Fraunhofer

MorgenStadt
City of the Future

INNOVATION NETWORK
»MORGENSTADT: CITY INSIGHTS

MORGENSTADT FRAMEWORK

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MORGENSTADT / CITY OF THE FUTURE: PHASE I

Final Report

Fraunhofer Partners:

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Content

1 Morgenstadt: City Insights

In phase I of »Morgenstadt: City Insights« (»m:ci«) we analyzed six cutting-edge cities on their approach towards sustainable development. This phase took place from June 2012 until October 2013. Over 50 researchers from 12 Fraunhofer-Institutes conducted a rigorous on-site analysis of six cities, which are leading examples of sustainable city development worldwide: **Freiburg, Copenhagen, New York, Berlin, Singapore** and **Tokyo.**

Over 100 best practices in eight urban sectors (*energy, building, mobility, water, productions and logistics, security, information and communications technologies (ICT),* and *governance*) were analyzed with a trans-disciplinary approach. Fraunhofer researchers systematically derived insights regarding key factors that create conditions for cities to successfully transition towards urban systems that make effective use of energy and resources while maximizing the quality of life for their residents. The research identified requirements for future urban markets and enabled new collaborations between private sector industry partners, research institutes, community groups, and city administrations.

The aim of phase I was to identify the cutting-edge global status quo of sustainable city systems and to create a starting point for the research and development of innovations in future urban systems. In order to make the best use of the data gathered on-site, the »m:ci« researchers went one step further and aligned and synchronized insights from all cities in one action-oriented model for sustainable urban development.

Results of the first phase of »Morgenstadt: City Insights« have been generated with regard to the following categories:

m:ci Method: Systems-analysis
The Fraunhofer »m:ci« consortium has developed the »City Insights Method«: a multidisciplinary method for analyzing complex urban systems. The on-site research in the six cities proved the general suitability of this method and generated possibilities for fine-tuning.[1]

Morgenstadt / City of the Future Model for Sustainable Development
Based on the analysis of six selected cities, 83 key application fields for sustainable urban development were identified in phase I and integrated to create a generic action-oriented model for sustainable urban development. The model is described in detail within chapter 11 of this document.

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[1] The »m:ci research design« is the main document describing the methodology developed and applied throughout »m:ci«. It can be downloaded from the Fraunhofer-livelink server: https://dms-prext.fraunhofer.de/livelink/livelink.exe/properties/2643813

Key insights

Based on the analysis results and several »Morgenstadt labs« a large number of hypotheses on the future of sustainable urban development were discussed and distilled into several »key insights«. These represent future action fields for cities, research, and business to engage in when developing new and innovative approaches towards shaping sustainable urban solutions. General key insights can be found in chapter 10 in this report. Specific key insights from the sectors can be found within the chapters focusing on sector results.

Best Practices

The in-depth analysis of over 100 best practices from eight urban key sectors delivers insight into success factors for sustainable urban solutions (finance, organization, structure, actors, strategy, and technologies) as well as their potential for transfer.

City Reports

All best practices are listed and described within six reports referring to the cities analyzed. Along with the best practices, the city reports contain information on strategies, aims and measures of the cities, links to history and path dependent development, social, economic and political systems, local impact factors and framework conditions, actors, energy and resource consumption.[1]

m:ci Database

All information was fed into a »City Insights« Database that tracks the relationships between indicators (over 200 per city), success indicators for each best practice case, and factors that impact sustainable urban development in general. Profiling and benchmarking of cities becomes possible.

Project Development

Over 50 ideas and concepts for urban development projects have already been generated out of the insights from the analysis of the reference cities. The first projects are in the process of implementation or are 'shovel ready'.

1.1 Systems innovation for cities

The main driver for the innovation network »m:ci« is the global development of cities. In 2030 – in 16 years – already 5 billion people will live in cities, with the largest share of them located in today's emerging economies.[2] It is expected that cities worldwide will expand their area by the factor 2.5 - leading to the sealing of up to 7% of globally available fertile ground. Cities account

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[1] All city reports can be downloaded from the Fraunhofer Livelink server at https://dms-prext.fraunhofer.de/livelink/livelink.exe/properties/3132757
Please note: access is restricted to members only.

[2] Angel et al. 2005

for 60-80% of global energy use and for a similar share of global greenhouse gas emissions[1] - although cities have the highest potential for gains in efficiency and minimizing the ecological footprint of individuals. Also, cities are the places of global value creation: between 2010 and 2025 the GDP of the 600 largest cities worldwide will increase by over 30 trillion US$, accounting for 60% of global economic growth.[2] In the same time span an additional amount of floor space will need to be built, equaling 85% of today's globally existing floor space.[3]

»Global urban infrastructure and usage expenditures in dwelling and transportation for the next three decades will exceed $350 trillion (…) or seven times the current global GDP«.[4]

We increasingly face global challenges such as climate change, scarce resources, and the exploitation of ecosystems that go beyond the planetary boundaries. If we are to avoid unprecedented shifts in our lifestyles forced upon us by external shocks, we have to prepare to advance a type of urban development that leads towards shaping sustainable cities.

Managing Transitions of Socio-Technical Systems

Clean and efficient technologies are the main enablers of the transition that has to happen throughout cities all over the world. But technologies are bound to path-dependent socio-economic systems and long-lasting infrastructures. Thus, technological innovations that help cities become more sustainable must always be embedded in entire systems innovations that take into account human behavior, business models, policies, and existing structures within the cities. These complex processes of co-creation and systems innovation are difficult and time consuming – they build upon multi-stakeholder constellations and are embedded in political power constellations of local governments. Nonetheless, cities represent the ideal environments for the innovation of complex systems and for their development by modification and adaptation. A great example of urban systems innovation is provided by Frank Geels who describes the innovation and gradual diffusion of waterworks in Dutch cities in the 19th century,[5] stressing that leading cities provide the ground for innovative solutions. Amsterdam was the first city to introduce a water pipe system in 1853, because water from wells and canals was of low quality. Den Helder followed in 1856. Only 40 years later, 69 Dutch cities had implemented waterworks. The motivations for the implementation of a water pipe system varied broadly and turned out to be of secondary importance.

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[1] OECD 2013.
[2] McKinsey Global Institute 2012.
[3] Ibid.
[4] WWF und Booz & Company 2010.
[5] Geels 2004.

The same effect was witnessed with the innovation of the electricity system. It was not until the whole system, with different actors and their corresponding roles, was built on a small scale in 1882 in New York that the benefit of electricity became apparent and many other cities implemented similar solutions. With a working system of electricity, innovation in other sectors was triggered. Electric tramways started to change urban mobility and mass production systems suddenly became possible with electric motors available for any machine. Systems innovation throughout history has shown that once one or two forerunners have proven the general validity of a system, it becomes much easier for others to implement similar solutions. Cities thus act as seedbeds for transition. They provide an ideal environment for the generation of socio-technical niches – alternative systems that benefit from the high density and turnover in a city. If we want to address the global challenges of the upcoming decades, we have to make use of this urban potential for creating sustainable systems in a strategic way. New solutions need to be piloted within the urban context and processes and technologies have to be refined and brought to the market from there.

Analyzing today's seedbeds of transition

In phase I of »m:ci« we analyzed the approaches six cutting edge cities are taking towards sustainable development. Just like Amsterdam in the 19th century, we found that many cities are moving towards sustainability because external pressures show them the necessity for rethinking an industrial growth model based on fossil fuel consumption. Learning from these cities requires a close look at which innovative sustainable solutions work, and why they work in which city. Learning from Singapore, Tokyo, Freiburg, Copenhagen, Berlin, and New York City means identifying the niches and socio-technical innovations that are helping these cities transition towards a state of higher sustainability and might become the foundation for other cities' transitions within the next decades – just like Amsterdam's waterworks solution was adopted by other Dutch cities.This report compiles the condensed results gathered in »m:ci« phase I. Not every sector was analyzed in each city, but comparison of indicators and best practices for each sector allow us to draw conclusions on the current global status quo of the eight sectors with respect to sustainable urban development.

Chapters 2 to 9 highlight the sectoral results. Chapter 10 gives an overview of »key insights«, that were discovered during the city analysis. Chapter 11 explains the »Morgenstadt / City of the future model for sustainable development« that has been derived from the compilation of all data and information on the six cities. This model will be used to develop an analytical instrument that enables the members of »m:ci« to analyze cities by their sustainability performance in phase II. Chapter 12 applies the »Morgenstadt model« to the six selected cities, demonstrating the potential of a multi-layered analysis of urban systems. Chapter 13 completes the report by giving an outlook on phase II of the innovation network, starting in January 2014.

1.2 Defining Morgenstadt

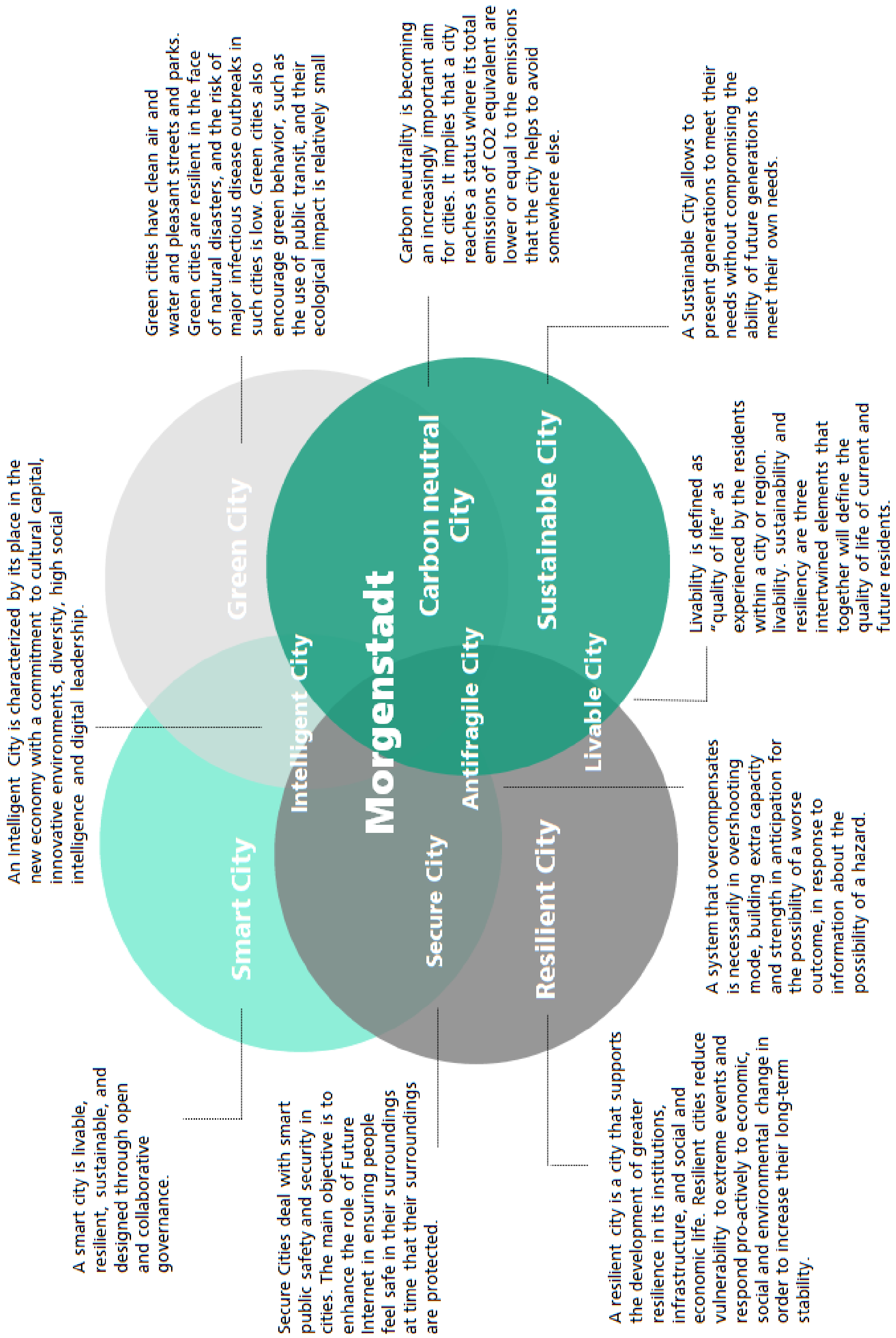

Figure 1: Positioning Morgenstadt within overlapping city frameworks

The »Morgenstadt / City of the future« initiative puts the quest for sustainable city systems at the center of its research and analyzes. However, it has important overlaps with alternative concepts of city development that have emerged in recent years, like »smart city« »carbon neutral city«, »resilient city« etc. Figure 1 gives an overview of the relationship of these concepts.

1.2.1 Broad Definition of Sustainability as Guiding Vision

The guiding vision of a »Sustainable City« served as a catalyst for a new and trendsetting alliance between industry, politics, city administrations, and research. In »m:ci« we refer to the underlying principle of sustainable development as defined by the World Commission on Environment and Development:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

For the purposes of »Morgenstadt: City Insights«, we defined the core aspects of sustainability as follows:

- reduction of resource consumption per capita
- careful handling of raw materials and environment
- reduction of energy consumption per capita
- reduction of emissions (CO_2, other climate gases like methane, or toxic substances)
- reduction of social imbalances
- meet security of supply
- creation of stable, long-term-oriented economic structures
- increase of social well-being and life expectancy
- increase of human health
- increase of health of urban ecosystems
- increase of resilience of physical infrastructures and social networks with regard to adverse events (of catastrophic dimension) as well as developments of radical change
- decrease of the societal and physical vulnerabilities of urban societies with regard to multiple man-made and naturally caused hazards

This broad definition of sustainability used in »Morgenstadt: City Insights« is the basis of the six city reports and this final report. The mission was to identify solutions that help cities become more sustainable, and thus address one or more of the above-named aspects of sustainability.

1.2.2 Aspects of urban sustainability

Throughout the course of the »m:ci« research, discussions on the assessment of urban sustainability emerged. Where possible, the impact of the practice examples upon each aspect of sustainability was assessed – which often led to frustration since economic, social, and ecologic aspects of sustainability are inherently different and cannot be analyzed with similar data and instruments.

The underlying hypothesis of the »Morgenstadt« definition of sustainability is that single solutions tend to support only one (or a few) aspects of sustainability, while the right combination of solutions at city level can increase overall sustainability. The concept of the triple-bottom-line (balancing social, economic, and ecologic aspects for enhancing sustainability) served as the guiding framework for analysis and classification. The best practices under evaluation in the city reports hence often refer to only one or two dimensions of sustainability and seldom meet the criteria of »strong sustainability«, which requires a positive impact on all dimensions.

After finalizing phase I of »m:ci«, the following conclusions provide an impression of the current state of the Fraunhofer urban sustainability discourse and point towards the necessity of further research:

1. **The triple bottom line needs to be redefined**
   With respect to cities – and single measures in cities – the three-pilar model of sustainability (social, economic, ecologic sustainability) has severe flaws that misdirect urban analysis. This dilemma comes from a forced comparison of totally different systems:

   - **The ecological system** is finite. It has clear boundaries. Hence, measurement of ecological impacts on the local level is rather straightforward.
   - **The social system** is very diffuse and mainly depends on soft factors like identity, culture, power, inequality, networks, etc. A balanced society in Tokyo is by definition different from a balanced society in Berlin. Impacts on urban societies thus have to be assessed individually and cannot be forced into a standard model.
   - **The economic system** obeys different rules. It is a part of the social system, but cannot be confined to it. It is also a part of the environmental system, but cannot be confined to that either. With respect to cities, while there are some standard indicators that explain economic impact and output, those standard indicators need to be complemented by an individual assessment of the local economic system in order to assess positive or negative short- or long-term impacts.

Balancing these systems in a city context by referring to indicators that equally represent each sustainability pillar thus seems to be the wrong approach.

For working towards a city's greater sustainability, we need new models that respect the different nature of the systems involved in sustainability. We should break away from the three-pillar-model and seek a way to identify a given status quo of cities and then start optimizing social and economic welfare within a finite ecological system.

The »Morgenstadt / City of the Future Model for sustainable urban development« (see chapter 11) tries to move in this direction by acknowledging the individual complexity of each city system and referring to environment, economy, and society on different levels.

2. **Resilience has to be a part of it**
   A city that has developed a sustainable management of its natural resources while fostering social welfare and economic stability can only be sustainable if it is also resilient. Cities increasingly have to bear external shocks like natural disasters, storms, floods, or attacks. In order to deal with those, resilience has to be built into the system. Resilience, in this context, is defined as

   "*the ability to repel, prepare for, take into account, absorb, recover from and adapt ever more successfully to actual or potential adverse events. Those events are either catastrophes or processes of change with catastrophic outcome which can have human, technical or natural causes*"[1]

   Any approach to enhance sustainability of a city must also incorporate resilience. Otherwise, long-term stability of social, technical, economic, and environmental urban systems cannot be guaranteed and a seemingly sustainable state is, by definition, only temporary.

3. **Morgenstadt needs a vision**
   We need to define the long-term goals for the sustainable development of cities. Cities need to know, which goal represents a »Morgenstadt«. This vision has to be simple, clear and highly ambitious, representing the ideal stadium of a sustainable city.

   We suggest a vision of the »Morgenstadt / City of the Future« that builds upon four main development goals:

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[1] This definition presents an extension of a version originally developed by the U.S. National Academies.

1. **Zero Waste**
2. **Resilience**
3. **Livability**
4. **Innovation Excellence**

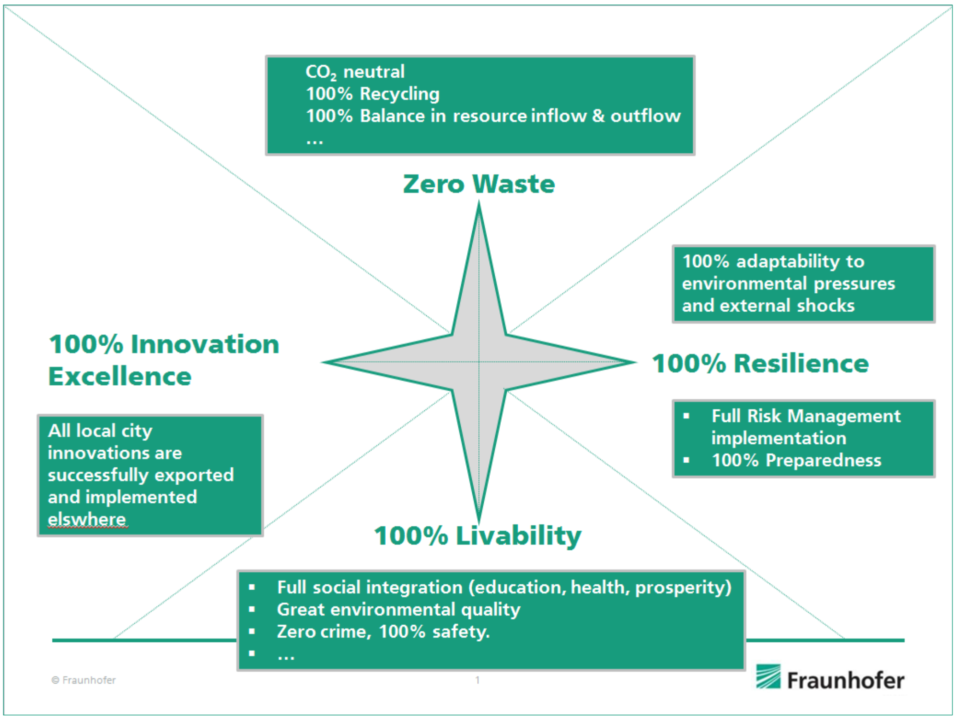

Figure 2: Morgenstadt Vision – early approach

This vision forms the necessary complementary side for future collaboration with cities. With this target image of the »Morgenstadt / City of the Future«, the main goal for development becomes clear. The »Morgenstadt Model for Sustainable Development« helps cities finding their individual approach towards achieving this goal in a distant future.

This vision represents a first step and an approximation towards a well founded goal for sustainable urban development. Throughtout Phase II of »Morgenstadt:City Insights« (m:ci²) this vision needs to be sharpend and refined by all Morgenstadt Partners.

4. Sustainability is the goal, maximizing fitness is the way

Most sustainable systems work not because of a »sustainability intention«, but because it is easier and more convenient to use them. Creating sustainable systems means focusing on functionality, easy access and high efficiency of use. Sustainability has to be built into the system if we want it to take off. For cities, this implies that maximizing their own fitness is the best way to prepare the ground for successfully moving towards sustainability.

Fitness can be referred to as the ability to adapt to changes and to steer transitions towards the intended direction. Fitness of a city comes from streamlining city administrations, effectively engaging with citizens, collaborating with the private sector and r&d, making best use of technologies, providing long-term stability in the political system, and staying open and flexible in case better solutions arise.

The »Morgenstadt Model on Sustainable Development« (see chapter 11) is designed for helping cities improve their individual fitness for working towards the Morgenstadt Vision.

1.3 Morgenstadt – alliance of innovators

The innovation network »Morgenstadt: City Insights« represents an alliance of »first movers« in industry, cities and research that addresses the growing issue of sustainable cities at an early stage from a systemic and integrated perspective.

The network consists of high-ranking partners from industry, leading German cities in terms of sustainable development, and Fraunhofer research institutes covering various sectors and disciplines of research. Each project partner has brought support to the network and enabled the research conducted during the 18 months between May 2012 and October 2013. The insights and conclusions presented throughout the city reports and in this compendium thus have to be seen as results of an intensive and open collaboration of many actors.

»Morgenstadt: City Insights« is supported by the following industry partners

»Morgenstadt: City Insights« is supported by the following city partners

»Morgenstadt: City Insights« is supported and realized by the following Fraunhofer Institutes

2
Morgenstadt Model

It was the declared aim of the Fraunhofer expert-teams to establish strategic contacts with the selected cities and to gain direct insights into important action-fields as well as current needs of the technology-sectors in these cities.
To achieve this, Fraunhofer researchers conducted 30 - 80 interviews with relevant stakeholders in each city (e.g. city administration, local utilities companies, NGO's, local institutions) and conducted several matchmaking-workshops with local stakeholders, researchers, and project partners. The herewith assessed data and information were compiled into comprehensive city reports, highlighting best practice analysis, as well as analysis of sustainability strategies, aims, and measures in the cities' governance sector and further relevant sectors.
Second goal of the Fraunhofer-Morgenstadt Network was to bring the information and results of all cities into a structure that allows for a generic analysis of sustainable urban development of any given city. The Fraunhofer-researchers followed the hypothesis that integrating the information on sustainable development of six very different globally leading cities into a comprehensive model will cover most of all relevant aspects of sustainable urban development. Focus was thereby put on a) measurable performance of the city, b) action and reaction of actors in the city and c) drivers, local framework conditions and dynamic local development.
The overarching question behind the city analysis was the **guiding vision of a sustainable city** and the qualitative definition of Sustainability by the Morgenstadt researchers (see chapter 1).
The following chapter shows how the different levels of information and data that were assessed in the selected cities are brought into a draft of a systemic model that serves as reference for creating an integrated analysis tool for assessing the sustainable urban development of any given city in the future. The chapter first highlights the different types of information used for analyzing the six selected cities. It then shows how the types of information are systematically transferred into a generic model for sustainable urban development. The validity and reliability of this draft model are then being discussed and a critical discussion on the relation to sustainability is added. The chapter closes with applying the model-structure to the selected cities in an exemplary way.

11.1 Types of information in city analysis

The Fraunhofer experience in the six selected cities has shown: in order to assess the status quo on sustainable development of any given city one needs to answer the following questions:

- **What** is the quantifiable sustainability performance of the city?

- **How** does the city address sustainability?
- **Why** do or don't things work in this city?

»Morgenstadt: City Insights« investigated about best practices of leading cities on sustainable urban development. Using the same methodology for data assessment and evaluation of best practices for each city resulted in a set of data and information that allow us to answer the above named questions for the cities under evaluation.

11.1.1 Urban Indicators – "What is the performance of the city"?

Fraunhofer researchers defined over 300 indicators for measuring the performance of the cities within the eight defined sectors and for measuring the social, economic and environmental state of the city. Data for all indicators were assessed for each city (data was found on ca. 60% of all indicators), allowing the »Morgenstadt Team« to generate quantitative and objective profiles of the energy and resource footprints, of the social systems and of the overall performance of the city in sustainability issues.
Table 1: Overview over selected Morgenstadt Indicators
24 shows the performance of the six cities on selected indicators and gives an overview of some quantifiable aspects of sustainability of these cities (ecological footprint, economic performance, density, resilience etc.)

Table 1: Overview over selected Morgenstadt Indicators

	Berlin	Singapore	NYC	Copenh.	Tokyo	Freiburg
Inhabitants in City (Total)	3,501,900	5,399,200	8,244,910	559,440	13,159,388	229,808
Size city (km²)	892	712	785	91	2.188	153
Increase of population (% p.a.)	0.39%	1.99%	0.90%	1.86%	0.46%	1.03%
Population density (inhab./km²)	3,927	7,163	10,506	6,127	6,029	1,501
Share of green areas/parks	11.93%	13.60%	3.44%	25%	-	3.70%
NO2 (µg/m³)	55.0	25	29.52	19.2	39.5	22
PM10 (µg/m³)	25	27	20	23.4	33.1	18
Amount of waste (kg /cap / a.)	652.86	1,198.82	1,602.56	1,478.44	341.96	168.15
CO_2 emissions per year (t. per cap)	5.4	6.67	7.1	5.38	4.8	7.97
Ecological footprint (gha/ cap)	4.4	5.34	7.2	-	4.9	3.9
GDP per capita (€ / year)	29,455 €	44,576 €	55,605 €	58,252 €	52,134 €	39,321 €
Rate of unemployment in %	12.80%	2.10%	9.60%	6.00%	5.00%	5.60%
Share of employment tertiary sector	87.60%	68.70%	95.00%	93.00%	80.80%	81.70%
Persons per Household	1.74	3.5	2.61	2.1	2.05	1.9
Average Age of population	42.9	33.5	35.9	-	41.8	40.3

Public spending on Education (%GDP)	4.60%	3.30%	2.23%	8.70%	-	10.92%
Total energy demand per capita (MWh/a/person)	19.8	19.2	25.8	13.6	15.3	22.6
Local renewable energy (%)	1.60%	2.30%	0.01%	37.30%	-	11.30%
Cars per 1000 residents	323.7	117.24	230	228	308	392
Exposure to natural disasters	low	medium	medium	medium	high	low
Water use per cap (liters per day)	112.8	155	476.2	104	249	93
Tariff for water supply (€/m³)	2.169	1.17	0.88	2.07	-	1.83
Size of Public Sector (city employees per 1.000 people)	19.8	38.7	54.5	35.8	12.5	18.3
Public confidence in government	low	high	high	high	medium	Medium
Voter participation in last elections	77.40%	93.18%	90.00%	87.50%	54.35%	67.00%
Police Officers per 1.000 inhabitants	4.61	1.60	4.14	1.37	3.52	5.24

11.1.2 Key action fields – "How does the city address sustainability"?

By analyzing the six cities on-site in-depth and from the viewpoint of different disciplines the Fraunhofer city-teams were able to identify the main action fields for sustainable development of each of the six cities (a full list of the action fields can be found in the annex of this chapter). They show how the different cities are addressing their challenges and potentials and give insight into strategies and priorities of the cities.

11.1.3 Impact factors – "Why do or don't things work"?

The identification of »**impact factors**« was a fundamental process of the analysis of the selected best practices in the cities, but also of the analysis of the governance level of the cities.

An analysis of impact factors uncovers why certain progress happens (or does not happen) in a particular way in a specific urban system. These are general factors that push or hinder the process of sustainable development on many different levels. We named them »key drivers« and »framework conditions«. Identifying impact factors also helps understand, why certain issues are of high priority in a city and other issues not at all. Understanding the constellation of impact factors of a city means to understand external pressures, underlying forces, dynamics, socio-cultural and historic implications that are present within a city and impact (often unnoticed) on decisions, structures, strategies and measures taken on the city level and on the project level.

Identifying impact factors is complex and needs trans-disciplinary reflection of the researchers. Impact factors are fuzzy and difficult to grasp with established methods of measuring and analyzing quantifiable data. The Fraunhofer researchers therefore developed a methodology for identifying, clustering and rating of impact factors (this methodology can be found within the »general research design« of »Morgenstadt:City Insights« Phase I)[1]. Fraunhofer researchers spend several hours every day on-site with the joint reflection of identified drivers and framework conditions. Collaborative mind-maps were used as main tool for structuring the identified factors. Relating identified factors to the analyzed best practices allowed for estimating the impact of each factor.

Figure 18 shows the range and intensity of impact factors for Copenhagen with the x-axis representing direct impact, the y-axis representing indirect impact and the size of the bubbles representing intensity of impact.

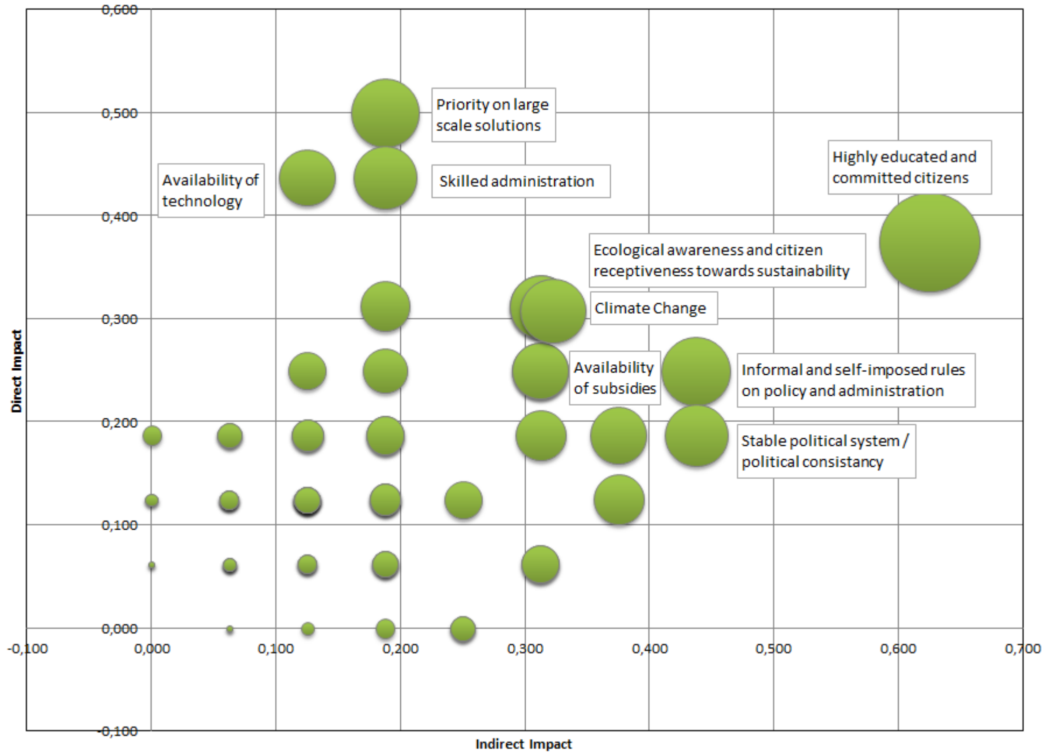

Figure 18: Impact factors in Copenhagen

[1] Morgenstadt Partners can download this document here: https://dms-prext.fraunhofer.de/livelink/livelink.exe/properties/2643813

Analyzing the three main levels of urban systems (indicators, action fields, and impact factors) thus allows us to describe the selected cities in depth and to understand their sustainability performance. We can see, for example, that Copenhagen performs very well on environmental and energy **indicators** (good air quality, comparable low energy demand per capita, high degree of renewable energy etc.). The analysis of **action fields** shows, that important measures and technologies within the energy sector are highly developed (district heating, renewable energies), but we can also see that important levers are being used for pushing sustainable development (long term planning, district management and transport oriented development). The analysis of **impact factors** shows the underlying forces and dynamics at work, which help Copenhagen move into the right direction: highly educated citizens with great awareness for sustainability issues, a stable political system, a skilled administration, the availability of technologies and public funding and the political will to impose rules for higher social and environmental standards on policy and administration.

11.2 From case studies towards the Morgenstadt Model

Starting from this three-level-approach of urban systems analysis the Morgenstadt-Network created a draft generic model for sustainable urban development. This model follows the purpose of generating an instrument that allows a systematic analysis of any given cities' sustainability performance and at the same time developing recommendations for action to improve the sustainability of the urban system.

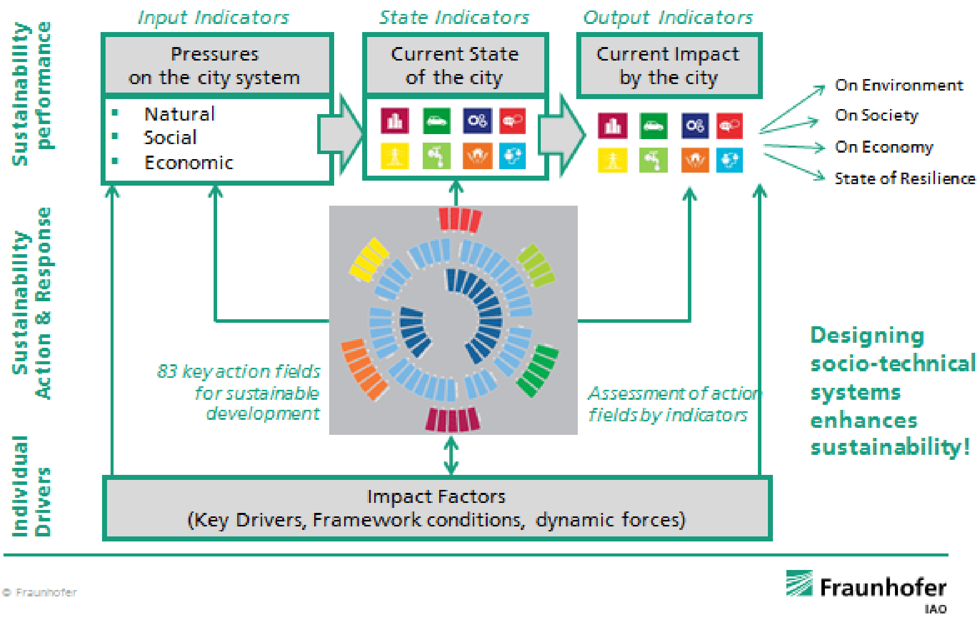

Figure 19: Morgenstadt / City of the Future Model for Sustainable Urban Development

The »Morgenstadt / City of the Future Model for Sustainable Urban Development« draws upon the three levels presented above: performance indicators, key action fields, and impact factors. It combines them in one integrated framework that serves as an analytical tool for systemic urban analysis, but also helps understand the contribution of technologies, policies and business models for enhancing sustainability of cities.

The Morgenstadt Model builds upon existing theoretical approaches that help understand and frame human-environment-interactions (e.g. Material and Energy Flow Accounting (MEFA)[1], Human Ecosystem Model (HEM)[2], Driver–Pressures-State-Impact-Response Model (DPSIR)[3]). Four main steps were necessary in order to lift the specific information of the six case studies on a more generic level:

a) Evaluation and revision of indicators
b) Generic formulation of key action fields
c) Cross-impact-analysis of key action fields
d) Compilation and analysis of impact factors

11.2.1 Evaluation and revision of indicators

Over 300 indicators (input, state and output indicators) had been defined in 2012 for assessing the state of the selected cities. Indicators related to the social, environmental and economic dimensions of the city but at the same time, indicators for each sector under analysis were defined.[4]

An evaluation process of the data assessment within cities provided valuable insights on the availability and the comparability of data: as the chapters on sector-specific results in this report have revealed - a high portion of data is only available for some cities and many indicators are compiled in a different way in different cities and thus remain useless for city comparison (e.g. crime rate, emissions etc.). A revision of the Morgenstadt indicators provided a set of 107 urban indicators that define the current state of a city with respect to several aspects important for steering sustainable development.

Following a modified version of the DPSIR-Framework, city indicators were identified by the Fraunhofer-Experts for each sector. At the same time indicators for environmental, social and economic analysis of the city were defined and compared with existing indicator systems on sustainable city development.[5]

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[1] Haberl et al. 2004; Hinterberger et al. 2003.
[2] Boyle und Marcotullio 2003; Low et al. 1999.
[3] Gabrielsen und Bosch 2003; Kristensen 2004.
[4] All defined indicators incl. data for six selected cities can be accessed via Fraunhofer livelink-server for members of the Morgenstadt / City of the Future Network: https://dms-prext.fraunhofer.de/livelink/livelink.exe/properties/2657817
[5] We referred to the following indicator systems: Cercle Indicateurs (Schweizerische Eidgenossenschaft 2013), GRI Indicators (Global Reporting Initiative (GRI) 2012), UN-Habitat Urban Indicators (UN-Habitat 2004), ICLEI

All indicators were then categorized into one of the following three categories:

a) **»Pressure Indicators«** - indicate which pressures exist on the city system from the different sectors and from the social, economic and environmental point of view.

b) **»State Indicators«** - describe the current state of the environment, the society, the economy and the different technology sectors within the city.

c) **»Impact Indicators«** - show which impact the city system has on the environment, the society, the economy and long-term resilience.

The following list shows all indicators defined by the Morgenstadt experts as relevant for assessing the quantifiable sustainability performance of a city throughout these three categories. This list is the product of an evaluation process of urban indicators that basically followed the SMART criteria for definition of indicators (Indicators have to be **S**pecific, **M**easurable, **A**ttainable, **R**elevant, and **T**rackable). [1]

Table 2: Morgenstadt / City of the Future Pressure Indicators

33 Pressure Indicators			
Primary category	**Indicator name**	**Indicator scope**	**Units**
Env. Pressures	Built-up area	Used area for buildings and facilities (incl. traffic)	In % of total city area
	Municipal Water Consumption	Municipal water consumption per capita	liter/cap.day
	Industrial Water Consumption	Industrial water consumption per industrial GDP	liter/annual 1.000 US$
Pressures from the energy system	Energy demand	Total	GWh/a
		Per capita	kWh/a/cap
	Electricity demand	Per capita	kWh/a/cap
		Share of private consumers	kWh/a/cap
Socio-economic pressures	Population Dynamics	Annual change in population (average of last 3 years)	% of total population
	Birth rate	Relationship between births and deaths	in % (positive / negative)
	Manufacturing companies in the city	Number of manufacturing companies in the city	In total
	Systemic dependence on industrial players	Share of top 5 tax payers on overall tax income	In %
		Top 10 largest	Type of

Sustainabilits Indicators for cities (ICLEI - Local Governments for Sustainability 2004); HEINZ – Sustainability Indicators for Hamburg (Zukunftsrat Hamburg 2013)

[1] Shahin und Mahbod 2007

		employers in city	Business / Production Energy use Nr. of employees GDP / Tax revenues
Political Pressures	Tax / interest relationship	Percent of tax income spent on interest rates for public debts. Last four years	total figures & in % of total household
	City expenses on administration, education, health, security, infrastructure, publicly owned buildings and social welfare		in total € or $ AND percentage of total city budget
	Cost-recovery of municipal enterprises	Sum of earnings of all municipal enterprises divided by sum of costs (under consideration of the participation quota of the city).	in % of total city budget
Pressures on Resilience	Exposure to natural hazards		
	Number of registered crimes		rates, absolute figures in %
	Terrorist attacks	number of events, absolute figures / average damage in € per year	
	Natural disasters (Earthquakes / Landslides, storms, floods etc.)	number of events, absolute figures / average damage in € per year	
	Central risk management	detail level (low, medium, high)	
Pressures from Transport & Production	Modal split	share of MIV / public transport / bicycles / foot / other in total traffic	in % of total traffic volume
	Modal split of freight system	% of goods transported on road, rail and waterways	in % of total freight volume
	Significance of freight transport in urban traffic system	share of freight vehicles in total road traffic / rail traffic / inland waterways traffic	In % each
	Urban area used by manufacturing companies	percentage of commercial area/land-use by production and logistics	In % of total land
Pressures from water system	Energy demand for wastewater collection and treatment including effects from energy recovery from wastewater		kWh/m3
	Energy demand for treatment and distribution of potable water (water supply)		kWh/m3
Pressures from built environment	Required floor space		m2 GFA/person
	Spatial distribution of GFA (residential and commercial and industrial)		% of total GFA
	Operational energy use/final energy demand-total building stock		kWH/m2 GFA*a
	Primary energy demand total for building stock		CO_2-

			equiv./m2 GFA
	Rent level	Average price of rented apartments	in € per m²
		Relation between rental expenditures and income	in %
	Rental increase (average of last 3 years)		%/a

Table 3: Morgenstadt / City of the Future State Indicators

59 State Indicators			
Primary category	**Indicator name**	**Indicator scope**	**Units**
Env. Quality and Energy	Biodiversity	Habitat connectivity	Share of green spaces in city that are directly connected with each other (without major roads crossing)
	Nature & Landscape	Ecologicaly valuable area	Sum of area under protection in % of city area
		Green Space Intensity	m2 of green space/capita
		water bodies	% of city area
	Water quality	Proportion of water bodies with high water quality	%
State of Energy System	Electricity generated in the city	Total amount an in percent of overall energy demand.	GWh/a AND %
	Importance of local district heating	Share of heat demand delivered by disctrict heating systems	%
	Renewable energies in the grid	Share of electricity demand generated by renewables	%
	Cost for electricity	average electricity price for private consumers	Euroct/kWh
	Cost for heat	Average price for natural gas for private consumer	Euroct/kWh
State of Security System	Reaction time of first responders		absolute figures
State of Transport	Density of rail network	Stations/surface/area	(no)/km2
	Road network	total length of road network	km

System	Share of road categories according to capacity /number of lanes / driving speed: category 1 (motorway, Expressway, Autobahnen)	calculation: length of roads in each category (km) related to total length of road system (km); city specific classifications can be described under comment	
	Share of road categories according to capacity /number of lanes / driving speed: category 2 (arterial roads, Bundessstraßen)	calculation: length of roads in each category (km) related to total length of road system (km); city specific classifications can be described under comment	
	Share of road categories according to capacity /number of lanes / driving speed: category 3 (local access roads, Stadtstraßen)	calculation: length of roads in each category (km) related to total length of road system (km); city specific classifications can be described under comment	
	Existence of logistics centres in urban area and their implementation level	consolidation centres, transshipment terminals, multi-user logistics centres (qualitative indicator)	
	Existence of traffic management systems and intelligent traffic control systems and their implementation level		traffic management systems such as bypass/ring roads for transit traffic (qualitative indicator)
	Relative length of cycling paths		km/km2
	Relative cost of transport	Share of individual budget spent on transport	in %
	Average commuting distance		km/day
	Average network speed		km/h
	Support for Electric Charging	Density of EV/FC charging network	(no)/km2
	Price of public transport	price of day-ticket in central area of city	in €
	Public budget for greening the mobility sector		Mio Euro/ year
	Mobility sector sustainability strategy in place		0- 5
Production & Resources	Recycling rate	Share of total waste being recycled	In %
	Existence of waste collection /sorting systems and their implementation level	solutions and fields of application can be specified under comment,for example Production -> container management)	
State of Water	Municipal investment on sustainable water infrastructure measures	share of total investment (see below); examples for sustainable water infrastructure measures (see below)	

System	Implementation of resource efficiency measures in water sector: e.g. water saving strategies, water reuse, nutrient recovery	0: no measures discussed within strategic process of the city, 1: measures implemented in strategic process of the city, 2: first measures implemented in reality, 3: measures implemented and regulary evaluated	
	Implementation of energy efficiency / energy recovery measures in water sector (water supply and wastewater management)		see above
	Implementation of sustainable stormwater management and/or flood protection measures		see above
	Implementation of water sector with safety/security sector (e.g. fire fighting) and/or ict sector (e.g. smart metering/smart grid)		see above
	Interlinkage of water sector with safety/security sector (e.g. fire fighting) and/or ict sector (e.g. smart metering)		in %
	Implementation of advanced wastewater treatment for water pollution control		g/m3
	Water supplied from stormwater harvesting/ reuse of treated wastewater	reused water resp. Stormwater, percentage of total water consumption (in %)	€ / m³
	Nutrient recovery from wastewater treatment	amount of N and P reclycled (g N per m3 wastewater; resp. G P per m3 wastewater)	g/m3
	Water price	Drinking water	€ / l
State of governance System	Degree of paritcipation	o = none, 1= information by city, 2= consultation of citizens by city, 3= cooperation (citizens have possibility to influence decisions), 4= active decision making by citizens possible. (nach Lüttringhausen 2000: 66ff)	
	Decision making autonomy in the building sector	Nr. of buildings owned by the city AND % of total building stock owned by city.	
	Administrative structures for sustainability management of city	Nr. of city staff working in an institutonalized structure / organization for sustainability within the city	

		administration.	
	Existence and state of CO_2-reduction goal	Goal, year and baseline (e.g. -50% from 1990 until 2040). And in % per year with respect to baseline 1990.	
	Existence and performance of sustainability management	1= Existence, 2= defined goals in the four sustainability dimensions , 3= associated measures, 4= measures under realization, 5= regular monitroing	
	Earmarked revenues for sustainability projects	In total in € or $ AND average of last three years	
	Characteristic e-government	0= not visible, 1 = information (e.g. homepage), 2= communication (e.g. opportunities for exchange and interactive download of information), 3= transaction (operation of service, e.g. PIN/TAN- procedures); 4= integration (offering integrated services independent from responsible agency)	
Buildings	Average investment in new construction and refurbishment		euro/a
Economics	GDP of city	GDp per capita	In EURO
	Size primary sector	share of total employmentprimary sector	in %
	Size secondary sector	share of total employmentprimary sector	in %
	Size tertiary sector	share of total employmentprimary sector	in %
Social	House ownership		%
	Average age		
	Health	Average life expectancy at birth	In years (male / female)
	Inhabitants per 1 doctor		
ICT	Mobile connectivity	Number of mobile broadband subscriptions per 100 inhabitants	In %
	Internet connectivity	Internet penetration rate per 100 inhabitants	In %
	Internet quality	Number of fixed broadband subscriptions per 100 inhabitants	in %
	Computer usage	Number of PC´s per 100 inhabitants	In %

	Activities on digital platforms (e.g. Twitter, Facebook, Tumblr and Instagram)	per 1.000 inhabitants

Table 4: Morgenstadt / City of the Future Impact Indicators

14 Impact Indicators			
Primary category	**Indicator name**	**Indicator scope**	**Units**
Environmental impact from combustion processes	CO_2 emissions	overall (global protocol)	t/per capita
		Per sector (residential / industrial / traffic / energy)	t/per capita
	Airborne pollutants	No2	µg/m3
		PM10	µg/m3
Mobility impact	Deaths from traffic accidents	number of annual traffic fatalities	#/1000/p/a
Impact from built environment	Soil consumption	Conversion rate	% of total city area - average of last 3 years
	Global warming potential for building stock		CO_2 equiv./m2 GFA
	Rate of new construction	In Percent of building stock	% per a
	Rate of refurbishment	In Percent of building stock	% per a
	Rate of demolition	In Percent of building stock	% per a or m2 GFA per a
Impacts from economic system	Growth rate	GDP growth p.a.	in % (average of last 3 years)
	Business volume 1:	total amount of imported goods per year	value of imported goods in Euro/Dollar
	Business volume 2:	total amount of exported goods per year	value of imported goods in Euro/Dollar
	Amount of waste produced	Total amount in city	Tons per year

This indicator-framework represents the basis for future engagement with cities throughout the Morgenstadt Network. It was created with the intention of delivering an indicator-set that allows assessing the current status quo of a given city with respect to the most important aspects relevant to a sustainable development. A full data representation of these indicators for one city will allow for optimal design of strategies and measures helping to achieve enhanced sustainability. However, it must be stated, that this list of indicators represents a draft version and needs to be refined in the future.

Indicators in this list will have to be:

a) Peer reviewed
b) Evaluated on their potential for assessment throughout different cities in different world regions
c) Prioritized

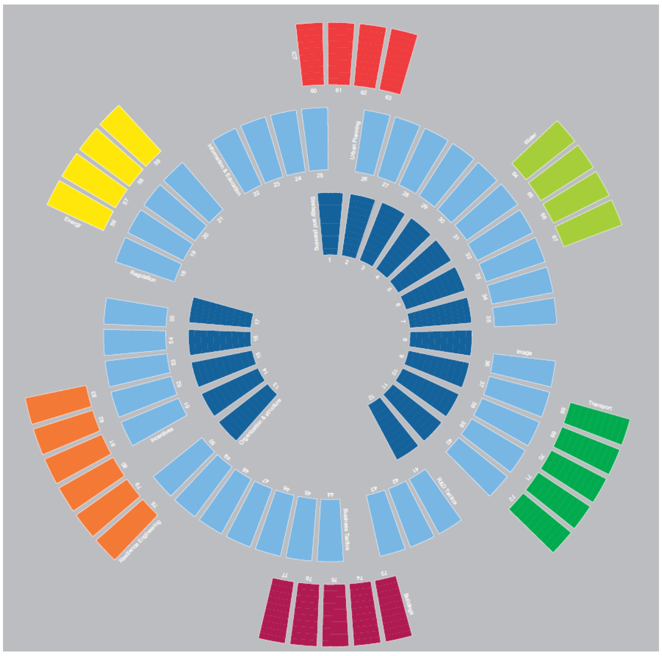
Peer review and evaluation of this set of »Morgenstadt / City of the Future indicators« will be part of the second project phase of »Morgenstadt:City Insights«.

11.2.2 Generic formulation of key action fields

The 83 defined key action fields for sustainable development represent the core of the Morgenstadt Model. Whereas the indicators describe *pressures*, *state* and *impact* of a city, the action fields tell us about the sustainability *action and response* of a city. Assessing the state of key action fields within a city allows the creation of city profiles and analysis of coherency of existing strategies and measures. Relating key action fields to indicators allows Morgenstadt Members to assess, whether the response of a city is in line with pressures and state and really helps optimizing outputs for enhanced sustainability.

Comparing and integrating all action fields of the six selected cities allowed the Fraunhofer researchers to structure a generic action model for sustainable urban development. 83 fields for action were identified within these six cities on 3 basic categories: **urban leadership** (*policy, planning, management & structuring of sustainable development*), **levers** (*urban planning, business tactics, incentives, regulations, R&D tactics, information & education etc*.), **points of action** (*smart grids, resilience engineering, urban big data systems, electronic ticketing, renewable energies, district heating, energetic refurbishment, storm water management etc.*). These are the foundational basis for a Morgenstadt model and served as a blueprint for structuring the sustainability profile of each city.

83 precise descriptions of action fields for sustainable development have been prepared between August and October 2013 with each containing the main information on the action field on 3-4 pages. Each document refers to the origin of the action field and gives a neutral description. Apart from this, the following information is listed for each action field: relevance for sustainability, importance for different sectors, impact (positive & negative), actors that can influence, barriers, preconditions, and indicators for assessing the state of the action field in a city.



Reading the diagram:
Colors represent categories of action fields.

- Urban Leadership
- Levers
- ICT
- Water
- Transport / Mobility
- Buildings
- Resilience Engineering
- Energy

A detailed description of all action fields is provided in a

Figure 20: Key action fields for sustainable urban development

A set of (mainly qualitative) indicators for each action field allows an objective identification of the occurrence of each field in any given city. By bringing the indicator-set into an ordinal scale system (1 – 10), city profiles can be processed within the graphic system shown in Figure 1920.

The following list gives an overview over all 83 key action fields for sustainable development. All 83 corresponding documents are available to Members of »Morgenstadt:City Insights« as part of the final project report. They can be downloaded from the Fraunhofer Livelink filesharing system by Members of the Morgenstadt Network.[1]

a) Urban Leadership

Strategy and Planning

1	Long-term political stability through planning and management approaches that exceed a single election period.
2	Definition of indicators, creation of a performance measurement system for sustainability and climate change
3	Establishment of sustainability advisory boards
4	Development of Visions / goals together with civil society
5	Alignment of budgetary policy with sustainability goals
6	Targeted management of climate change protection & sustainability within the administration with modern tools for management and planning

[1] All key action fields will be represented under this link: https://dms-prext.fraunhofer.de/livelink/livelink.exe/properties/3499038

7	Negotiated / Voluntary agreements to higher social and environmental standards
8	Communal climate change management.
9	Control of city over capital assets by shareholding of infrastructure providers etc.
10	Collaboration between city and region for environmental protection and sustainability
11	Establishment of semi-formal and informal networks
12	Development & implementation of a communal innovation strategy

Organization and structure

13	Creation of flat hierarchies within city administration
14	Establishment of a learning organisation within the city administration
15	Creation of administrative structures for communal sustainability management
16	Creation and administration of platforms for citizen participation.
17	Training of administrative staff in sustainability issues.

b) Levers

Regulations

18	Regulation of building processes
19	Creating and maintaining a socially equitable rent level
20	Enforcement of sustainable behavior and investments by regulation (e.g. thresholds).
21	Modal shift of traffic flows towards foot, bike and public transport through regulations.

Information and Education

22	Creation of an atmosphere open to innovation and transformation regarding sustainability.
23	Awareness/Education: Creating awareness of sustainability through the integration of sustainability issues in education and information
24	Awareness raising campaigns for saving resources (e.g. water).
25	Education for sustainable development.

Urban Planning

26	Systematic long-term planning of the city structure
27	Development of goals and guidelines for a sustainable district development.
28	Development and implementation of market- and center concepts.
29	Innovative bottom up housing concepts.
30	Deployment of alternative concepts for re-using existing infrastructure.
31	Alternative criteria and procurement procedures for real-estate-property.
32	District Management - small-scale use-mix in local districts
33	Transport Oriented Development
34	Urban development planning for a city of short distances
35	Development of green inner city industry parks.

Image & Brand

36	Cluster Management (Support of specialized and small businesses through networking, promotion and marketing, communication, and enabling market access)
37	Creation of a green, attractive urban environment for creating a green image.
38	Offers and services by the city for raising attractiveness for qualified personnel.
39	Business Environment / identity management
40	Professional City Marketing / creating an international image for / by the city

R&D Tactics

41	Joint research institutions between industry and science for sustainability issues.
42	Creation of "city labs" (experimental areas) for deploying innovative technologies)
43	Attracting and supporting institutions of science and research as incubators for sustainable development.

Business Tactics

44	Financing of innovative technologies and projects in PPP / partnerships
45	Assignment of urban development tasks to large private companies.
46	Elimination of barriers for attracting skilled personnel, investors and businesses.
47	Activation of business actors for supporting the sustainability strategy of the city.
48	Contractual obligation of energy service provider to reduce CO_2 emissions.
49	Active partnership between city & private sector for pushing sustainability topics. (PPPs)
50	Development and implementation of services for supporting sustainability solutions.

Incentives

51	Sponsorship / subsidies by the city for sustainable technologies & solutions
52	Creation of markets for sustainable products & solutions
53	Financial incentive schemes for implementing sustainable technologies at city level.
54	Creation of incentives and opportunities for investing in innovative technologies (experimentation clauses)
55	Non-monetary incentive schemes for implementing sustainable technologies at city level

c) Points of Action

Energy

56	High-efficient centralized energy supply (District Heating / District Cooling)
57	Promotion of renewable energies
58	Communal energy management.
59	Use of Smart Grid Technologies

ICT

60	Interoperable electronic ticketing systems in public transport

61	Open Data System for / by city
62	Urban Big Data Systems
63	Intelligent traffic management based on real-time information.

Water

64	Use of smart water grid-technologies
65	Storm water management (strategic planning and implementation of measures)
66	Active Management of the Water-Energy-Nexus (technological progress, strategic topic)
67	Decentralised infrastructure for urban water supply

Transport / Mobility

68	Innovative, sustainable distribution concepts for city centers
69	Intermodal urban freight traffic
70	Provision of E-Mobility-Infrastructure
71	Optimizing road network and transport routes for traffic distribution.
72	Targeted combination of different modes of transport

Buildings

72	Targeted combination of different modes of transport
73	Energetic refurbishment
74	Tightened standards for new buildings and for modernization of buildings
75	Certification systems for buildings
76	Design and management of material flows
77	Reduction of building costs through prefabrication

Resilience Engineering

78	Networked Security Solutions
79	Integrated Risk Management
80	Economic Recovery and Business Continuity Management (BCM)
81	Flood protection / Coastal protection strategies
82	Crime Prevention Concepts
83	Resilience-by-design approaches in critical infrastructure protection

11.2.3 Cross-impact-analysis of key action fields

For a full understanding of the systemic interrelations between the action fields, a cross-impact analysis was conducted by over 40 Fraunhofer researchers. As a result, figure 21 shows, which action fields are highly important for leveraging a sustainable urban development (***levers***), which ones are main drivers of the process (***drivers*** have high impact on other factors) and which ones are main enablers for pushing the urban system towards sustainability (***enablers*** are impacted by many other factors). The scale in figure 17 represents the sum of active and passive impact for each action field.

The underlying cross-impact-matrix of the key action fields provides Morgenstadt Members with a deep understanding of the interconnectedness of actions in cities and shows clusters of action fields that belong together for addressing sustainable urban development with coherent strategies and roadmaps.

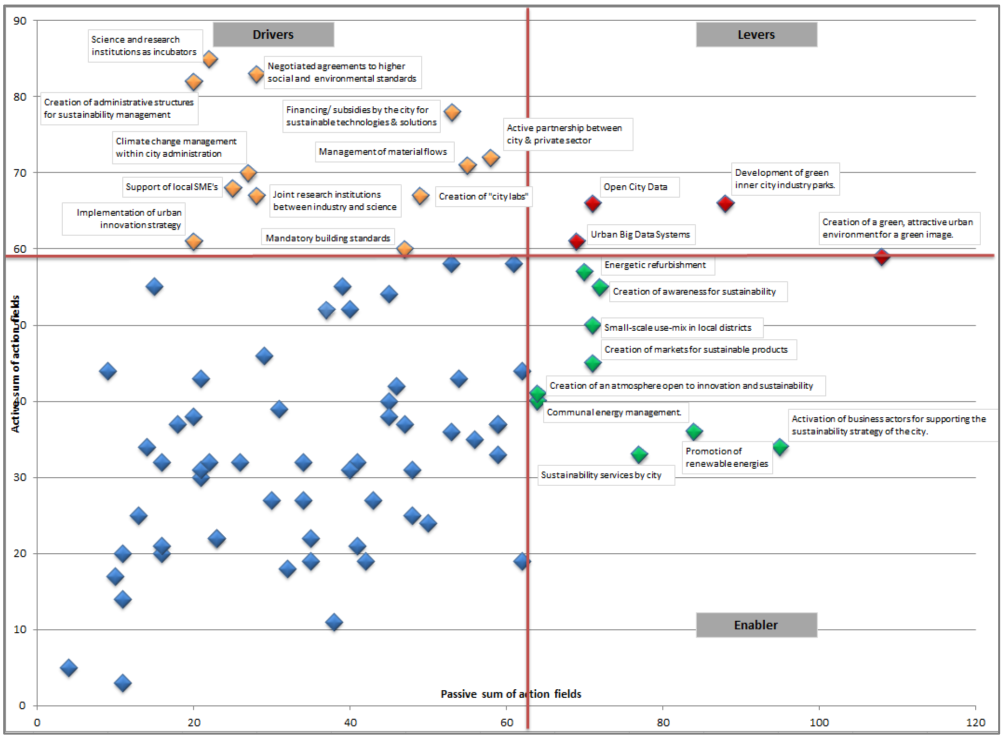


Figure 21: Cross-Impact Analysis of key action fields

12 Key action fields show high importance as **main drivers** for sustainable development, since they impact on a large number of other action fields. These ones are Nr. 43, Nr. 7, Nr. 15, Nr. 53, Nr. 76, Nr. 49, Nr. 8, Nr. 36, Nr. 41, Nr. 42, Nr. 12 and 74.

4 key action fields show high importance as **biggest levers** for sustainable urban development, since they impact on a large number of other action fields and are also impacted by a large number of action fields. These ones are: Nr. 61, Nr. 62, Nr. 35 and 37.

9 key action fields show high importance as **enabler** of sustainable urban development. They are impacted by many other key action fields and thus represent good starting points for enabling a transition towards enhanced urban sustainability. These ones are: Nr. 73, Nr. 23, Nr. 32, Nr. 52, Nr. 22, Nr. 58, Nr. 57, Nr. 47 and Nr. 50.

This classification of key action fields helps cities identifying their specific strengths and weaknesses and it helps to define low-hanging fruits and milestones for strategic action towards sustainable development.

A second – even more relevant aspect of the cross-impact-analysis lies within the formulation of coherent action clusters. It shows which key action fields have high interrelation each with other and allows to identify coherent trajectories for long-term transitions towards enhanced sustainability.

Figure 22 shows in an exemplary way, how using the model by starting from the action field "smart grid technologies" results in 2-3 coherent action clusters that show high congruency of action. Combining several action fields with each other in coherent development strategies thus becomes possible. This analysis can be conducted for each of the 83 action fields by Morgenstadt Partners.

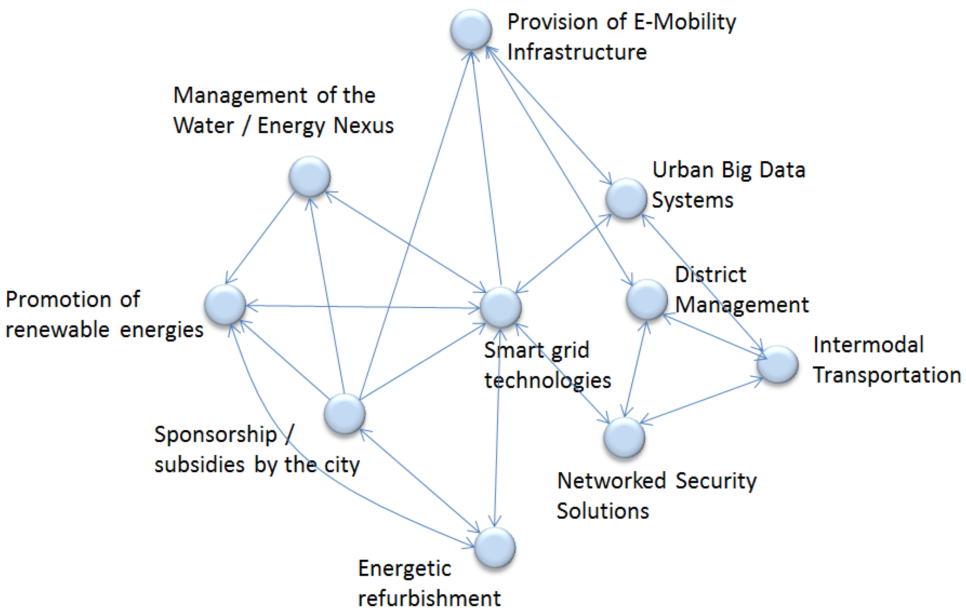


Figure 22: Action clusters for smart grid technologies

11.3 Specificity & relevance of the model

Important to notice: this core-model based on the action fields is not intended to be seen as a benchmarking system. There is not one best way of addressing sustainability within a city or as a city. Fraunhofer city analysis made clear that each city has to be seen as an individual complex adaptive system with specific framework conditions and local structures. City transitions towards enhanced sustainability therefore need individual strategies and solutions. This model aims at expressing this individual complexity within an adaptive framework that helps cities optimize the performance of their individual system. It does not recommend cities to enhance their performance within all key action fields; it rather has to be seen as tool that serves as basic starting point for a systematic analysis of a complex adaptive system which allows the creation of individual city profiles and the generation of individual action- and response strategies for sustainable urban development.

With this the Morgenstadt Model does not resemble existing city benchmarking frameworks like the Global Compact Circles of Sustainability[1] or the Siemens Green City Index.[2] It rather represents a multilevel analysis framework that allows cities, research and business develop strategies and precise projects that help tackle individual shortcomings and problems in cities by addressing the right issues and building upon existing strengths.

Morgenstadt Members will be able to access an online database that links all action fields on the basis of the cross-impact-matrix in a dynamic way, helping them create coherent strategies for project design and implementation.

11.3.1 Compilation and analysis of impact factors

The third level of analysis within the draft Morgenstadt model is represented by individual drivers, framework conditions and local structures and systems that have a strong impact on sustainable development. These »impact factors« represent the individual DNA of a city and they cannot be brought into a standard model that would be applicable to any city. The 170 identified impact factors – especially the most important ones – give valuable hints for researchers on where to look to, when analyzing a given city. However, they cannot substitute an individual analysis of local impact factors by a team of qualified researchers.

The analysis of the six selected leading cities brought about 170 factors that were distilled as important underlying pressures, drivers and barriers of sustainability within those cities. By relating them to the single best practices analyzed in the cities, researchers were able to determine the relative strength and importance of all impact factors per city. Figure 23 shows the distribution of the standardized impact factors over all cities. It gives an impression of the relative importance of specific impact factors for those cities and thus helps understand some general questions with regards to sustainable urban development:

[1] Global Compact Cities Programme 2013.
[2] Sumner 2012.

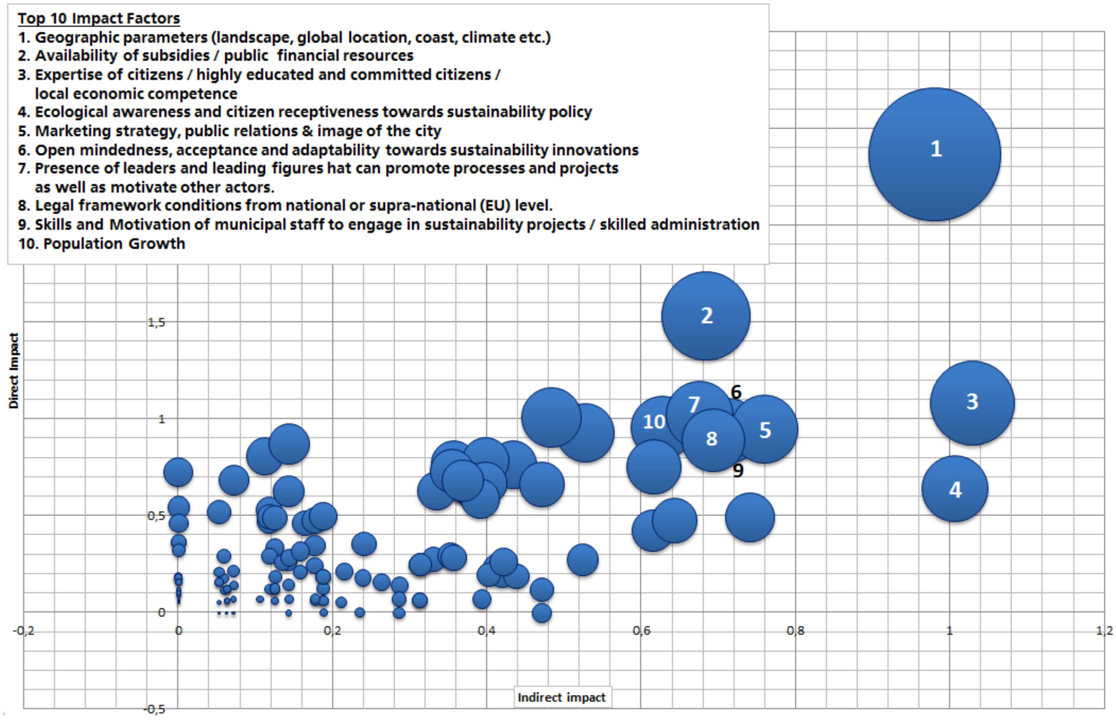


Figure 23: overall compilation of impact factors on sustainable urban development

1. **Geography is the most important driver for many sustainability projects.** Four of the six cities under analysis are located at the sea (Copenhagen, New York City, Singapore and Tokyo) and thus have to deal with extreme whether events and storm water protection. At the same time geographical imperatives like the likelihood of earthquakes (Tokyo), the lack of own resources (Singapore), a lot of wind (Copenhagen) or the exposure to rising sea levels (NYC), are the most important drivers behind projects that aim at enhancing resilience and sustainability of the city.

2. **Sustainable Development is still mainly government funded**
   The availability of subsidies is the impact factor named second most often, when asking for the origin and the success of sustainability projects. Functioning business models that would enhance sustainability and at the same time generate sound return on investment are still lacking. Only a few projects (like the Tokyo Metro system) manage to be successful without public support.

3. **Educated, open minded and aware citizens are drivers of sustainability**
   All cities under evaluation have a high share of service-industry and knowledge work. In addition important universities are located there and citizens are highly educated and aware of the necessity of sustainable development. Awareness and high education not only allows people to grab the complexity of sustainability issues in their cities, it also enables them to raise their voice and demand sustainable policies and public

investments from their political leaders. This is one reason, why education plays such an important role for sustainable development.

4. **A green image is the main argument for municipalities to push sustainable development**
   Although best practices under evaluation were highly inspiring and represent a real contribution towards enhanced urban sustainability, none of the analyzed cities can claim to be sustainable. Unsustainable resource use, high greenhouse gas emissions, high energy use, social inequalities and unbalanced city finances also exist in these leading cities. However, these cities have taken a decision to foster a green and sustainable image – city leaders want the world to look upon them as role models (and of course they want to attract clean industries and highly skilled workers). A green image needs to be nourished with real progress, if it shall not be perceived as fake. This is why formulating a sustainability vision and developing a city brand on sustainability and climate change protection serves as a catalyst for real change on the ground. Decision makers in these cities increasingly tend to take the argument of sustainability into consideration for any decisions they have to make.

5. **Sustainable cities need bold leaders**
   Inspiring leaders at the city level have a high impact on sustainable development. The examples of Freiburg, New York and Tokyo show in very different ways, how single persons in relevant positions (as mayors, as head of division, or as private investors) can push sustainable development into the right direction. Their success bears on high public support (e.g. Mayor Bloomberg in NYC), high autonomy in decision making, intelligent strategies for pursuing their goals (Prof. Ohno - head of environmental section in Tokyo Metropolitan Government), or courage to accept higher risks for investments in innovative technologies (Rolf Disch – investor for solar district in Freiburg).

6. **Sustainable cities need supportive legal framework conditions from higher levels:**
   A big dilemma of the cities under evaluation consist in their dependence on national- or supra national legislation. Singapore is the only city that has direct access on national legislation and thus is very efficient in linking urban development issues to the modification of national laws. All other cities heavily depend on national framework conditions for very different issues (Freiburg: e.g. management of public space, Tokyo: energy grid, New York City: e.g. private industry and consumer behavior). Legislation from the national- or supra national level can spur local investments into sustainability (e.g. EU Water Framework Directive) or prevent sustainable behavior (e.g. German directive on provision of parking spaces).

7. **Knowledge and skills of staff in city administrations have a big influence on sustainable development**
   In virtually all cities under analysis we found highly skilled and knowledgeable experts on sustainability and climate change protection within city administration. These people have a high impact and a high lever on projects that help cities become more sustainable.
8. **Population growth continues as main driver for investments**
   All cities under analysis are growing. They all see population growth as a positive phenomenon, since tax income rises and local economic growth is spurred. However, population growth only contributes to sustainability, when it goes along with densification, a lower resource footprint per capita and a higher effectiveness of local infrastructure. Cities like Freiburg use their growth potential for new concepts of dense urban living, most of the cities, however, have a rather linear perception of population- and economic growth and invest into new districts with fairly low footprints rather than struggling for the most sustainable solution.

From this compilation it becomes clear that the analysis of impact factors as third level of the Morgenstadt model cannot be brought into a standard approach – it rather needs a trans-disciplinary methodology for identifying and analyzing local impact factors of a city. This methodology is based on the research design that has been developed throughout phase I of »m:ci« and builds upon an on-site analysis of cities through Fraunhofer researchers, addressing specific interview questions, applying defined interview techniques, using pre-structured interaction of the researchers and working with mind-maps and clustering of impact factors.
The general research design of »Morgenstadt: City Insights« is available for project members via the Fraunhofer- file sharing platform.[1]

11.3.2 Validity of the model

The »Morgenstadt / City of the Future Model for sustainable urban development« builds upon an empirical basis of the in-depth analysis of 6 leading-edge global cities. It contains the biases of these cities (relevant action fields that could not be identified in these cities may have to be integrated later) and it contains blind spots of urban analysis that were not covered by Fraunhofer-researchers (e.g. waste management, biodiversity, ecosystem services etc.). It does not claim to be an exhaustive compilation of all indicators and action fields that are relevant for sustainable urban development. It rather

[1] Braun und von Radecki 2012 ;

is intended to serve as a draft for future urban systems analyses and is considered to represent a living framework that will develop and gain in depth and differentiation over the course of the upcoming years.

For gaining full validity this model needs revision by third party institutions (e.g. LSE cities, ICLEI, C40 etc.) and by project partners of »Morgenstadt:City Insights«. For full applicability as analytical tool it also needs simulated application, testing with real-world cities, and evaluation by Fraunhofer researchers.

The next steps for enhancing the validity and reliability of this model thus will be taken throughout the beginning of phase II of »Morgenstadt:City Insights«.

3 City profiles

In this chapter the »Morgenstadt / City of the future model for sustainable development« is applied in a simplified and exemplary way to the six cities under evaluation. This exercise allows creating city profiles that show the sustainability performance of the cities, their action and response towards sustainability and the local drivers and framework conditions that impact upon policies, projects and city development.

This overview shall give an impression of the multilayered »Morgenstadt / City of the Future« approach for analyzing cities on their sustainability performance. For application the model has been simplified in the following aspects:

- Indicators: Only a few indicators out of the final set of Morgenstadt City Indicators on pressure, state and impact of the city are highlighted in an exemplary way.
- Key action fields: The model of 83 key action fields for sustainable development is an outcome of the analysis of the six cities. Thus, these action fields were not assessed via defined indicators in each city, but rather the specification of each action field was estimated by each Fraunhofer city team on a scale from 1 – 10. The characteristic profile of key action fields – as represented here – hence does not claim to represent exact real-world occurrence, it has to be seen as an approximation towards existing structures and serves as demonstrator for future city analysis based on this model.

The so created city profiles demonstrate the three layers of city analysis that represent an integrated analytical approach towards assessing the sustainability of a given city.

Please note: sustainability is referred to with reference to the qualitative definition given in chapter 1 and by comparing the six cities against each other. No benchmark was applied.

12.1 Freiburg – small, green bottom-up city

Freiburg is well-known in Europe as green city with a lot of cyclists that shape the city, best practices like the Vauban- and Rieselfeld districts and an active citizen participation in the urban development process.
The city in the Southwest of Germany leads the way, when it comes to air quality, waste avoidance and waste management, efficient water use and renewable energy. Freiburg performs excellent especially in the energy sector. But Freiburg also has deficits, when it comes to the CO_2 Emissions per capita, and to the energy demand.

A comparison of indicators between the six cities demonstrates - the city of Freiburg performs best or second best of all cities in the following categories:

- Production of waste: only 168 kg / person / year
- Air quality: low levels of PM 10 and NO_2
- Water use per capita: only 93 liters per person per day
- Share of local renewable energy in the grid: 11.3%
- Size of public sector: only 18.3 city employees per 1,000 inhabitants
- Modal share of bicycles (27%) and pedestrians (23%)
- Share of heavy trucks in total road traffic (only 0.51%)

Freiburg performs last or second last of all cities in the following categories:

- CO_2 Emissions per capita (7.97 t CO_2 e per person / p.a.)
- GDP per capita (only 39,321€ p.a.)
- Total energy demand per person (22.6 MWh/a/person)
- Individual car possession (392 cars per 1,000 residents)

Freiburg has come a long way from the first development of a green public awareness in the 1970s to a city administration that today actively pushes sustainability throughout all sectors, backed by local policies.

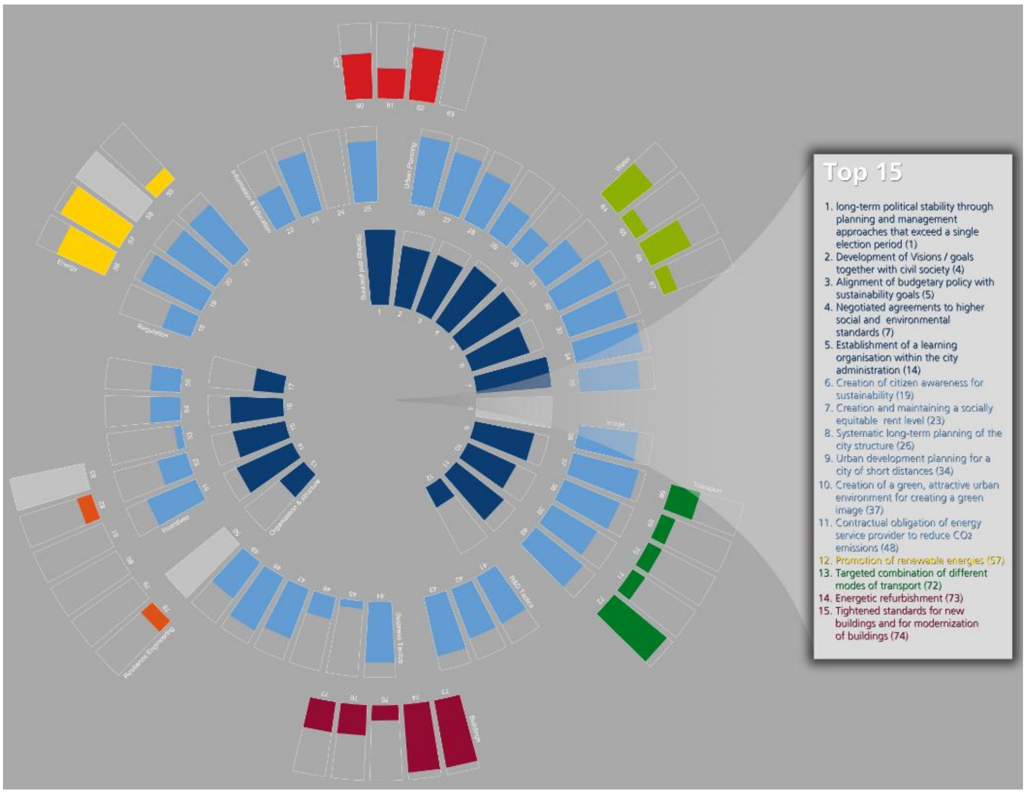


Figure 24: Representation of key action fields - Freiburg

Freiburg shows the following top 15 key action fields for sustainable development:

1. Long-term political stability through planning and management approaches that exceed a single election period
2. Development of visions/goals together with civil society
3. Alignment of budgetary policy with sustainability goals
4. Negotiated agreements to higher social and environmental standards
5. Establishment of a learning organization within the city administration
6. Creation of citizen awareness for sustainability
7. Creation and maintaining a socially equitable rent level
8. Systematic long-term planning of the city structure
9. Urban development planning for a city of short distances
10. Creation of a green, attractive urban environment for creating a green image
11. Contractual obligation of energy service provider to reduce CO_2 emissions
12. Promotion of renewable energies
13. Targeted combination of different modes of transport
14. Energetic refurbishment
15. Tightened standards for new buildings and for modernization of buildings

One third of all citizens in Freiburg are somehow connected to the education system (as students, teachers, employees of the institutions of higher education etc.). Consequently the educated, highly committed and critical local society represents the backbone of the sustainable development of Freiburg.
The most important impact factors in Freiburg – as they have been identified by the Fraunhofer city team – are:

- Professional competence and state of knowledge of active players
- Ecological awareness and citizen receptiveness towards sustainability policy
- Open mindedness, acceptance and adaptability towards sustainability innovations
- Informal and semi-formal networks
- High involvement of the citizens representing district and thematic interests
- Availability of scientific competence and institutes
- Active/ propelling local council

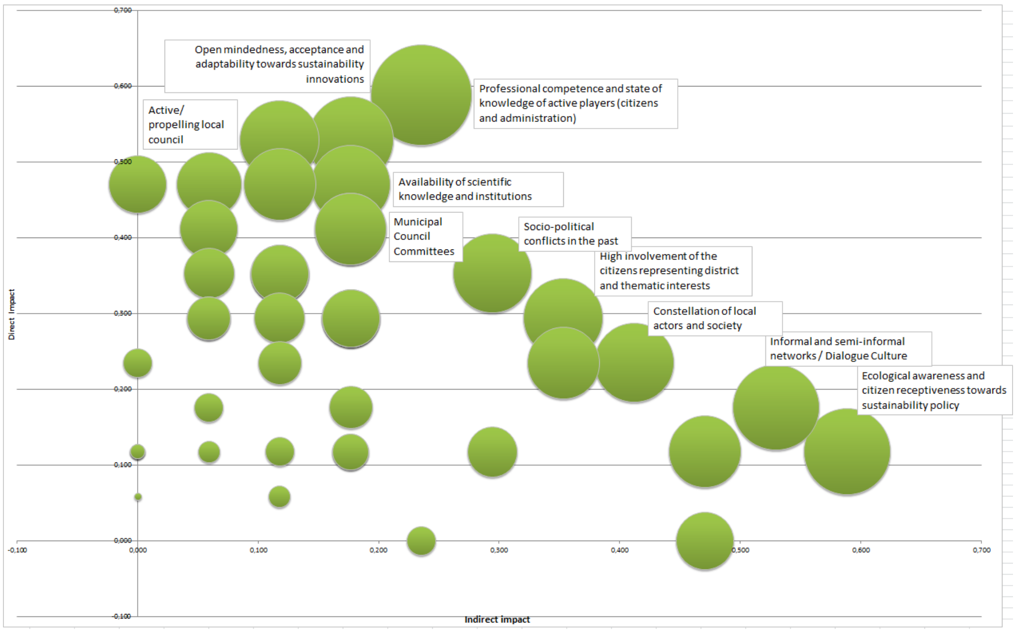


Figure 25: Impact factors Freiburg

4 R&D Platform

The aim of phase I was to identify the leading-edge global status quo of sustainable city systems and to create a starting point for the research and development of innovations in future urban systems.
This research, however, has to be seen as starting point towards an action oriented approach of applied research that aims at designing and implementing technologies and systemic solutions that help cities become more sustainable in the future.

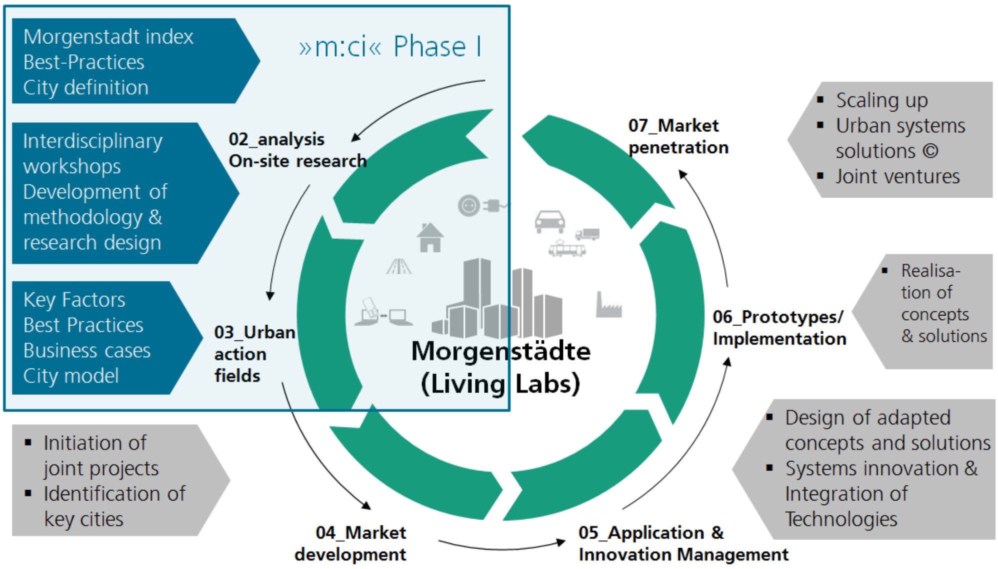


Figure 36: The Morgenstadt / City of the Future Cycle

Over 50 ideas and concepts for urban development projects have already been generated out of the insights from the analysis of the reference cities and the first projects are in the process of implementation or are 'shovel ready'.

The list on the following page shows the broad range of ideas for future projects to be generated and brought into realization out of the Fraunhofer innovation network »Morgenstadt: City Insights«. These project ideas represent the background for collaboration between cities, industry and research throughout the next phase of »Morgenstadt: City of the Future«.

URBAN SUSTAINABILITY SOLUTIONS
Projects Emerging from the M:CI Network

No.	Title/Name	Project "Owner" (Project Partner, Institute)
1	Integration of Enterprises in Local Climate Protection	Badenova Regional Cluster
2	Energy Master Plans for Industry/Business Parks	Badenova Regional Cluster
3	Regional Cluster	Badenova Regional Cluster
4	Connected- Regional Mobility	Badenova Regional Cluster
5	Building Renovation in the City of Tomorrow	Badenova Regional Cluster
6	Local District Heating Network for the City of Tomorrow	Badenova Regional Cluster
7	3D City Models—Simulation of Changes/Threats to Cities	Dorsch International Consultants
8	Integrated IT-Solutions for Modulations in the Water Sector	Dorsch International Consultants
9	Transformation of Existing City Structures	Drees & Sommer
10	SCIM: IT-Planning Tool for Simulation of Resource-Connected City Transformation Processes	Drees & Sommer
11	Methods for Sustainability Measurement of Urban Development Processes	Drees & Sommer
12	Methods for Measurement of Sustainability in Industry Locations	Drees & Sommer
13	Planning and Usage Circles for Autonomous City Quarters	Züblin
14	Circle-able Buildings	Züblin
15	Decentralized Water Management	Züblin
16	Integrative Solutions For Resource-Saving Solutions for Development of Existing Structures	Vattenfall
17	Berlin Urban ICT Lab	FOKUS
18	Trade Logistics for the City of Tomorrow	IFF INTERNATIONA-Institute for Field Research
19	Evaluation Tool for Security Classification of Buildings	EMI, Siemens
20	Tool for Identification of Sustainable Local Energy Systems	ISE, Energieversorger, ICT-Unternehmen
21	Conception and Construction of a Matchmaking Platform for Urban Innovations	Fraunhofer IAO
22	Technologies Innovation Radar for the City of Tomorrow	Siemens, TÜV Süd, Bosch, Fichtner IT Consulting
23	Energy Planning Tools	IBP, UMSICHT, ISE, AST, IWES
24	City Quarter Energy Concepts	UMSICHT, ISE, IBP, AST, IWES, EMI
25	The Multi-Energy-Smart-Grid	UMSICHT, ISE, IBP, AST, IWES, EMI

URBAN SUSTAINABILITY SOLUTIONS
Projects Emerging from the M:CI Network

No.	Title/Name of Project	Project "Owner" (Project Partner, Institute)
26	Urban Quarter Net Concepts/ Urban Quarter Storage Technologies	UMSICHT, ISE, IBP, AST, IWES, EMI
27	Solarizing City Quarters	ISE, IBP, UMSICHT, AST
28	Power Plant Engineering of Decentralized Supply Solutions	ISE, IBP, UMSICHT
29	Connected Operation of Decentralized Energy Plants	ISE, UMSICHT, AST, FOKUS
30	Urban Production Centers and Increasing Value Added Activities in Urban Spaces	IAO, IML, IBP, UMSICHT
31	Security of Supply and Efficient Logistics in the City of Tomorrow	IML, IAO
32	Virtual Experiment Fields for the Logistic in "The Versatile City"	IML, IAO
33	Intelligent Connected Mobility Systems and Infrastructure for the City of Tomorrow	ISE, IAO, FOKUS, IML, IISB, IVI
34	Multimodal ("Convenient City") Traffic Construction	IAO, IBP, ISE, EMI
35	Construction for Existing and Future Potential Cultural Heritage in Cities	IBP, ISE
36	City Buildings Physics (Urban Surfaces and Planning Instruments)	IBP, UMSICHT, IAO
37	Evolutionary (and Minimal Invasive) Planning and Building Processes for the Transformation of the City of Tomorrow	IAO, IBP, ISE, UMSICHT
38	Energy Efficient and Innovative Buildings in the City of Tomorrow	IBP, UMSICHT, EMI, IAO, IISB
39	City Mashups	FOKUS, IAO
40	Urban Data Platform for Real-Time City Management	FOKUS, IAO, IOSB
41	Mobil M2M (machine-to-machine)	FOKUS, UMSICHT, AST
42	High Performance/Sustainable Processes for Working and Living In the City of Tomorrow	IAO, IBP
43	Innovative Social Value Added Demonstration Projects	IAO, AST, ISE, UMSICHT
44	Citizen Participation in City Processes	IAO, FOKUS /ELAN, ISST
45	Multifunctional Building Structures for Security-Relevant Infrastructure	EMI, IBP
46	Holistic Risk Management for a Resilient City	EMI, IOSB-AST, IAO
47	City-Cockpit: Sustainable Technology Management Instruments for the Synchronization of Innovation Cycles in the City	IAO, IBP, UMSICHT, IML
48	Towards an Overall Model on Consequences for the Environment: Potential Analyses and Evaluation of Sustainability	IBP, IAO, IML, UMSICHT, IOSB- AST
49	Goal Balancing for the City of Tomorrow: Consensus on the Requirements for Needs-Based City Design	IBP, IAO
50	Transfomation of the City of Tomorrow (Scenarios, Implementation Processes, Project Monitoring)	IAO, ISE

5 Outlook Phase II – m:ci²

Starting in January 2014, »m:ci« will be transformed into an ongoing alliance of industry, cities, and research partners that will join forces for the purpose of accelerating innovation throughout the various research sectors and for creating both international and German showcases for transformative urban projects. The focus of Phase II will be on developing detailed, innovative cross-sectoral urban sustainability projects and on implementation within context-specific complex city systems.

The primary mission of the City Insights Network is to **identify, conceive, initiate and implement pilot and demonstration projects for sustainable urban solutions** in cities in Germany and around the world. Projects will be developed in variable consortia made up of industry, city, and research partners.

Throughout phase I of »m:ci« researchers witnessed several challenges that industry and businesses face in working together with cities:

- No single company can meet the needs of a city nor can it implement innovative solutions without partners from the city and businesses from other sectors.
- Companies find it difficult to engage cities directly as a customer. Procurement regulations can complicate the ability of companies to develop a reliable relationship with city clients.
- Public contract directives usually lead to large and inefficient bidding processes. They produce high upfront costs on both sides and often do not result in the best solution.
- Good solutions to pressing problems are often not implemented because evidence based long-term planning and sound analysis of consequences are not being applied or because investors fear the risk that goes along with innovative technologies.

The City Insights Network is designed to address these challenges with a new collaborative approach.

The aim of »m:ci²« is to **initiate and accelerate the long-term transitions of selected cities towards sustainable urban systems** and to thereby create both international and Germany based reference projects on the level of entire cities.

»m:ci²« aims to become the first global alliance for planning and implementing large-scale sustainable urban solutions in a range of cities around the world.

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VATTENFALL

VW

Waldshut lädt ein

Xella

ZÜBLIN