649-760
622 Woetzel, 2011
623 Musall et al., 2011, p. 5ff

where clean energy generation and rigorous efficiency measurements, both in new and existing buildings, are possible as well as marketable. Regulation by the Energy Saving Ordinance in Germany, however, is more comprehensive and demanding. The EU requirements derived from the EPBD are the most demanding by worldwide comparison. Due to the EU's Energy Performance of Buildings (EPBD) Directive (cf. Chapter 3.1.5.), all new buildings in Europe, from 2021, must meet the standard of "nearly zero-energy buildings".[623] In the context of the study, it was found that demanding energetic requirements could already be implemented in many industrialized states. While in Europe a *reasonable combination of higher legally required energetic standards*[624] *and the creation of transparenc, with regard to energy efficiency* is common, other states are intensively focused on strict market-related solutions. Examples include the obligatory "Energy Disclosure Laws" for owners of real estate portfolios, which are already in effect in many cities of the USA.[625]

In *emerging and developing countries, until now, the focus has been placed on the creation of living spaces, and the energy efficiency is not perceived as an urgent problem*. There are, however, positive examples and flagship projects. As an example, an African development bank supported the *Trust for Urban Housing Finance (TUHF)* in redeveloping inner-city waste objects and thus also placed high demands on the energy-efficient rehabilitation.[626] The total loans are, however, still limited and are also constantly made by involving international partners, such as KfW or/and the World Bank. Based on the analysis, it therefore appears that solution approaches can indeed be implemented for industrialized states, which can expect decarbonisation in the field of new buildings according to the COP21 objective. In emerging and developing countries, the decarbonisation of new buildings, however, is still insufficiently progressed – projects in particular have a lighthouse character. This is why increased efforts are essential by involving international know-how carriers and financing solutions. This is central, in particular against the background of the anticipated new buildings in these regions.

The national objectives for existing buildings, derived from the INDCs, as well as the national legal performance targets seem to be essential. Cities should *push* the implementation by related projects, however, *basically* with those that are *technology-oriented*, *in order to avoid path dependencies*.

In developed national economies, there is an increase of situations where the *quick technological change leads to a faster economic (over)ageing of new objects and, finally, works as a brake on investments*. Thus, there are clear development trajectories that become evident. In particular with regard to innovative solutions for realizing particularly high energetic requirements, it must be ensured, that they do not lead to higher construction costs, since the acceptance of essential stakeholders will genuinely be reduced.[627]

Energy and material flows can be optimized in many different ways. The *regional value-added share,* for example, should be actively strengthened in various sectors by the city, which, for example, would massively reduce emissions due to longer transport routes. The usage of locally occurring raw materials for construction and a stronger recollection of local architectural styles (with often historical increased approaches for natural ventilation, shading etc.) has for the majority of the sustainability labels (such as LEED, German Association for Sustainable Building (Germ. DGNB) etc.) already been firmly established. Cities should rather focus on these existing guidelines. Positive examples can be found in Chicago. *Locally adjusted architectural styles,* such as the increased usage of natural ventilation, can also substantially reduce the consumption of cooling systems in warmer regions. In Asia, for example, the first shopping centres in mall areas were built, which are completely based, on natural (intelligent) ventilation, emissions being massively avoided.

In almost all analysed cities (or countries), there were specific programmes which ensured the "old through new", i.e. the reduction of emissions in the usage phase through energy-efficient technologies. In doing so, attempts to

624 European Council, 2010 and European Council 2013 // see also RICS, 2013, p. 10ff as well as Energy Saving Ordinance (Germ. EnEV)
625 Hamilton, et al., 2010
626 For example, www.energydisclosure.com, with overview of the law in individual states or cities // Roth, 2013
627 TUHF, 2016
628 ZIA, 2016

integrate real LCA considerations when looking at the realized greenhouse gas effects were rarely made. The relevance of the ***grey energy***[628] , against this background, is an increasing challenge, given that it refers to all of these products. When it comes to the built environment, the requirement of also considering energy coming from construction and not only from usage is particularly clear. ***Plus energy houses***[629] have also increasingly gained in importance. In doing so, aspects related to indirect emissions or grey energy also have to be taken into consideration (as well as the affordable living space for low and medium income groups). Infrastructure and the built environment are signs of expanding urban areas. Currently, ***large quantities of building materials, especially cement, steel, aluminium, glass etc.,*** are used. The demand for these materials has multiplied in the past few years; emissions do not only result from the construction of structural systems on-site but, to a higher degree, also from upstream process stages.[630] Furthermore, durable materials, such as concrete, must be used in the future. The ***fact that concrete cannot be recycled at a high-quality level***, in this context, is not problematic. According to estimates, solely for the expansion of the infrastructure until 2050 due to the global increase in the population and with constant technology, additional emissions amounting to 350 Gt CO_2 can be expected. This would corresponded to almost half of the still acceptable emissions according to the COP21, amounting to 750 billion tons and meeting the 2.degree objective.

Solution approaches are complex in this field. Firstly, a potential approach would be the ***increased use of renewable raw materials***, such as wood. The often propagated usage of wood (for the extraction of CO_2 from the atmosphere), for furniture and buildings[631] , of course, has the disadvantage that deforestation is necessary. Furthermore, the raw material can only be used in the context of the construction of buildings and is less durable. A possible reduction of the infrastructure and residential construction might also be a potential “approach” with the purpose of ensuring participation and creating livable cities (since, currently, several hundred million people live in slums[632]).

Consequently, a mixture of the following solutions must be taken into consideration when realizing infrastructure and various structural systems:

- ***increased use of renewable/natural raw materials*** (for example substituted by wood, clay, brick, stone) without endangering the regeneration rates of renewable raw materials,
- ***modular building and construction methods*** for promoting recycling and the recycling economy,
- ***consistent recycling of materials*** from demolition objects, dismantling of old traffic routes etc.,
- promotion of technical solutions for reducing the ***emission intensity for new materials*** (for example, CCS in the production process, ecologically optimized concrete etc.),
- ***use of regenerative energy*** for producing materials and, in the context of construction processes on-site,
- ***reduction of material usage*** (optimizing the density of building structures for maximizing usable surfaces, statistically optimizing planned projects etc.),
- ***redimensioning of space requirements*** per se (reduction of the space requirement per head, promotion of multi-person households, innovative space concepts/micro-living etc.).
- ***bionic buildings***, which use nature as a model for building components and as a attempt to imitate it in architectural and technical terms.

Decarbonisation can, however, also rely on very simple elements, such as very bright (white) house roofs and streets (for sunlight to be reflected). This might also include the ***collection of rainwater*** in buildings (as for example enacted in India).

629 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 21
630 Schellnhuber, 2015, p. 625
631 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 188
632 Müller et al, 2013
633 Schellnhuber, 2015, p. 587

One of the *biggest challenges for the reduction of greenhouse gas emissions through constructions results from the poor energy situation of existing buildings.* In developed national economies, the annual rate of new constructions amounts to between 0.8 and 1.5 percent. As an example, approx. 2/3 of the existing buildings in Germany were built in the 1970s.[633] The increase of the annual (energy-efficient) rehabilitation rate in Germany from significantly under 1 to 2 percent per year related to the total number of existing buildings has, however, been pursued with high priority, at least since the energy concept 2010 was launched. *The Energy Efficiency Strategy for Buildings (ESG) and the German Climate Protection Plan (KSP)*[634] *were further accelerated as a result of the European and global targets of this development.*

It is not only in Germany that the expansion of high and compelling requirements for the improvement of energy efficiency in the existent building stock meets with big resistance from the economy and also from other stakeholders. The opportunities created in Germany by the KfW for modernizing living spaces, rank among the most successful approaches in Europe. It is thereby estimated that, in the context of this modernization, they are used each year for approximately 1 percent of the single-family homes in Germany.

In the field of *municipal housing policy,* decision-makers face the challenge of creating (favourable/affordable) living spaces in a way that goes beyond the pure energy efficiency in the usage phase and which has already largely been decarbonized during the construction. Here, financial means and, if applicable, also an increase of *urban (non-profit) companies based on the model of German housing co-operatives* are a reasonable approach which is feasible with the help of the GCF, also in developing countries.

A mix of the following instruments should be used (or are already used), in order to promote the decarbonisation in the existing building stock:

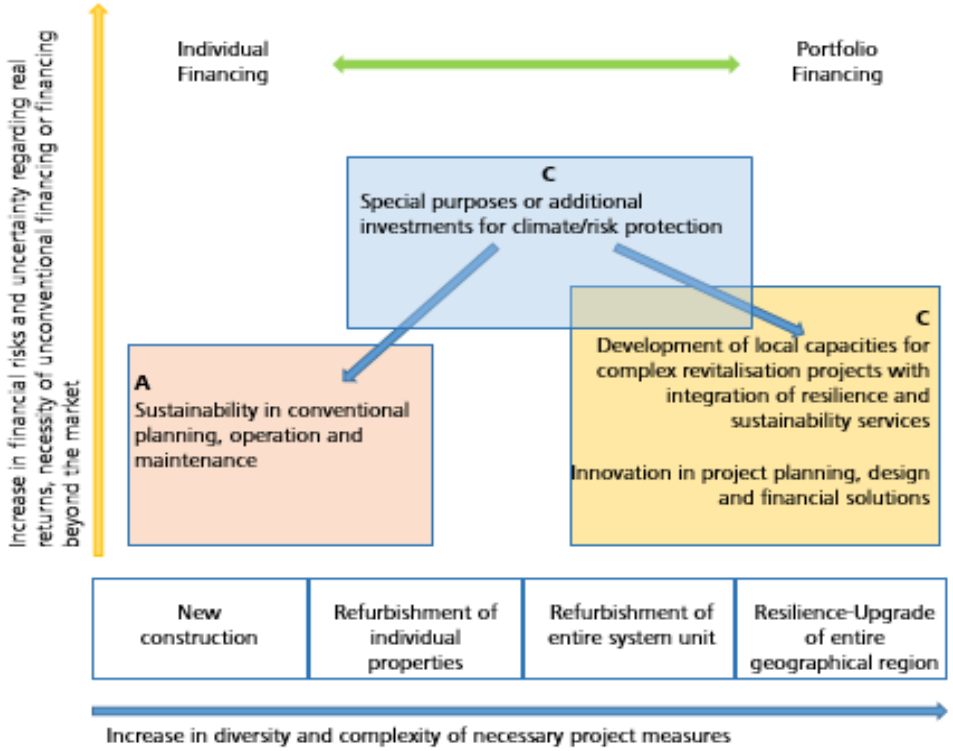
- *market information on the respective good/poor energy efficiency* (for promoting self-regulation analogously to the EPCs in Europe),
- *implementation of nationwide green rent indexes* (this instrument has until now only been presented in Germany, however, it can also be of use in other countries),
- *regulatory interventions in case of a particularly poor energy efficiency-related condition* (for example, ban on night storage heating in Germany or on leasing objects in England which have a particularly low energy efficiency class),
- *municipality model function* with regard to energy efficiency-related retrofitting,[635]
- reference to *coupling functions ("business-as-usual costs") when it comes to pending rehabilitations,*
- *financial or fiscal incentivizing* (funding programmes analogously to opportunities of the Kfw or special depreciations for example in Singapore),[636]
- *open technological solutions,*
- *specification of clearer development goals so that investments can be planned* throughout the market.

Given the fact that the cost/value ratio still does not permit for a pure market-based solution, state subsidies are essential, in particular when, on a voluntary base, impulses for investment measures should be achieved. The various publications of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (Germ. BBSR) , in this context are to serve, as international best practices with regard to the explanation of the

634 German Institute for Housing and the Environment (Germ. IWU), 2015 // Loga, 2015, p. 5ff
635 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB) 2016d // Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB), 2016e
636 Danish Building and Property Agency, 2012
637 American Institute of Architects – AIA, 2016

cost/value ratio, since a very high transparency for interested stakeholders will be generated, which, on a comparable basis, was not identified in the surveys of other cities/countries undertaken here.

Figure 19: Strategic dimensions of climate resiliency



Source: own representation following ICLEI, 2010: Strategic dimensions of climate resiliency with regard to variations, complexities and financial risks

With the above-visualized approaches, no-regrets strategies can be implemented, which are profitable, in each case, economically and socially – irrespective of the forecasted scenarios regarding climate change. In this way, energy efficient household devices or solar hot water processing can be provided as examples, leading to the reduction of greenhouse gases at the same time, without presenting a financial risk.

In addition to the intensive legislation with object reference, sustainability will be reinforced and legally consolidated at the level of companies. For example, the *European Parliament* and the European Commission have reinforced the regulation of CSR and implemented an ***obligation regarding the sustainability report*** for very big companies.[637] Project developers and real estate entrepreneurs should approach these aspects pro-actively and, as an example, implement voluntary reporting (such as according to the GRI standard).[638] Although the implementation resolutions, in Germany, first of all affect large companies, nevertheless, a proactive approach is also reasonable in this area.

The results of "TRANSFORM.eu"[639] are helpful when it comes to defining a transformation agenda, at municipal levels, with regard to the real estate portfolio.

The initiative of the "Energy Atlas of Amsterdam"[640] can be presented as an outstanding example. Essentially, this refers to software that presents a "heat map" for identifying various energy consumptions at block level. Through

638 European Parliament, 2014
639 See here *Global Reporting Initiative* at http://www.globalreporting.org
640 www.urbantransform.eu: A six-part programme, for the reduction of greenhouse gas emissions, financed by the EU, implemented from January 2012 until August 2015.
641 http://maps.amsterdam.nl/energie_gaselektra/?LANG=de

the graphic reappraisal of the greenhouse gas emissions, thus, the transparency of the emission sources can indeed be increased. TRANSFORM.eu currently offers a free-of-charge version of the latest software for testing.[641]

Table 48: Area of energy-efficient buildings

Cluster	*A, B high demand for C especially for new constructions. Solutions have been so far limited.*	**CO_2 impact**	*Direct and indirect (Scope 1 and Scope 2)*
Implementation effort	*High to very high*	**General population acceptance**	*Good, but fragile when additional costs occur.*
Long-term stability	*High when transformation undergoes clear legal frameworks.*	**Regulation necessary**	*Yes, partially*
Financial effort	*High to very high* *In case of proved "cost-neutral" energy-efficient new constructions de facto also "low".*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*Increased with additional costs during construction*

Source: own representation

The increase of the energy efficiency in the present and future building stock may happen by means of various transition phases, which are differentiated according to their extent and financial circumstances, as the following figure illustrates.

11.3.5 Changed spatial and urban development strategies

A change of spatial planning, in the context of decarbonisation, is one of the subsequent key elements. Individual *priority areas, such as the accessible city, an optimized density, the creation of polycentric structures, the activation of wastelands as well as the reinforced involvement of property developers,* for urban targets, will be subsequently clarified.

The *compact and thus also strongly condensed city* will be regularly emphasized as advantageous for sustainable cities – in Chapter 4, you can find facts regarding the significantly low greenhouse gas emissions, from persons who live in highly populated areas. Populated cities basically show a relatively reduced energy consumption[642] per head, due to their advantages regarding traffic volume/distances as well as the increased structural density. Nevertheless, there is no general scientifically founded postulate for the highly populated city. The structure, however, must not necessarily be highly populated. In the more recent literature, a high advantageousness was described especially for *polycentric structures*. Polycentric urban developments[643], for example in Copenhagen, can facilitate an improved usage of resources, since they genuinely reduce supply routes compared to the structures that are very widespread. An easier provision of renewable energy at neighbourhood levels is also possible in areas that are not highly populated. Governance and participation of the civil population are also easier to realize, in "one's own neighbourhood" and on the basis of decentralized settlement structures.

A *high (residential) quality of the built environment* increases the willingness of the population to spend their time (outdoors) and thus requires the space suitability as well as the increase of the local bindings.[644] Cities which

642 http://www.deco.macomi.nl/TransformBackend/gui/index.html#/login
643 Hoornweg et al, 2011, p. 207-227
644 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 35ff
645 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 167

offer and care for high-quality public places, which are, at the same time, simply accessible, functional and friendly to the environment, have a multitude of advantages.[645] Ultimately, the felt perception of "my city" is also an essential prerequisite of the population, in order to become actively engaged in the environmental protection on-site. As an example, Chicago has published good approaches and guidelines, in order to create livable neighbourhoods, with a high level of synergy between the individually integrated effective uses.

The *structural-spatial design, sensu stricto, the new "urban design"*[646] must consider the following aspects, in order to actively support decarbonisation:[647]

- *guaranteeing the sovereign usage regulation through functional urban planning* (spatial planning through land use and legally binding land-use plans),
- complete (sovereign) *registration of the existing surfaces* and their usage as well as related ownership structures,
- realization/expansion of *green corridors and recreational areas* (upgrading public open spaces within cities for improving the quality of stay outdoors),[648]
- stimulation of the available *extension potential* (for example, through forced usage of speculative unused surfaces so far, through high progressively increasing taxes or other instruments),
- *establishment of a meaningful environment ("my city") for the mobilization of the middle class with regard to environmental protection* (in particular involvement and participation of the local population in the development of usage concepts),
- *intensification of mixed-use concepts* (for example living and working in the same neighbourhood or "shared space" for example through multiple usage of traffic-calm streets, for sport, pedestrians etc.),
- improvement of the adaptability and *polycentric structures* with an increased density,[649]
- *taking decentralized and regenerative energy production into consideration* (for example for "district heating" or "district cooling"),
- avoidance of the degradation and overdevelopment or surfaces (for example, through brownfield redevelopment and, correspondingly, a higher density in central locations),
- use of innovative instruments for the reduction of the land consumption (for example, through *land use development* or introduction with *businesses with land certificates*),[650]

Functioning *regulatory systems for land usage*[651] are thus essential for the achievement of the urban decarbonisation targets. Central levers, such as the general infrastructure, circulation and constructions, can only be steered in this direction.

Through the *organisation of their building regulations and spatial planning*, cities can basically support the public local transport and, thus, encourage local residents, to cover distances, on foot or with the bicycle. Preferably, the *non-motorised transportation* should *be recorded as an essential component in the development concept*, in order to develop an integral infrastructure for this area, from the components of walking, bicycle driving and the public transportation means. In essence, this means the realization of attractive, relatively dense neighbourhoods, with a mixed usage of transport means, in which it is comfortable and safe, to walk on foot or use a bicycle. In addition to density, the decision of individuals, with regard to the form of mobility, will be influenced by a number of other factors, such as the relative costs of other mobility forms and the street layout (grids against

646 Barton et al., 2009
647 See also Gehl, 2010
648 UN-Habitat, 2015d, p. 2ff
649 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 147
650 With regard to density, there are various contributions to discussion and opinions. However, in the meantime, a special „urban-form2" will no longer be favorited, but increasingly argumented based on the general planning premises (which should be met). // See for example Seto et al., 2014, p. 958
651 German Advisory Council on Global Change (Germ. WBGU), 2016, p. 178
652 OECD, 2015a

intertwined roads as well as cul-de-sacs). Therefore, in the past few years, many cities have adopted new approaches and, in addition to the integration of these components in traffic routes, they also have considerably expanded *existing walking and cycle paths*. Thus, overall, ***"pro-poor transport policies"*** are directly aimed at the fact that the traffic routes are also not accessible for not-motorized vehicles. With the ***"transit-oriented development"***, new neighbourhoods should be organized in such a manner, that the local public transport can be reached on foot. Both elements are expressed in almost all of the cities analysed here – although, with a very different intensity.

Furthermore, a better integration of large real estate in Europe should also be intensified. While in Asia, in many metropolises, it is "normal" to also consciously cross , lobbies and other generally accessible areas of offices or malls on foot on the way to the subway, this is not yet the case in this country. In the context of realizing larger real estate projects, it is necessary to create public spaces, by which citizens can identify themselves and which they can use.

The establishment of carbon reservoirs through the *expansion of the biomass* is limited within cities. Nevertheless, a further establishment of green spaces, park areas and green corridors along traffic routes, is an important element in the context of decarbonisation. In particular in this way the awareness of the population regarding the value of nature will be increased and the acceptance for environmentally friendlier behaviour patterns supported (for example, by using bicycle paths, the avoidance of waste etc.). When it comes to target achievement, these measures are also helped by other aspects, such as the prevention of heat islands and, thus, influence the micro-climate of the urban areas in a positive manner. The following measures for a city could also accelerate this transformation:

- usage of "urban voids" for greening,
- involvement of the population with regard to planting and maintenance (for example, "urban gardening", school projects etc.),
- creation of "green roofs".

The *activation of brownfields (so-called brownfield redevelopment)* holds a great potential for sustainable development opportunities in neighbourhoods, where such areas exist, and comes along with a wide range of benefits. The recultivation of brownfields, for example, with the so-called "energy trees", , in addition to the CO_2 fixation, had further positive secondary benefits, such as the improvement of the soil quality, the possible combination with the expansion of bicycle and pedestrian pathways as well as a better local climate. In many countries, the recycling of brownfield land in the context of urban and spatial planning processes is not placed in the foreground. On the contrary, many of the here assessed cities, furthermore, favour the usage of present green surfaces (green fields).[652] The *usage diversity, in a dense and compact urban structure* should also be *promoted*. In this context, the revitalization of real estate or whole urban areas is a suitable alternative, since it uses existent resources in an advantageous manner and connects the urban structure with the less compact areas. The material improvement of a brownfield also leads to better property features, such as a lower pollution, improved accessibility and, eventually, also to a better reputation of the neighbourhood. The recycling of areas, thus goes beyond the mere decontamination of contaminated sites and is aimed at the reintegration of buildings and areas in the economic cycle. For the revitalization of brownfields, in this respect, not only the ecological scope but also the political, social and economic framework conditions have to be analysed. The European provisions emphasize the significance of a healthy urban environment. The Ministerial Declaration from Parma, in 2010, approached this theme and established that governments should thereto work together with local, regional and other stakeholders, so that the effects of the overdevelopment are actively counteracted.[653] *Overdevelopment* and the associated

653 Schellnhuber, 2015, p. 587 // Glumac, et al. 2013
654 Fifth Ministerial Conference Environment and Health, EUR/55934/5, 1Rev2, 11.03.2010, p. 2

ecological[654] and logistical[655] implications – ***are taken back within the focus of international politics***. The draft of the *Geneva Declaration on sustainable housing and urban development*[656] , which is to be adopted in December 2017, contains four[657] preambulatory clauses[658] regarding overdevelopment, but no *operative clause*[659] It shows that, although increased attention has been given to the field, ***there is a lack of conceptual solution pathways***.

In contrast to this, the common Greenfield developments (according to the motto "business as usual") lead to fewer complicated ownership structures and, as a general rule, also to faster authorizations by the municipal administration – this is frequently the ground for the stronger focus of investors on "unloaded" surfaces. Nevertheless, the material improvements regarding the land quality and legal structures often also require financial advantages, such as the value generation through increasing real estate prices for former brownfields. Through targeted cooperation with the urban planning and based on the often inner-city locations, marketable returns are possible.

In the general process of the emission reduction, the solidarity with all participants is, central. At the level of cities, it seems ***reasonable to integrate private project developers intensively and to offer them targeted incentives***, especially when it comes to pursuing a low-carbon neighbourhood development. This can, for example, be achieved through:

- monetary incentives: subsidies, extraordinary fiscal depreciations etc.
- non-monetary incentives: increased intensity in completing certain sustainability requirements etc.

Worldwide, there are various cities, which, through the formulation and implementation of CO_2 reduction targets, have implemented additional projects and initiatives at the level of districts or areas (federal state, county etc.). These ***flagship projects*** are often related to a specific neighbourhood and can hereby display a ***visibility and exemplary function:***

- São Paulo, with the county action "Operação Urbana Consorciada Bairros tun Tamaduatei".
- Toronto, as the sponsor of the revitalization project "Regent Park".
- Hangzhou and the Xiacheng borough, with the pilot project "CO_2 inventory" at district level.
- Helsinki, with the Low2CO2 city-block actions.
- Lyon, with the borough project "La Confluence", which has been ranked as one of the biggest European urban development projects.
- Freiburg in Breisgau, with the revitalization project "Vauban" – neighbourhood.[660]
- Singapore, with the district cooling project in Marina Bay.

These current ***best practice examples should be publicly recognized and appreciated***. Various examples show that the involved private developers have used the specific sustainability focus for promotional purposes and, thus, a win-win situation concerning those involved was achieved.

Table 49: Area of spatial planning and settlement structures

Cluster	*A, B, C*	**CO_2 impact**	*Indirect, but high*

655 For example, through the acceptance of water absorbency of urban areas through building development and, thus, an accompanying increased flood risk. // See Chapter 4.5.4
656 For example, through the relation between urban density and transport emissions. // See Chapter 4.5.7
657 UN-ECE, 2016
658 Preamble 8, 24, 26 and 31 in UN-ECE, 2016.
659 *Perambulatory clauses* establish the ground, why a committee should become concerned with the theme.
660 *Operative clauses* contains solution proposals for the problems defined in the perambulatory clauses.
661 Haag et al. 2012 // Hoppe, 2009 // Kenkmann et al., 2011 // Schickle, 2011

	However, due to inadequate governance structures often feasible only in A and B.		
Implementation effort	*High*	**General population acceptance**	*Inconsistent*
Long-term stability	*Questionable – depending on stable governance structures*	**Regulation necessary**	*Yes*
Financial effort	*Low (from the point of view of the municipality)*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*High – for example, through speculators and corruption*

Source: own representation

11.3.6 Transformation of the urban mobility

Transportation is the second most important area for the reduction of greenhouse gases. Correspondingly, municipalities should actively influence the manner in which mobility is experienced at the level of cities. This, in particular, includes the reduction of motorized individual transportation, the intensification of public transport expansion as well as the reinforced usage of electric low-emission vehicles. The ***quick decarbonisation of the transport sector will be regularly considered as one of the biggest challenges.***[661] In many studies, it was determined that the motorized individual transportation is a provoking moment for regional environmental problems and persistent traffic chaos in growing megacities. Thus, this is accompanied by a high percentage of CO_2 emissions. Decarbonisation is, against this background, first, connected with the reduction of the individual transportation and, second, with the electrification of the (remaining) individual means of transportation. In this field of action, essential changes of the current behaviour patterns are necessary – in particular, the replication of the western mobility in the aspiring emerging and developing countries is to be avoided. Radical transformations, such as the resolution to turn Oslo into the first (inner-city) auto-free capital city in Europe, mark ambitious and target-oriented approaches.[662] Other European cities[663] examined intensively innovative development trajectories in the field of urban mobility, which have been promoted by the European Union.

The plan developed by the European Commission for sustainable urban mobility (Sustainable Urban Mobility Plan (SUMP)) is built on the "existent planning practices considering integration, participation and evaluation practices", in order to attain its goal of increased life quality and quality of public spaces.[664] The planning concept increasingly gains in significance and public awareness.[665]

662 Schellnhuber, 2015, p. 629: Assessment of the economists regarding the PIK.
663 Fouche et al., 2015 // BMZ, 2011
664 See Chapter 9.1, Chapter 9.5 as well as urban analyses for Madrid, Helsinki and Stockholm (Excel-Sheet)
665 www.mobilityplans.eu
666 http://www.mobilityweek.eu

The Transport White Paper[666] of the European Commission also encourages the development of urban mobility plans with a wide offer of diverse transportation means. Core elements of such plans range from spatial planning, price models, an efficient public connectivity, an infrastructure for pedestrians and bicyclists as well also the loading/fuelling of vehicles.

With regard to the challenges of the thematic field "sustainable mobility", the problem areas *"scope" as well as "capacity" (with regard to public transportation means) are* regularly *mentioned. , In the urban context, both aspects are largely unproblematic.* The targeted expansion of attractive public transportation offers (and car sharing systems) is, therefore, of high priority.[667]

Cities should, in particular, *limit the motorised individual transportation* – both through an improved urban design, efficient public transportation and through the active management of the demands for transport services. The transfer of movement away from private vehicles to low-emission public transportation means is a huge challenge. The focus should, in general, be placed on the creation of infrastructure for transport systems, which are characterised by a limited land use and innovative financing models (for example, introduction of road toll, customs duties, higher parking fees, higher vehicle taxes, higher costs for the authorization of personal vehicles with fossil fuel sources). The additional revenue coming from the limitation of individual transportation should be simultaneously used as a financing source for the expansion of the public transportation system. In some cities in China, it is already common, that the new approval of a conventional personal vehicle requires a waiting period of several months and the "license plate" will be then additional auctioned off (i.e. the first-time approval is very expensive / costs can go up to 10000 Euro and more). However, the approval of an electric vehicle takes place immediately and without any other additional fees. This approach is an interesting alternative to the merchandising that often takes place in Europe, for example, with subsidies for electric vehicles.

Sao Paulo demonstrates that well-intended initiatives can, if necessary, lead to counterproductive effects. There, the use of cars in the city area, dependent on the respective license plate (even / odd), was restricted. On certain days, only even numbers were allowed to drive and vice versa. However, this has led to the purchase of additional cars by the middle and upper class, in order to have the right number "for each day".[668]

The *reduction of the motorized individual transportation and expansion of the public transport* promise the biggest effect, if a combination of the following measures will be aspired[669]:

- *Pull effects:*
  - subsidies for electric vehicles,
  - promotion of public transportation: expansion of safer, more affordable, more comfortable/cleaner and of higher frequency circulating buses, subways etc.[670]
  - promotion of car sharing as well as innovative concepts such as bicycle rickshaws[671]
  - development of pedestrian and bicycle pathways (in particular bicycle pathways, which, in the context of the daily life of commuters, offer an alternative[672]),
  - exemplary function of the urban administration,
  - specification of concrete targets (for example, proportions of daily routes with the bicycle per year XY),
  - development of a bicycle infrastructure (for example bicycle stations, lockers etc.),
  - communication infrastructure (per apps etc.) as well as general awareness raising.

667 European Commission, 2011b
668 Newman et al., 2015
669 Maranhão, 2014
670 German Advisory Council on Global Change (Germ. WGBU), 2016, p. 352f
671 UN-Habitat, 2015g, p. 1ff
672 Ecocabs Fazilka in India.
673 For example Radschnellweg Ruhr.

- *Push effects:*
  - increasing the fuel prices,[673]
  - reduction of traffic routes for personal vehicles,
  - taxes or interdictions for personal vehicles in the city centre,
  - no or overpriced versions of new license plates for vehicles that use fossil energy sources,
  - long waiting times for the approval of these personal vehicles,
  - introduction of road guidance, customs duties, higher parking fees or higher taxes for motor vehicles,
  - intelligent control systems, which automatically restrict the access of the individual transportation in the city centre at specific rush hours.

Additionally, urban planning should take the following framework conditions into consideration:

- Planned new cities and neighbourhoods should, in all cases, still be realized as emission-free – at least the planning should take a most extensive decarbonisation into consideration.
- In the city centre, already, only emission-free transportation means should be allowed for a short-term period.

In the context of ***vehicle electrification,*** municipalities can offer incentives for using electric, low-emission vehicles, for example, through:

- the purchase of the same vehicles for the urban vehicle fleet (exemplary function of the city, such as for example in Hangzhou),
- the regulation of taxis (mandatory use of electric vehicles),
- ensuring a higher network coverage of electric filling stations (electric filling stations in public places and parking spaces),
- the support of car sharing providers with electric fleet,
- fiscal facilitations, subsidised parking fees etc.

In doing so, municipalities should especially place their focus on options, which deliver the latest technological state (for example biofuels, fuel cells, plug-in hybrids, and electric hybrids). The concrete structure of these options is massively subject to financial incentives offered by national, regional and urban administrations. Such incentives are, for example, subsidies or credit facilities.

Young people, in particular, place less and little importance on their own vehicle. The ***increased usage of car-sharing offers by the population must also be promoted through targeted information provision,*** in order to further accelerate the environmentally friendly behaviour patterns. The increase of electric vehicles offered by car sharing providers in metropolises within this context has genuinely increased in the past few years.

Table 50: Area of mobility

Cluster	*A, B – car sharing / electric* *C – development of public transportation*	**CO_2 impact**	*Direct*

674 An example of the steering effect offers the USA, where a 10% increase of the gas price led to a 10% reduction of the construction activities in the outskirts of cities. // Molloy and Shan, 2013

Implementation effort	*High*	**General population acceptance**	*Very high*
Long-term stability	*High*	**Regulation necessary**	*Yes, according to the chosen strategic measure*
Financial effort	*High*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*High*

Source: own representation

11.3.7 Expansion of the usage of renewable energy sources

The substitution of fossil energy sources with regenerative energy carriers is a basic requirement on the road towards decarbonisation. This is also valid for cities. In turn, this also involves the reinforced usage of electricity from green energy sources and the abandonment of combustion engines (see also Chapter 11.3.6). Scotland has, for example, shown that the transformation of the energy sector is possible. In 2014, the country already produced 29 percent of the whole electricity that comes from renewable sources in the UK. With a reduction of greenhouse gas emissions by 42 percent (compared to 1990), Scotland has already reached its climate targets for 2020 six years earlier.[674]

For cities, this area of intervention is a challenge, from multiple points of view. The ***production of regenerative energy***, within the city boundaries, is, due to the limited land availability, also manageable on a long-term basis, with regard to the realizable relative proportion. Experts estimate that, in megacities a very low proportion of the necessary energy can be self-generated within city boundaries. A difficulty is that, ***within a country, there are major differences between the greenhouse gas intensity of energy production, between urban and rural areas***. The majority of the urban areas are expanding, which leads to an increasing energy need. These aspects, related to the increased need with regard to electricity from "green" energy sources, however, reach natural limits in terms of the opportunities of available offerings. Urban areas are often constructed in a dense manner, which is why, ***in the urban area, regularly, there are only limited opportunities for the development of area-intensive, regenerative energy sources*** (for example, through solar energy, wind power). The recommendation for action, thus, must be organized in a package of measures, which are based on the following aspects:

- identification and active usage of surface reserves for renewable energy production in the urban area.
- development of common energy strategies in bigger regions (meaning the integration of the surrounding area into cities for "balance").
- usage of cross-sectoral coupling effects (for example, charging of batteries in single-family homes in the suburbs, using photovoltaics).

Furthermore, the complexity lies in the problem, that regenerative energy from the sun and wind is not continuously produced and, also, that, when it comes to the opportunities of energy storage, there are technological limits to be considered. ***Energy from renewable sources*** should especially be stored through CO_2-neutral, regenerative gas. [675] Therefore, innovative procedures, such as the "***power to gas"*** or "***power to liquid", respectively***, should also be accelerated at municipal levels. Further solution approaches include the development of smart grids and the stimulation of new storage (for example, batteries of electric vehicles).

675 http://www.spaceforemail.com/uploads/mnd/18-10-2016/LowCarbonEconomy.html
676 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB), 2016d, p. 7

The *conversion of the energy supply is not a so-called "low-hanging fruit"*, since every development of new energy sources is linked to substantial investments. For the improvement of the cost-benefit ratio, i.e. for the comparison of disadvantages regarding regenerative energy sources, the following aspects are to be taken into consideration:

- CO_2 taxes (for example in South Africa).
- miscellaneous price increases for fossil energy carriers (for example in England),
- subsidies or additional fiscal incentives for regenerative energy sources (for example in Singapore).
- feed-in tariffs for "green" electricity with attractive tariffs also at local levels (for example in China and Germany).

The *specification of clearly-defined development targets for renewable energy sources* is essential for decarbonisation. Based on the necessary dimensions with regard to the capacity expansion, more attention is to be paid to the fact that they take place in an eco-friendly and resource-friendly manner. *An innovative electricity market design* is, in particular, characterised by the development of electricity networks and the *plurality of actors when producing renewable energy*.

Local *citizen-energy projects* should, against this background, be promoted at municipal levels. However (even with polycentric strictures), the opportunities are also restricted, due to limited areas. Nevertheless, an *intensification of the planning for decentralized energy supply in neighbourhoods* should be accelerated. Basically, it requires the comprehensive development of regional energy systems by municipalities. The demand forecast could take place in a targeted manner and contain alternative energy sources at the level of neighbourhoods, such as heat pumps, biomass, cogeneration plants, combined heat and power plants and other systems, which, for example, make waste usable. In the field of *heating and cooling systems, at the level of neighbourhoods*, there is a wide range of solutions, such as power-heat coupling, heat accumulators etc. Publications like those of the UNEP show the best practices in detail and give clear implementation indications.[676]

The integrated conservation of resources also includes an adjustment of consumption profiles. The development of *smart grids*[677] might represent a target-oriented approach. The extent to which the current propagated *energy services*, hence the change from the purchase of energy to the purchase of heat and light etc., might cause major efficiency enhancements through the incentives offered by suppliers, remains to be seen. In any case, based on the initial analysis, the observation of the neighbourhood-relevant energy consumption sectors and available energy conservation potentials as well as the creation of a total energy balance is essential.

In conclusion, innovative neighbourhood-related approaches[678] to the heating and cooling supply as well as to the water supply include the following:

- highly-efficient energy or thermally conducted systems for the supply with heat and combined heat and power on the basis of natural/bio gas (combined cooling, heat and power schemes),
- systems for the usage of industrial waste heat,
- decentralized heat and cold storage systems,
- supplying neighbourhoods with heating and/or cooling networks,
- optimization of the measurement and control technology,
- heat recovery systems.

677 UNEP, 2015b, p. 1ff: „District Energy in Cities".
678 Marshall, 2012
679 Grübler et al., 2012: „Urban energy systems."

Due to the high investments, the integration of financing solutions is especially essential in developing countries (cf. Chapter 11.3.9). With the initiative "100% Renewable Energy Cities & Regions Network", ICLEI offers an ideal platform for the structured implementation of the presented contents.

Table 51: Area of renewable energy

Cluster	*A, B, C*	**CO_2 impact**	*Direct*
Implementation effort	*Very high*	**General population acceptance**	*Very high*
Long-term stability	*High*	**Regulation necessary**	*No*
Financial effort	*Very high*	**Quick wins**	*Generally speaking only medium-term target achievement*
Scalability	*Only possible within limits.*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*High owing to previous energy providers*

Source: own representation

11.3.8 Exemplary function of public authorities and sustainable procurement

In order to fulfil their leading role regarding the reduction of greenhouse gases, municipalities should proactively reduce emissions caused by their own constructions and services. In doing so, the ***exemplary function of the public authorities*** will be particularly emphasized. Furthermore, municipalities and their associated companies (for example from the field of public transportation, waste management etc.), are responsible for a substantial proportion of all CO_2 emissions. The energy, which will be necessary, for example, in order to operate the water or waste water supply, can thus make up a substantial part of all urban emissions and offers starting points for optimizations. Doing without air conditioning systems to the best possible extent and increasingly using natural ventilation are further exemplary instruments how municipalities might set a good example.

In order for municipalities to ensure credibly that their sustainability engagement is also reflected in the upstream and downstream value-added processes, it is crucial to take not only their own services with regard to decarbonisation into account. The ***sustainable procurement management (green management)*** itself, , first and foremost, meaning to select and deal with business partners, is also path-breaking. Already today, a proof of the adherence to sustainability aspects will not only be required by one's own clients. The collaboration with service providers and suppliers will be increasingly made dependent on related proofs (so-called supplier sustainability). In this context the major procurement power of metropolises can also develop important steering effects. A large hardware manufacturer, for exmaple, for example changed his products, since the state of California was no longer interested in obtaining them. Cities can actively oblige suppliers to follow their own "***code of conduct***", which takes the adherence to norms and standards in the sustainability area into consideration, ensures reasonable work conditions and stipulates measures for the reduction of greenhouse gases. The city of Hamburg, for example, prohibited the purchase of Nespresso taps, due to the poor resource efficiency for its employees.[679]

680 Kapalschinski, 2016

In this context, the many city networks should publish clear directives for the municipal procurement management, which go beyond the existent general decarbonisation targets of the world community and, thus, take the exemplary function of public authorities into account.

Table 52: Exemplary function of public authorities area

Cluster	*A, B, C*	**CO_2 impact**	*Direct*
Implementation effort	*Very low*	**General population acceptance**	*Very high*
Long-term stability	*High*	**Regulation necessary**	*No*
Financial effort	*Low*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Conditional – rather exemplary function*	**Resistances**	*Low*

Source: own representation

11.3.9 Financing the transformation

Cities finance themselves through taxes (property tax, value increase taxes, trade tax etc.), fees and revenues from provided services or goods. In the majority of the cases, there are allocations from the national government and, if the case may be, also access to the capital market or the possibility to fall back on specific credit lines from development banks. In the context of the transformation, to a decarbonized city, optimizations are necessary in all of the outlined fields, in order to be able to realize the planned investments.

While in developed countries, the ***budget share of municipalities*** can include up to 2/3 of all government expenditure, this is noted, in almost all of ***emerging and developing countries***, to be at a very low level.[680] This leads to the fact that the ***financial scopes for action, with regard to the sustainable urban redevelopment, which is often limited***, [681] are partly minimal, since even the smallest investment measures cannot be implemented and a long-term focus is not possible. It is clear that target objectives, such as the increase of local revenues through taxes and fees[682], the national redistribution of the budget or the control of corruption, are fundamentally reasonable. The realization of these target objectives is , however, associated with many obstacles and, if at all, only implementable on a very long-term basis.

A prerequisite of investments at municipal levels is the fact that the ***respective administrations are capable of acting***. In many developing countries, this situation must be first created. The ***Green Climate Fund*** (GCF) is, among others, aimed at the following motto: “Creating climate-compatible cities”[683]. It would be useful here and feasible on a short-term basis, that financing funds, in the context or the GCF or other ***development aids, would be linked with the corresponding requirements, which will*** ensure ***an intensive inclusion of the municipal administrations and, thus, the use of funds on-site***. Funds could also be ***linked***, at any rate, ***to the reform requirements*** (introduction of duplicates, introduction of cadastres and land registers, long-term financial planning, increasing the tax revenues, disclosure of account statements etc.), in order to create positive impulses, at local levels, with regard to good governance prerequisites and, thus, to facilitate extensive measures.

A positive example regarding international cooperation in the context of urban redevelopment financing is offered by the KfW: On behalf of the Federal Ministry for Economic Cooperation and Development (Germ. BMZ), it has

681 UN-Habitat, 2015c, p. 3
682 UN-Habitat, 2015b, p. 5 // UCLG, 2016, p. 26ff: „Rethink local financing systems”.
683 C40, 2016, p. 4: „Increase Own-Source Revenue (OSR)”.
684 GCF, 2015

financed the construction of the streetcar line "VLT Carioca" in Rio de Janeiro/Brazil with a credit of 133 million euros. In total, 265 million euros went to a Brazilian development bank, which, in turn, passed on the funds to diverse suitable projects regarding an energy-efficient and climate-friendly local transportation in Brazil. Analogously, a credit of more than 85 million euros was provided to the Republic of India for the financing of an environmentally-friendly water metro in Kochi.

The traditional financing sector, until now, has been limited with regard to its ability to invest in low-carbon projects to a large extent. This has so far led to a false allocation of capital.[684]

In addition to the mobility area, the required funds also cover the energy industry, the general infrastructure and the housing industry to a large extent. Here, apart from the capital related to the development aids, ***the mobilization of private financial funds*** is central[685] and has already been establisihed in developed national economies. In times of low interests, pension funds, insurances and other institutional investors are no longer in the position of being able to reasonably offer their former notified liability for the distribution (so-called liability stream), which leads to high potentials also for low-interest investments. A primary challenge with regard to the preparation of funds from the point of view of investors is that these investments must be correspondingly secured against losses. The risks that result are found especially in the following areas:[686]

- currency risks,
- political risks,
- lack of transparency,
- lack of institutionalised contact making and processing,
- safeguarding.

This results in ***high risk premiums***. Against this background, often no investments are made.

Currently, when it comes to the real estate industry, there is a development, which frres itself from the allocation considerations, which will only be defined based on the macroeconomic framework conditions of whole states. ***Cities and their individual growth perspectives*** are rather found ***in the focus of the real estate investors***. Currently, 2/3 of the total commercial transaction volume are worldwide represented, by the top 300 cities.[687] Transparency, growth, comparative attractiveness and safety are central investment criteria here. Cities must practice active ***location marketing for sustainable development***, in order to control related capital flows. The interlinking of infrastructure and real estate investments also has to be used just as intensively as before. When it comes to the creation or renovation of the infrastructure (which, in turn, will be promoted by the real estate users), a larger (financial) participation of the private sector, is also important.

Solution approaches for the targeted reduction of the above-mentioned risks and, thus, the attraction of private capital are the following:[688]

- ***safeguarding through international default guarantees*** in the case of insufficient local collateral securities,
- ***stronger institutionalisation of the evaluation and verification of investment measures,***
- revision and clearer ***definition of lending standards*** based on the proven approaches of the EBRD, World Bank, KfW and other successfully active market participants in this segment,

685 UCLG, 2016, p. 118
686 UN-Habitat, 2015c, p. 3: Only 4% of the cities in low-income countries have access to the capital market.
687 CCFLA, 2015, p. 4 // Barnard, 2015, p. 7 ff. // De Boer, 2015, p. 4
688 For example, the „Global 300" Report about cities from JLL, McKinsey, 2011 as well as Barnard, 2015, p. 10: „Climate funds are increasingly targeting cities".
689 Li, 2011: „Synthesis of Financial Instruments".

- *strengthening of the national financal sector, in particular through the development of related development banks* (for example the TUHF in Africa). They could identify, promote and verify the granting of credits in a very detailed manner, and, in particular, also concentrate them into capital marketable mediums/categories.
- *strengthening of local municipal carriers, in the context of a transparent and solid (fundamental) financing basis* / strengthening of the governance structures and fighting against corruption. The creditworthiness of municipalities will be strengthened and investments attracted.[689]
- Establishing a *stringent allocation of resources* also at local levels,
- *integration of present sustainability standards such as PRI*[690] *or the Green Bond Principles*[691], as well as at the levels of individual sectors, such as buildings, according to LEED, BREAM, German Sustainable Building Council (Germ. DGNB) etc. in the context of granting credits or subsidies,
- *supporting cooperative projects as well as neighbourhood projects* with financial means.

With regard to the financing of cities and municipalities, it is recommended, to take different alternatives at federal, regional and federal state levels into consideration, when specific financing models will be developed for investors and building owners.

The **"Green Finance Network" (GFN) of R20** is an innovative example of approaches, showing how decarbonisation projects, their carriers and potential investors can be brought together. The approaches for example of the *World Bank in cooperation with the "Low Carbon, Livable Cities Initiative (LC2)"* are basically targeted-oriented and directed towards the clear planning and identification of reasonable low-carbon investments. The measurement of the status quo and the derivation of related emission reductions as well as the qualification of local decision-makers including the optimization of the creditworthiness are central elements.

One of the least extensive funding lines with regard to the energy-efficient neighbourhood rehabilitation comes from Germany and should be presented as a best-practice approach. The KfW conducts diverse municipal and social infrastructure programmes. The **KfW programme family** "Energetic urban rehabilitation" finances the planning, implementation and the monitoring of integrated neighbourhood concepts which increase the energy efficiency. During the last five years, the energetic rehabilitation of over 550 neighbourhoods was initiated in this way.[692]

The funding line "Energetic urban rehabilitation – grants for integrated neighbourhood concepts and rehabilitation manager" (Grant 432) is also included. The grants provide a contribution to the increase of the energy efficiency levels within buildings and infrastructure, especially with regard to the heat and cooling supply. The CO_2 reduction is in the foreground here. Integrated concepts thus support the climate protection target objectives of the state and municipality on local levels, but also other target objectives, such as the preservation order or social aspects as well as the citizen participation, should be taken into account. The concepts show short, medium and long-term saving potential and the rehabilitation manager accompanies the implementation of the measures, in case of realization.

An additional line of the KfW is "IKK – Energetic urban rehabilitation – Neighbourhood maintenance" (201 Credit). Hereby, through subsidised, long-term promotional loans, investments for the increase of energy efficiency in neighbourhoods, in the area of heat and cooling supply, as well as water and waste water supply, are financed.

The KfW also offers the programme "IKK – Building and rehabilitating in an energy-efficient manner" (217/218 credit). The programme promotes the construction of municipal and social infrastructure for the improvement of the

690 World Bank Group, 2013, p. 1ff // C40, 2016, p. 3ff
691 www.unpri.org
692 www.climatebonds.net
693 KfW, 2016

energy efficiency in the context of the national "CO_2 building rehabilitation programme". A wide range of individual measures for building envelopes or technical building equipment were supported.

With regard to the energetic efficiency, the subsidy standards of the KfW are oriented, towards the so-called KfW efficiency home standard, according to which the credits, i.e. the subsidies rise with increasing efficiency. Furthermore, the KfW offers a wide range of subsidies in the context of the "Renewable Energies" programme.

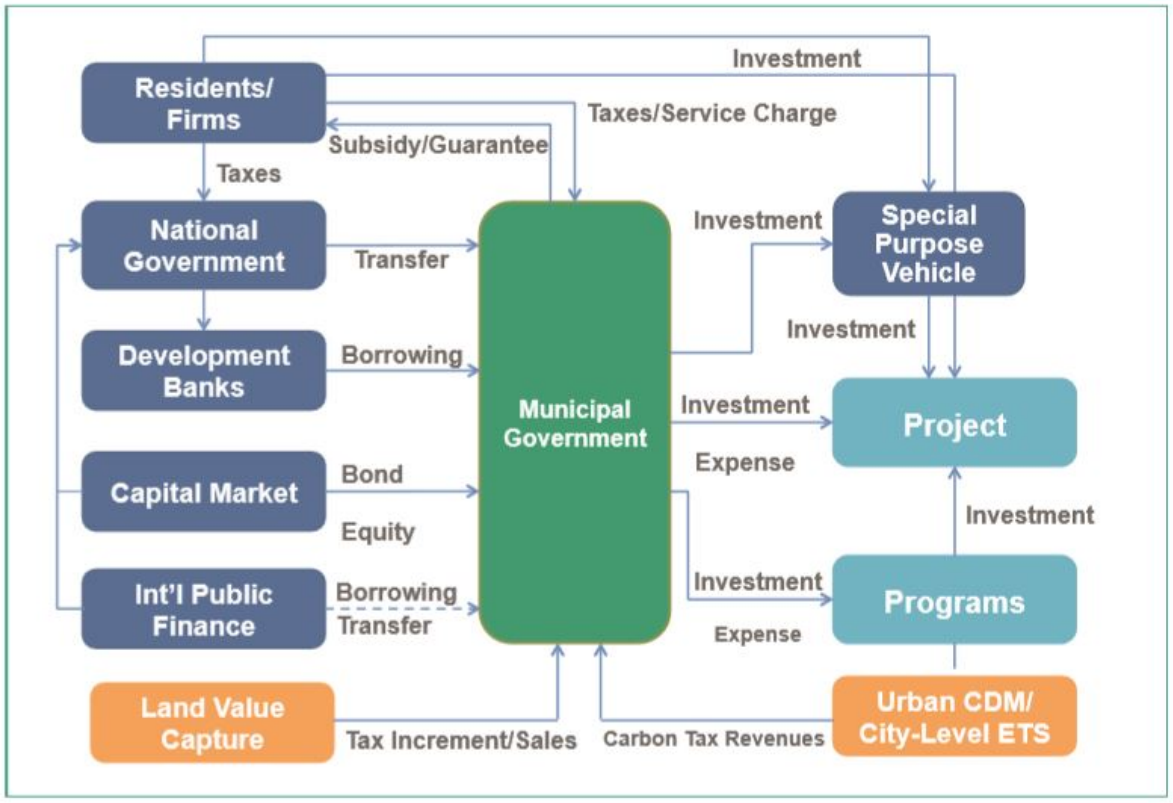
Table 53: Area of financing

Cluster	*B, C* *In developed national economies, access to the financial means is already extensively available.*	**CO_2 impact**	*Indirect, but high*
Implementation effort	*Very high*	**General population acceptance**	*Very high*
Long-term stability	*Questionable*	**Regulation necessary**	*No*
Financial effort	*Very high*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*The minimal support of supranational organizations or other financing partners is central.*

Source: own representation

The question of the internal strategy is directly dependent on the possible financial sources which are offered to municipalities. The following table should give an overview of the possible financing sources.

Figure 20: Dimensions of municipal financing opportunities



Source: Rosenzweig, 2015, p. 9.

The tendency is, thus, to complete the traditional financing mechanisms by innovative concepts.[693] As an example, a city-wide emission trading scheme can be mentioned, such as the one implemented by the city of Tokyo.[694]

11.3.10 Promotion of digitization, data management and transparency

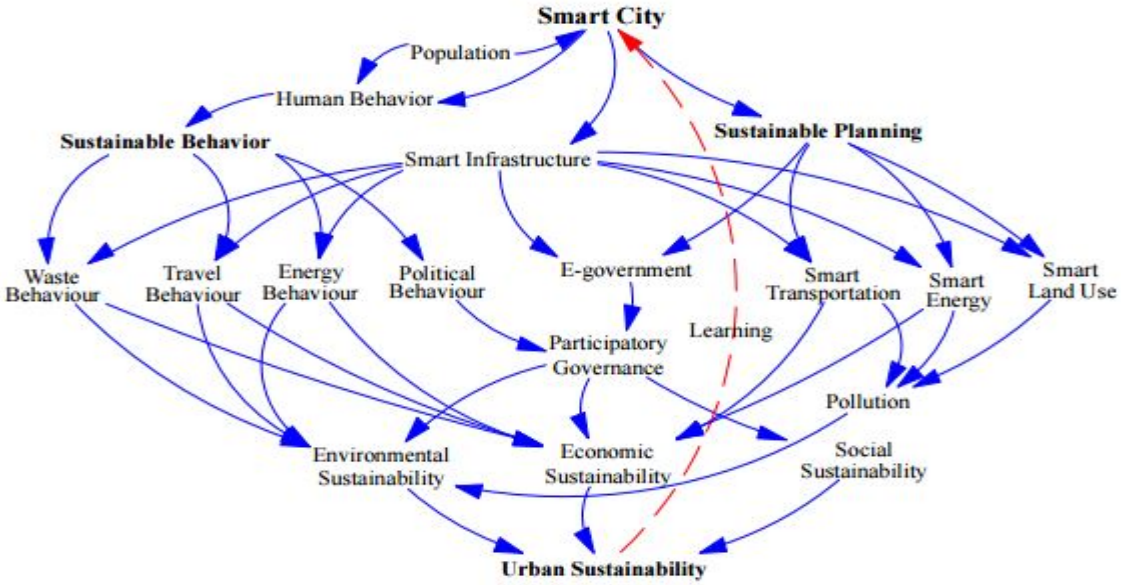
The *advantages connected with smart cities*[695] are especially concentrated on an efficient resource usage and, in this respect, promise high potentials in the context of decarbonisation. Subcomponents include the following:[696]

- *Smart metre:* In addition to the transparency regarding consumption, intelligent electricity metres can also guarantee high savings.
- *Smart lighting*: Illumination (private and public) represents approximately 15 percent of the total energy consumptions. Intelligent illumination systems with needs-based illumination as well as the LED technology can help save about 60 percent of this energy.[697]
- Sharing economy: examples of the sharing economy typically work intensively with apps, for example, the general digital support of a needs-based provision of products and services.
    - *Car sharing*: It offers advantages related to the utilisation of vehicles as well as the general reduction of individual transportation. Within cities, these concepts are also regularly assigned to electric mobility and can, if need be, strongly rely on regenerative energy.

694 See Chapter 11.3.9
695 http://www.kankyo.metro.tokyo.jp/en/climate/cap_and_trade.html // Tokyo Metropolitan Government, 2016: „Tokyo Cap-and-Trade Program".
696 German Advisory Council on Global Change (Germ. WGBU), 2015, p. 53 // Grand Lyon, 2012
697 UN Habitat, 2015h, p. 4ff
698 Manville et al., 2014, p. 152

- In megacities, traffic jams already lead today to energy losses that encompass 3 to 4 percent of the local GDP (Germ. BIP), healthy risks still not being really factored in.[698]

Figure 21: Network of relationships between "smart city" and "urban sustainability"



Source: Khansari, 2013.

Digitisation and data management will also be associated with the idea of the targeted usage of "***urban data***".[699] The use of sensors can, for example, give information about the traffic situation (so-called transport demand management)[700] and suggest optimal means of transportation. Intelligent systems, on this basis, can be upgraded to bus times or dynamically adjusted to the status of parking spaces. An area of application could also be the urban illumination, which adjusts itself to the usage pattern. Furthermore, there are applications available in the sectors of waste management or energy.[701]

In addition to the processing of data regarding the control of their own processes, cities should do well to use central indicators, so-called *KPIs for control and stakeholder communication*, which go beyond pure monetary values, such as the GDP – and, thus, support sustainable economies and decarbonisation. In doing so, the comprehension of citizens of welfare foundation instruments will be reinforced. With the *select commission*[702], the German Federal Government has delivered numerous examples. The cataloguing of greenhouse gas emissions is a first essential step. In this context, ***options regarding the usage of certain protocols*** (see Chapter 6) as well as ***software and databanks for cataloguing*** (see Chapter 7) were presented in detail in this report, which support the data management in this area.

For cities, the targeted control and reduction of their emissions is essential. However, through the usage of national or international input dat, for individual calculations, serious errors can occur. As an example, there are often ***no individually derived and locally adjusted emission factors*** available at regional levels. The results at neighbourhood levels should be compiled on the basis of activity data and specific emission factors and made accessible on a platform. This would offer the opportunity to those responsible to react especially to neighbourhood-related requirements and to take adequate measures, which will generate an advantage for the whole city.

699 UN-EP, 2012a, p. 34
700 UN-Habitat, 2015f, p. 11
701 UN-Habitat, 2015g, p. 2
702 Saujot, 2015, p. 11
703 www.enquette-kommission.de: Here „Growth, prosperity, living quality".

The *clear delimitation of the responsibility for emission sources* is also an additional field of action. As an example, the handling with supraregional traffic flows, from the perspective of cities, is often not clear. Thus, many cities do not deal adequately with aviation, navigation or other traffic hubs that cross their urban area, such as Singapore.

Best practices for digitization exist in many of the cities examined here, for example in Toronto and London.[703] The strengthening and broadening of the exchange of knowledge with universities is essential here. With incentives, cities can thus succeed to develop "digital medium-sized companies"[704] by promoting start-ups, which, in turn, does not only lead to higher income tax revenues but also to the upgrading of neighbourhoods and which supports the transformation to sustainable economy.

Central prerequisites of this field of action are, once again, clear (good) governance structures and a sufficiently developed urban administration with regard to finances and personnel. In developing countries, it can be difficult to create a reasonable and resilient data supply in many of the above-described areas or to build complex digital structures with a high system stability.

Table 54: Area of digitization and smart cities

Cluster	*A, B* *C – Opportunities are, due to the equipping of urban administrations in developing countries, actually limited.*	**CO_2 impact**	*Indirect, but high*
Implementation effort	*High*	**General population acceptance**	*Very high*
Long-term stability	*High*	**Regulation necessary**	*No*
Financial effort	*Medium*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*Low*

Source: own representation

11.3.11 Establishment of awareness, participation and promotion of innovation

The objective of an extensive decarbonisation cannot only be achieved through technical progress according to current knowledge. *Dematerialization through reduced consumption as well as voluntary renunciation will be primarily possible through the citizens of the cities themselves* and, thus, through the success of cities in establishing a changed environmental awareness. It is therefore important to also address the ethical scope of the climate change[705] and the primacy of the present over the future through high consumption and to demand or to encourage the necessary changes from people. Many people are open to such offers, which proves the increasing affinity for the sharing economy and, generally, the *downsizing movement*. It is therefore essential to turn those

704 Kleinman, 2016: For example, Kitchener-Waterloo for Toronto and diverse, for example, Oxford and Cambridge, for London.
705 Kleinman, 2016, p. 53
706 Shue, 2014

concerned into involved parties: a reasonable action planning oriented towards people and the establishment of a common target objective among all participants are essential success factors.

Behavioural changes require a corresponding sensibility for negative consequences and, thus, an adequate transparency. As an example, history has shown that, in India and China, the biodegradable packages from the food products consumed on commuter trains, where thrown out the window (for example, banana leaves). Since, in contrast to today's packages, they were, biodegradable, the rail line is nowadays more strongly contaminated – in such cases, simple awareness campaigns (in addition to interdictions) could raise awareness.

The *involvement of individuals at local levels, i.e. social consensus*[706] are therefore essential for the achievement of the decarbonisation targets. The often widespread perception, that climate protection involves problems, which one cannot solve on his/her own so that he/she gets into calculated optimism that future generations have to cope with the challenges, must be stopped. *Participation through, for example, citizen participation processes* (engagement) is essential for the reinforced identification of people with the defined, necessary measures. Therefore, it is important to also offer *low-threshold offers* for the involvement of people at neighbourhood levels. What is central is, in particular, the *maximal information of consumers* through comprehensive *dialogue and participation processes* as well as the corresponding *training and information offers*.[707] Analysis has shown diverse examples, with regard to how internationally transparency has been created in order to stimulate consumers to adopt a CO_2 low-carbon consumption behaviour:

- labelling of consumer products with reference to consumption values, when it comes to purchasing and renting: household appliances, buildings etc.
- awarding “leaders”: awarding companies, private persons, public administrations in a media-effective manner for particularly low consumption/high efficiency,
- school projects regarding “urban gardening” or general environmental protection,
- establishing “museums” on the relevance of decarbonisation of lifestyles, for example in Hangzhou/China.

A good example, which illustrates the *interplay between transparency, innovations and cities*, is offered by the *Future Melbourne* programme. Through a wiki and blog-based platform, citizens can directly comment and edit plans regarding future developments. This transparent procedure motivated approximately 30.000 citizens to become involved.[708] Through such platforms, numerous innovations in the areas of design, strategy, culture and even in the field of management and service, were made possible for the first time.[709]

Especially in the past decade, more studies have emerged, which have analysed the role of the intensive engagement by stakeholders with the focus on sustainability.[710] The analyses managed to identify aspects which *influence stakeholder engagement* in a negative manner:[711]

- gaps between solutions and users,
- institutional fragmentation,
- context diversity, which complicates comparisons and transfer of solutions,
- accessibility issue, since some stakeholders[712] are given only conditional access,
- permanent maintenance of motivation and interests,
- opinions and prejudices, for example, that poor residents are not taken seriously,

707 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB) 2016d, p. 3
708 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB) 2016d, p. 5
709 Future Melbourne, 2016
710 Hilgers, 2010
711 Since this is always also a question for the respective (company) culture, cf. Larn et al. (2011), for a study in Hong Kong, as well as Spitzeck et al. (2010) for the UK, Boesso and Kumar (2009) for the USA (and reference to Italy) as well as Lim and Yang (2008), with regard to Australia.
712 Based on a UN Review (UN 2010).
713 For example, in informal settlements (slums).

- problems of upscaling locally successful projects at the level of the entire metropolis,
- insufficient communication means (addresses and channels).

The manner in which engagement processes take place today or what the population expects, has genuinely changed.[713] The variety of stakeholders has increased. ***Best practice approaches for citizen participation*** have evolved with regard to real estate projects or neighbourhood developments and urban proposals regarding spatial planning issues[714] In order to achieve solutions and acceptance, today, there are fewer clear legal and contractual facts in the foreground, but increasingly themes, such as "ethical behaviours", "responsibility" and "sustainability". The inclusion of citizens in combination with a wider information basis as well as digital solutions can positively influence their willingness to actively supporting far-reaching transformation processes.

The implementation of laws and decrees (for example on the increased energy efficiency of buildings) also influences the behaviour of all market participants (for example real estate investors and tenants).[715] For example, ***the increased transparency of the investors' behaviour*** is important, which, in turn, has an indirect effect on their willingness to pay and, thus, supports the economic sustainability.

The ***consumer behaviour*** can be positively influenced in a targeted manner, in particular through ***simply accessible information***. In this context, the ***platform*** www.codecheck.info is a very good example. Consumers can discover the ingredients of practically all consumer goods using barcode scanning and, thus, consuming them in a conscious manner. Such approaches could also be easily extended to the CO_2 footprint of food and other consumables by using an app. The related CO_2 consumption can also be transparently shown on each sales slip/receipt.

The ***intensification of training programmes for disseminators*** is an additional measure, which influences the behaviour in a targeted manner and raises awareness. Thus, in Singapore, for example, the so-called "energy managers" were trained, which can handle optimizations internally within companies. The ***integration of environmental and climate protection contents in the curricula of schools or voluntary additional offers*** are simply instruments, which can support decarbonisation. Practically, all city networks and NGOs offer easy-to-adapt slide sets, case examples and studies, which can be adopted in the context of education and training. Cities have a huge potential to increasingly provide such contents within educational establishments in their catchment areas.

Table 55: Area of behaviour and awareness

Cluster	*A, B, C*	**CO_2 impact**	*Indirect, but high*
Implementation effort	*Low*	**General population acceptance**	*High*
Long-term stability	*Questionable*	**Regulation necessary**	*No*
Financial effort	*Low*	**Quick wins**	*Possible*
Scalability	*Very good*	**Pilot projects**	*Possible*
Critical for success	*Yes*	**Resistances**	*The necessity of a reduced consumption will be often understood as an interference with the personal freedom.*

714 Based on UNEP, 2005.
715 ZIA, 2014 // See also UN-EP, 2005, p. 21: For the role of these approaches within UN projects // Bal, 2012
716 Dent, 2012, p. 51f

Source: own representation

11.4 Core issues for the further implementation of political provisions

While, in the previous chapters – 11.1 to 11.3, the essential recommendations for actions, with regard to the operative implementation of decarbonisation strategies in the urban area were compiled, in the following section, the core issues derived from the analysis will be brought together for additional political provisions.

The core issues will also be mirrored against the ten statements, which were established in the context of the publication "The CO_2-free city – desire and reality".[716]

11.4.1 Significance of municipal activities

Mirroring of the first statement:

- CO_2-free city: local strategies with global significance

The relevance and the high necessity of the field of action "city" was derived and presented in detail in the present report (see Chapter 4 as well as 11.3.1.). The explosive nature regarding the achievement priority of decarbonisation in the urban environment has exponentially grown, due to the progressive urbanisation as well as the general population boom in the coming years (see Chapter 4). The complex and global scopes of the anthropogenic greenhouse gas emissions were also intensively analysed (see Chapter 3). From the point of view of all states, it is essential to actively participate and to accept the major significance of cities in the context of solutions, and to appreciate the political prioritization. The statement can thus be pursued in full.

In the context of the Framework Convention on Climate Change and other political processes, these scopes have until now, only insufficiently been reflected and must be strengthened (see Chapter 3.5).

The potentials regarding the successful realization of the significant reduction of greenhouse gases within cities are very high. Mobility and behaviour/engagement promise, short- to medium-term, the biggest potentials. The recycling economy and energy-efficient building stocks are, medium- to long-term, essential elements of transformation. Strengthening governance is central.

In contrast to Europe, the worldwide analysis has shown, that many nations plan to reduce the CO_2 intensity of their added value, however, ***the reduction targets are often planned to start from 2030 or 2050***. Many ***cities follow these national provisions*** and seldom go beyond that. Urbanisation and a growing economy make it difficult, in certain cities, to be particularly ambitious in this regard.

The incentives for cities with ambitious, absolute reduction targets, until now, have been limited and are indirectly available. Thus, Copenhagen has primarily profited, through the better "image" and other "indirect returns". In order for more cities to be persuaded to ***actively participate in initiatives for the reduction of emissions*** and, thus to promote best practice approaches, ***related national and international incentives should be implemented.***

In this context, it would be more important to ***establish more internationally coordinated incentives***, ***first, in order to persuade cities to achieve absolute reduction objectives and, second, to use the exemplary function of the majority of the big cities in the respective countries as a multiplier***. By strengthening decentralized structures and administrative bodies, the decision-makers involved should furthermore be qualified in order to facilitate good governance.[717]

717 Müller et al., 2012, p. 321ff
718 UN-Habitat, 2015b, p. 6: „Need for capacity building programs."

11.4.2 Embedding into international frameworks and initiatives

Mirroring of statements 2 and 7:

- International cooperation and knowledge transfer (2.)
- Regional norms (7.)

City networks represent an important success factor for the realization of decarbonisation endeavours. The now very wide field of initiatives was analysed here in detail, including the respective service ranges and advantages (see Chapter 5). Networks offer a constantly growing quantity of innovative best practices; when it comes to the procedural approach, they give both strategy development and implementation orientation assistance; serve as exchange and contact forum and offer a platform, on which cities have the possibility, to articulate their interests at international levels – for example, with regard to climate negotiations. Furthermore, there are numerous instruments, tools and software services, which support the governance and the general monitoring of decarbonisation approaches. A large number of the analysed cities already participates in related initiatives and the accession to such initiatives has been propagated as clearly advantageous (also see Chapter 10.3.1).

When it comes to the presented initiatives for decarbonisation, German public officials should first of all clearly define the respective content-related requirements, at municipal levels. Based on this, from the pool of the proposed initiatives, those should be chosen which can address the identified problems with their catalogues of measures. Furthermore, it is necessary to clarify, by which intensity the municipality is interested in binding itself to the initiative. Thereby, a difference must be made between close programmatic binding or free participation with reduced commitment. Considering these two aspects builds the framework of participation in the proposed alternatives.

The various organizations of the *city networks should from the perspective of international climate talks* i*actively be included* **i**n order to establish, at national levels, the "upgrading" of cities as significant field of action in achieving climate objectives. In doing so, *for example, individual climate protection plans with concrete sub-goals and steps for the 15 biggest cities worldwide could be demanded as integral component in the context of INDCs*. *Grouping cities in specific efficiency clusters* (see Chapter 11.1) in order to increase the transparency within the global context and to support the race within a (at least largely comparable) peer group for climate neutrality would be innovative.

It is also desirable, to ***strengthen*** the activities of *Habitat* and to significantly shorten the cycle of meetings (currently every 20 years) (see Chapter 4.4.).

The German Federal Government already financially supported cities, which entered into self-commitments, within the context of *Climate Alliance* (see Chapter 5.2.2.4). Here, additional incentives should be created and also the corresponding multipliers, such as the Association of German Cities, should be intensively included. On the international level, Germany can participate as an active partner with technical and process-related solutions and thus strengthen the foreign trade.

Through self-commitments, in the context of participating in (ambitious) reduction objectives of city networks, substantial reductions of greenhouse gas emissions can be reached. However, the long-term commitment as well as the accountability are essential, in order to avoid "green washing". Pure self-regulation is to be refused, since the scope of the need for action would not be reflected in an adequate manner.

11.4.3 Consistency of national, regional and local policies and strategies

Mirroring of statements 6 and 7:

- Integrated action plan in city and region (6.)
- Regional norms (7.)

In addition of the clear commitment of the national governments to (ambitious) INDCs, an essential recommendation is to ***strengthen*** regional governments and ***city administrations with regard to their self-administration*** (see Chapter 11.3.1 and 11.3.3). The collaboration and consistency of national, regional and local administrations are also be strengthened.[718] For this purpose, the constitutional framework conditions must be established and also the financing of measures, participation and corresponding personnel capacities are essential prerequisites. The implementation of stricter efficiency standards is, in many of the analysed cities and nations, still strongly capable of development and not comparable with the EU standards.

In the growing metropolitan regions, specifically, the ***elaboration and implementation of decarbonisation strategies, which are purely confined to the urban area, are not very effective*** (see Chapter 11.2 and 11.3.5).[719] Interconnections with the surrounding area in the sectors of real estate, traffic, waste as well as opportunities and limits of producing regenerative energy or of spatial planning, in particular, are too intensive. Approaches regarding a structured, coordinated procedure in metropolitan regions, for example, in Paris or Sao Paulo, barely exist (see Chapter 9). However, they face major challenges due to the institutional framework conditions. Positive examples regarding the upgrading of large urban areas, in metropolitan regions with far-reaching competencies come from Jakarta as well as South Africa (category "A" areas). Internationally scalable solutions appear to be difficult, since the individual (legal) framework conditions are diverse. Since decarbonisation addresses interdisciplinary problems and mobility, traffic, construction etc. may not be considered separately, the intensification of cooperation between various specialist departments within the city administration is also essential, in order to ensure good governance. Thus, on the basis of these findings, the statements can be fully accepted.

Although the EU has gained a lot of competence areas over the years, until today, there is no formal spatial competence. The European spatial development concept *EUREK* is based on the voluntary nature of the member states and only serves to formulate the superior key objectives. One of the denominated objectives is the conservation of natural livelihoods and of the cultural heritage. Against this background, a recommendation is to further strengthen the EU competencies on major regional development issues in the context of decarbonisation.

In the EU, the construction (as well as the traffic and agriculture) sector is not included in the European emissions trade (European Union Emissions Trading System, EU ETS), but it is considered in the EU Effort Sharing Decision (ESD) and further instruments (such as the Energy Performance of Buildings Directive) (see Chapter 3.5.3.). In other countries, this is partly not the case. China, for example, has initiated pilot projects within cities also involving the building stock (see Chapter 9). Related considerations regarding urbanisation could also be reasonable here.

The German *national Climate Protection Initiative* (NKI)[720] includesfunding programmes for cities, in order to support the municipal climate protection through information, counselling and capacity building. The German *Municipal Directive* also offers a wide range of possible instruments, in order to achieve decarbonisation at local levels. Not many analogous instruments are available at international levels (see Chapter 9), which is why an intensive interlocking between national provisions at international levels based on these coordinated, locally usable instruments would be reasonable.

Studies according to Section 140 no. 1 Federal Building Code (Germ. BauGB), urban planning according to Section 171b (2) Federal Building Code, development concepts according to Section 171e (4) Federal Building Code, which neglect the energy efficiency-related rehabilitation of a neighbourhood or district, often still take place in Germany. In these cases, defined scopes would be desired.

719 UN-Habitat, 2015b, p. 5: „Multilevel governance."
720 UN-Habitat, 2015c, p. 2
721 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB) 2016c, p. 19

11.4.4 Necessity of a clear governance structure

For the achievement of CO_2 neutrality, cities should basically undertake a change from “city management” to “city governance”. A *clear and good governance is a basic requirement for each concrete approach to decarbonisation*. In the present study (see Chapter 11.3.1), the elements of a good governance structure were presented in detail. High deficits regarding viable structures in emerging and developing countries were discovered. *The international community of nations* is even more required to support the *implementation* more intensively by incentives as well as conditions in the framework of development aids. The established structures must also intensively be monitored and guided, in order to guarantee their long-term functioning.

11.4.5 Relevance of the starting situation for deriving a strategy

Mirroring of statements 4 and 5:

- Urban redevelopment and urban new constructions require different strategies (4.)
- Local framework conditions must be taken into consideration (5.)

The present explanations can provide clear proof, that there is no “one” solution pathway to follow, when it comes to decarbonisation. However, there are similar challenges in practically all metropolises around the world (see Chapter 4.5) – for example, the expansion of renewable energies. As an example, there is the implementation of renewable energy in Sao Paolo, which, however, faces other obstacles as, for example, in Munich. Independently from the considered sector or the concrete measures, this is mostly dependent on the various climatic conditions, divergent stakeholder interests / influences, financial opportunities / restrictions, the efficiency of governance structures, the local environmental awareness and other factors at the same time (see Chapter 9). Urban redevelopment in the growing urban structures of the industrialized states is also subjecd to other problems, as is the case with the creation of new megacities in Asia. The two counterfactual situations, presented in the statements, were completed by one more and summarised into clusters (see Chapter 11.1). Besides, the undertaken analyses confirmed that mutual learning and exchange of best practices between the clusters are naturally target-oriented, since the concrete *solutions* in terms of products from the case studies and options offered, which are gathered especially by city networks (see Chapter 5), are often identical, however, although *approaches* (see above), differentiate. Thus, the introduction of a car sharing system in a European metropolis, for example, would take place in a largely analoguous form in Asia (type of solution). Due to the needs and financial as well as technical equipment of the population in Indonesia, this approach, however, possibly makes little sense. Options such as the expansion of public transportation, electric scooters, bicycle rickshaws etc. would perhaps appear more adequate there. Thus, the transport systems and their modifications are dependent on climatic and sociocultural aspects. The mutual exchange and learning, based on best practices, can help to ensure reasonable transfers of tested approaches into other cultural environments.

11.4.6 Long-term planning with clear prioritization

In the present study, it was stated, that in practically all cities (see Chapter 9), there are *formalized structuring framework concepts*, which address decarbonisation, directly or indirectly, and which are derived from the INDCs. Due to the reduced financial resources, changing political majorities, corruption and other uncertainties, especially in emerging and developing countries, the implementation is frequently in sharp contrast to the intended target objective. Thus, firstly, it is essential, that the *objectives regarding decarbonisation* are fixed *based on broad political consensus*, and, thus, beyond diverse legislative periods. Intensive citizen participation, in the context of development is helpful.

When it comes to the expansion or renewal of the infrastructure – in particular in the fields of transportation and energy – so-called *log-in effects are to be avoided*. They, for example, arise when long-lasting fossil energy

production systems are further financed or even subsidised and the change to a sustainable economy, due to the already made (bad) investment, is impeded.[721]

In accordance to the approach of states, based on the Framework Convention on Climate Change of the UN, it is also important at municipal levels to implement a ***verification and ambition mechanism***[722] over a period of at least five years. The international community of nations can and must provide assistance.

A clear planning and detailed formulation of goals are essential. In this way, Chicago has decided to transfer the planned savings precisely to individual fields of activity and did not only define general guidelines.

11.4.7 Complementarity to other economic objectives

Mirroring of statements 3, 8:

- A secure energy supply is also imperative in the future (3.)
- Conflicting goals in the field of spatial planning (8.)

Decarbonisation is also clearly directed against industrial sectors which are energy-intensive and often belong to the old economy (see Chapter 11.3.2). Conflicting goals especially arise in growing cities, which fail to promote and establish companies of the green economy to an adequate extent, in order to compensate for ***job losses in the old economy***. Here, a strengthened and close interlocking of communication instruments, decarbonisation objectives as well as economic impulses is necessary. While the IPCC still assumed real costs – from 1 to 5 percent of the GDP – for the large-scale transformation, studies which took the low-interest rate into account, have shown, that, ***the change produced positive cash values and, thus, added values***.[723] Noteworthy in this context are the ***studies of the OECD regarding "green growth" cities***, which, in addition to general guidelines[724], also analysed different cities worldwide.[725]

Decarbonisation and regenerative as well as decentralized energy supply are elementary for securing the future energy supply (see Chapter 11.3.2 and 11.3.7). Apart from elements increasing the level of energy efficiency, stakeholders and smart grids must also in the future be integral parts of objectives. The efficient dealing with limited resources, against this background, can also be understood as risk management.

Conflicting goals regarding land use in the context of the alternative energy production (due to the spatial demand) mainly go beyond, city borders. Chapter 11.3.5 referred to the necessity of a balanced approach which also took other objectives into consideration (for example, derived from the SDGs). They include participation, food supply, adequate job offers etc.

11.4.8 Impulses regarding financial feasibility

Mirroring of statement 10:

- Financial feasibility and overall costs (10.)

The decarbonisation of cities is a major economic challenge, due to the necessary capital sums for the necessary conversion. A current study has analysed the direct costs, returns and amortization patterns, regarding investments in low-emission measures within cities. The investigation showed that investments in public and low-emission mobility, waste disposal and construction efficiency, can lead to savings with a net present value of over 15 billion euros until 2050.[726] Political decision-makers and urban administrations are equally conscious of this fact; but

722 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB) 2016d, p. 7, 24f
723 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germ. BMUB) 2016d, p. 9
724 Enkvist et al., 2010, p. 9
725 Matsumoto et al., 2014
726 OECD, 2009 // OECD; 2012 // OECD, 2013abc // OECD, 2015b
727 Gouldson et al., 2015

already more than 75 percent of the cities see financial advantages in the measures taken against the climate change.[727]

Especially in emerging and developing countries, the financial feasibility, however, faces enormous difficulties. This is why the present study identified various approaches towards the raising of capital (see Chapter 11.3.9). Apart from the GCF, current subsidy instruments in the context of development aids are not sufficient to finance this transformation. Further (financial) aids and the implementation of new development banks and instruments are indispensable.

The approaches of the *World Bank* in connection with the *"Low carbon, livable cities initiative (LC2)"* can basically be positively evaluated. However, it is problematic, that the present *target achievements of the programmes* are *limited.* Related efforts must therefore be intensified. The approaches of the KfW could internationally be used as a blueprint for additional programmes and, thus, offer approaches for scaling.

Innovative financing instruments of measures are increasingly necessary. As an example, poorer social classes should be granted better access to micro-credits, which can be used for innovative solutions to decarbonisation (citizen projects regarding sharing economy, purchase of rickshaws , waste management projects etc.). So far, there has been an access barrier, since investments in decarbonisation usually have a bigger project scope and related funding programmes are strongly oriented towards these requirements.

With regard to revenue from taxes, *local trade taxes in emerging and developing countries should be increased*;[728] the basis should then provide for market values and not outdated standard values. There are also major opportunities for absorbing conversion revenues. Hong Kong can serve as an example.[729]

The funding volumes of the KfW in the fields of environment, housing (in particular energy-efficient building and refurbishment) and of the energy efficiency programm, in the first half of 2016 with 4.6 billion euros, 10.4 billion euros and 2.2 billion euros are very high compared to the rest of the world. Nevertheless, German municipalities have also addressed an investment delay of 136 billion euros[730]. In this context, many of the respondents might only estimate the current need, but not transformation in the context of the urban decarbonisation. A consolidation and a further expansion of the funding lines in quantitative and qualitative terms are thus to be taken into consideration.

11.4.9 Quantitative progress report and success monitoring

Decarbonisation can only take place in a targeted manner, when the corresponding target achievement can quantitatively follow, which is why cataloguing and other solutions are indispensable for the ongoing monitoring. Sufficient instruments are available, however, according to the present study (see Chapter 6 and 7), they are used voluntarily and largely without control. With this in mind, municipalities should define clear socioecological threshold values and measuring mechanisms for urban infrastructure investments and their financing, in order to support a sustainable green development.

Transparency is an essential prerequisite forthe targeted reduction of greenhouse gases. But only in a few cases, the necessary data quality is achieved. Furthermore, the data is also difficult to be compared on the international level. For one of the biggest emission sources, the real estate, current studies have proven, that cities, as well, are able to provide only insufficient information about values, sizes and other real estate-related data.[731]

728 CDP, 2014, p. 11
729 UN-Habitat, 2015c, p. 2: „3-4% of local revenues compared to 40-50% in cities in UK, US etc."
730 UN-Habitat, 2015c, p. 5
731 Press release from 21.06.2016 // KfW.
732 Kaganova et al., 2000, p. 6ff // Garmendia et al., 2013, p. 8ff

Against this background, the *WBGU* justifiably criticized the fact that, due to ***various standards, insufficient data quality, diverging calculation methodologies and missing data, a comparability of the urban greenhouse gases is made difficult.***[732] International politics should strongly promote the related quantitative progress monitoring and push for the harmonization of various standards. The GPC should be used as a guideline.

It was also stated (see Chapter 4), that the biggest urban areas, worldwide, have a massive proportion[733] of the anthropogenic greenhouse gases. Besides, the 300 biggest cities in the world attract 69 percent of all global, cross-border investments and 72 percent of all real estate investment activities.[734] At the global and also at the respective national levels these metropolises present a leading function with regard to economy, innovations and changed consumption patterns. Against this background, ***transparency regarding the sustainability KPIs of the biggest metropolises worldwide*** (for example, the biggest 100), was a milestone in the context of decarbonisation. Indeed, the majority of these cities have already published progress reports today, they also include the greenhouse gas cataloguing and developments with regard to the reduction of emissions. However, these are not final, neither fully comparable, not verified and do not seem to be made on an annual basis. The preparation should be centrally monitored, for example, by the UN and built in component sets in addition to information provided by the cities themselves, from elements from rating agencies, certified auditors, HDI figures[735], for welfare as well as from additional, new urban-related sustainability aspects.[736] A coherent ***annual progress report*** can offer the basis for constant development and high visibility. In this way, the population can also clearly be explained the urgency and spatial dimension of the need for action.[737] Furthermore, cities would have, by comparison, bigger incentives to constantly intensify their efforts. With regard to the national progress reports, the reports could also be useful in the context of the INDCs.

"If just 100 of the world's largest cities embark on a low-carbon development path, global greenhouse gas emissions could decrease by an estimated 10 percent a year."[738]

Web-based information platforms, such as NAZCA (see Chapters 6 and 7) should be developed and extended, in addition to clear memorandums (on emission reduction, in percent, over a specific period of time, in a particular field), in individual sectors, in order to benefit from concrete progress reports and best practices, when it comes to the implementation of the established decarbonisation objectives. A long-term goal should be that also concrete contributions and *(potential) target achievements, within the meaning of INDCs, could be "matched" to the recorded measures*. The contribution and, if applicable, the gaps regarding the adherence to the 2 degrees target would thus be transparent.

11.4.10 Promotion of transparency and awareness

Mirroring of statements 9 and 10:

- Individual behaviour (9.)
- Financial feasibility and overall costs (10.)

In the present elaboration, it was carved out, in different places, that the change of lifestyles and the reduced consuming behaviour (see chapter 11.3.3 as well as 11.3.11) , in the end, are the essential keys for the realization of the successful decarbonisation strategies. Transparent communication, trainings, citizen participation, promotion of the sharing economy etc. are exemplary instruments, which can be promoted by cities in a low-threshold and, finally, cost-efficient manner. In this context, internationally, essential intensive impulses must follow. The personal

733 German Advisory Council on Global Change (Germ. WGBU), 2016, p. 220
734 70% in 2015, and up to 98% in 2060, in case the carbon dioxide intensity remains the same.
735 JLL, 2015, p. 3
736 German Advisory Council on Global Change (Germ. WGBU), 2016, p. 157: To various alternative welfare measures.
737 German Advisory Council on Global Change (Germ. WGBU), 2016, p. 160ff: To proposals for assessments of cities, based on key figures.
738 UN (Habitat), 2015b, p. 6: „Need for performance monitoring."
739 http://www.worldbank.org/en/topic/urbandevelopment/brief/low-carbon-livable-cities

awareness regarding the necessary change in behaviour is, in many of the analysed cities, still deficient and the consumption style is, further on, characterised by a clearly increasing CO_2 footprint, in connection with the increasing revenues.

The so-far *integration of environmental and climate protection contents in the educational learning plans* is worldwide insufficient. Although, in industrialized countries, at the latest since the emergence of the Agenda 21[739], different intensive initiatives are practiced within schools, however, by far, these do not have a distribution and depth, which corresponds to the current urgency. The following procedures would be possible:

1. Resolution of the participating countries to the Framework Convention on Climate Change regarding a *"education impact plan"*, which must be implemented, on a very short-term basis, at national levels.
2. Qualitative and quantitative development, for the individual training levels (kindergarten, primary school, secondary schools), of differentiated contents for the regions.
3. Adaptation of the content at national levels.
4. Integration of the learning content as a separate subject (analogously to the teaching of the national language as well as mathematics).

The *consumer behaviour* can be positively influenced, in a targeted manner, especially through simply accessible information. The *platform* www.codecheck.info offers an excellent example. Consumers can discover the ingredients of practically all consumer goods, using the barcode scanning and, thus, consume them in a conscious manner. Such approaches could also be easily extended to the *CO_2 footprint of food and other consumable, with the use of an app*. Strengthened international initiatives would be preferable here.

11.4.11 Consideration of costs and benefits as well as compliance with the polluter pays principle

Mirroring of statement 10:

- (Socially equitable) financial feasibility and overall costs (10.)

There is a clear connection between incomes/assets and the average accompanying (higher) emissions level.[740] The acceptance of the higher social classes regarding action and their insight that, according to the *polluter pays principle*, they also have to bear the biggest encumbrances regarding the necessary change, is thus essential. A substantially stronger exposure of higher income brackets could not be found in the here undertaken analysis. In the context of financing the transformation (see Chapter 11.3.9), different sources of revenue of cities were shown which are, to some extent, suitable to promote these redistributions.

In this context, the Federal Government speaks of "*socially equitable financing concepts"*[741], which, ultimately, have a lesser effect on the weaker income layers – in particular when these are only responsible for a moderate percentage of the total amount of emissions. Innovative solutions, such as the Tobin tax, CO_2 taxes, progressively growing prices for electricity/water/waste water etc. were target-oriented instruments.

740 Agenda 21, 1992: Thinking globally and acting locally.
741 For example Chakravarty et al., 2009, p. 11884ff
742 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2016d, p. 3

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Appendix

Appendix I: Exemplary data structure (example of Hangzhou)

Project: CO2 neutral in Cities and Districts

ANHANG I - Cities data collection

City/District: Hangzhou | Country: China | Coordinates: 30.2936500 , 120.1614200

Category	Type	#	Variable	Entry	Unit	Date	Source
Population and Density	Demographics	1	Area	16,847.00	km2	2013	http://www.lareg.wzw.tum.de/fileadmin/OPULS_euphor/issue01/txt_english/hangzhou_gu.pdf
		2	Population	8,700,400.00	inh.	2013	http://www.lareg.wzw.tum.de/fileadmin/OPULS_euphor/issue01/txt_english/hangzhou_gu.pdf
		3	Population growth rate	3,36	‰	2007	http://www.chinatouronline.com/china-travel/hangzhou/hangzhou-facts/hangzhou-population.html
		4	Urbanization rate	50.29	%	2008	https://books.google.de/books?id=b19WuHMmk0AC&pg=PA65&lpg=PA65&dq=hangzhou+urbanization+rate&source=bl&ots=nEKz50boR4&sig=GD2bZiICmpqwftNG-
		5	Population density	516	inh./km2	2012	http://www.lareg.wzw.tum.de/fileadmin/OPULS_euphor/issue01/txt_english/hangzhou_gu.pdf
	Economic Activity	6	Gross GDP	152,914,951,800	$	2015	http://www.hubpold.com/2016/01/25/hangzhou-china-the-10th-trillion-gdp-city-gdp-per-capita-reached-levels-of-rich/
		7	*GDP per capita*	13 659	$	2008	https://books.google.de/books?id=b19WuHMmk0AC&pg=PA65&lpg=PA65&dq=hangzhou+urbanization+rate&source=bl&ots=nEKz50boR4&sig=GD2bZiICmpqwftNG-
		8	*Consumption per capita*	5,141	$	2015	http://en.dioscript.net/article/14610
		9	Unemployment rate	1,85	%	2013	http://www.chinaknowledge.com/CityInfo/City.aspx?Region=Coastal&City=Hangzhou
	Governance	10	Voter participation in last municipal election		% of eligible voters		
	Energy	11	*Energy consumption per capita*		kg TCE/inhabitant		
		12	Energy consumption per unit GDP	0,7	tons of cole/ 10000 RMB	2009	https://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/documents/Invest-Hangzhou-Energy-Conservation-Environment-Protection-Industry-201104.pdf
		13	Energy consumption of residential buildings		MJ/m2		
		14	Percentage of renewable energy consumed by the city		%		
	Solid waste	15	Percentage of city population with regular solid waste collection (residential)	100	%	2008	https://books.google.de/books?id=b19WuHMmk0AC&pg=PA65&lpg=PA65&dq=hangzhou+urbanization+rate&source=bl&ots=nEKz50boR4&sig=GD2bZiICmpqwftNG-
		16	*Municipal waste per capita*	427	kg/inhabitant	2009	http://www.iswa.org/uploads/tx_iswaknowledgebase/Dorn.pdf
		17	Percentage of waste recycled	10	%	2010	http://www.chinadaily.com.cn/m/hangzhou/e/2010-01/25/content_9370127.htm
		18	Number of personal automobiles per capita	114	un./1000 inhabitants	2012	http://chinaautoweb.com/2013/06/more-chinese-cities-consider-limiting-car-consumption/

Appendix II: Overview – project-related cities

Land Code[742]	Land	City	#
AT	Austria	Vienna	1
BR	Brazil	Rio de Janeiro	2
		São Paulo	3
CA	Canada	Toronto	4
CN	China	Shanghai	5
		Tianjin	6
		Hangzhou	7
DK	Denmark	Copenhagen	8
FI	Finland	Helsinki	9
FR	France	Lyon	10
		Paris	11
DE	Deutschland	Berlin	12
		Freiburg im Breisgau	13
		Hamburg	14
		Munich	15
IN	India	Andhra Pradesh New City (Amaravati)	16
NL	Netherlands	Amsterdam	17
RW	Ruanda	Kigali	18
SG	Singapore	Singapore	19
ZA	South Africa	Durban (eThekwini)	20
KR	South Korea	Seoul	21
ES	Spain	Madrid	22
SE	Sweden	Stockholm	23
AE	United Arab Emirates	Abu Dhabi (Masdar City)	24
GB	United Kingdom	London	25
US	USA	Chicago	26
		New York City	27

Source: own representation

[742] Nach ISO 3166-1:2013 “Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes”

Appendix III: Typological summary of used assessment criteria

Category	Type	#	Variable	Unit
Population and density	**Demography**	1	Area	km^2
		2	Population	citizens
		3	Population growth	%
		4	Urbanisation rate	%
		5	Population density	citizens/km^2
	Economic activity	6	GDP	$
		7	GDP per capita	$
		8	per capita consumption	$
		9	Unemployment rate	%
	Political leadership	10	Election turnout of last local election	% of eligible voters
Development and use of infrastructure	**Energy**	11	Energy consumption per capita	kg crude oil/citizen
		12	Energy consumption per GDP-unit	kg crude oil/$ GDP
		13	Energy consumption of residential buildings	MJ/m^2
		14	Percentage use of renewable energy compared to overall urban energy use	%
	Solid waste	15	Percentage of urban population, whose solid waste is regularly collected (only residential sector)	%
		16	Urban waste per capita	kg/citizen
		17	Recycling quota	%
	Transport	18	Number of private motor vehicle per capita	units/ 1,000 citizens
		19	Percentage of walking and cycling commuters	%
		20	Percentage of population that uses public transport	%
		21	Length of bicycle lanes	km/km^2
		22	Length of public transport	km/km^2
	Urban planning	23	Green space per 100,000 citizens	km^2
	Waste water	24	Percentage of urban population that is connected to the sewage system	%
		25	Properties that are connected to the sewage system	%
	Water and sanitary facilities	26	Percentage of urban population with direct connection to drinking water supply	%
		27	Annual water consumption per capita	litre/citizen
		28	Tightness of water systems	%
Climate and environment	**CO_2 emissions**	29	CO_2 emissions per capita	tons/citizen
		30	CO_2 missions per GDP-unit (carbon intensity)	g/$ BIP
	Emission in CO_2 - equivalent	31	Average daily nitrogen dioxide emissions	$\mu g/m^3$
		32	Average daily ozone emissions	$\mu g/m^3$
		33	Average daily mass of particles	$\mu g/m^3$
		34	Average daily CO_2 emissions	$\mu g/m^3$

Source: own representation