Fraunhofer

EXECUTIVE SUMMARY

INNOVATION NETWORK
MORGENSTADT: CITY INSIGHTS
PHASE I

MorgenStadt
City of the Future

This joint research project is part of the Fraunhofer Initiative Morgenstadt.

Project coordination
Fraunhofer Institute for Industrial Engineering IAO

Project Steering Board
Fraunhofer Institute for Industrial Engineering IAO
Fraunhofer Institute for Building Physics IBP
Fraunhofer Institute for Solar Energy Systems ISE

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CONTENT

PREFACE

Urbanization – E-Mobility – Industry 4.0 – rise of renewable energies – demographic change – internet of things …: our world is speeding up more and more and entire industries are in the process of reinventing themselves in order to co-create our future. Throughout the last legislature, the Science and Industry Research Union (Forschungsunion Wirtschaft–Wissenschaft) has worked towards defining the ten most important future-oriented projects of the German hightech strategy 2020 together with the German Ministries. We want to successfully position Germany with regard to the big technical and social challenges of the future, and to point out the future missions for achieving economic innovation and social prosperity.

Prof. Hans-Jörg Bullinger
Senator of the
Fraunhofer Society

One of the first future-oriented projects of the high-tech strategy 2020 is »Morgenstadt / City of the Future«. In fall 2010 we presented the vision of a »CO_2 neutral, energy efficient and climate-adapted city« to the German Government. In addition we framed needs for action and developed roadmaps as further suggestions. The »National Platform Zukunftsstadt« is actively working with these suggestions since July 2013 and has adopted them for further refinement and implementation.

We at Fraunhofer initiated the »Morgenstadt-Initiative« in order to support this agenda process at an early stage and to strengthen the fundamental meaning of sustainable city development within the context of the German »energy turnaround« and the big socio-economic challenges of the future. Our goal was to pool existing expertise from the outset. The central project of this initiative is the innovation network »Morgenstadt: City Insights« which has been designed as a pioneering project between industry, cities and research to create the foundations for a sustainable and innovation-oriented transformation towards the »Morgenstadt / City of the Future«. Systems analyses in six leading global cities and the development of a »Morgenstadt Model« for deriving future key measures have helped us establish this new approach. Today real innovations for a sustainable society arise out of systems thinking and interdisciplinary collaboration.

I would like to thank all pioneers and innovators who have supported this project from the beginning. Bringing these innovations into realization over the course of the coming years will be one of the most exciting tasks of our times.

ABSTRACT

The joint research project »Morgenstadt: City Insights« (»m:ci«) is an alliance of high-ranking partners from a range of industry sectors, leading-edge sustainable cities, and key Fraunhofer research institutes. Using innovation management methodologies and a range of tools and measures (international city surveys, »city labs«, analytical tools, online assessment instruments etc.), »m:ci« aims at developing and implementing socio-technical innovations and lighthouse projects to give an answer to the challenges of the cities of tomorrow. »m:ci« focuses on the interplay of technologies, business models, and governance approaches for sustainable urban development. The network's fundamental goal is to accelerate development that helps to reduce energy and resource consumption while enhancing the livability and prosperity of a city.

In order to shape the transition of today's cities towards sustainability, resilience, and liveability in a demand-oriented way, »m:ci« partners strive to address two main fields of action:

On the one hand, designing task-force groups on specific topic areas to result in concrete project concepts and to pilot research- and implementation projects on national, European and international level with multi-partner, interdisciplinary consortia. Concrete demand from municipalities and impulses from science and research are our key focus points. The »m:ci« management team identifies potential funding sources as well as both formal and informal opportunity windows for implementation on an ongoing basis.

On the other hand the »m:ci« network deploys the systemic knowledge developed throughout phase I for accelerating the development and implementation of new breakthrough innovations within a comprehensive sustainable systems transition strategy. In collaboration with selected cities the »m:ci« process includes deep analysis, strategic road mapping, project concept development and prioritization.

Both evolutionary and revolutionary innovation can only emerge at the interface of existing disciplines and technologies. For identification and shaping of the right action fields for the city of the future, »m:ci« members developed a global status quo on existing and functioning solutions for sustainable urban development in the eight sectors energy, mobility, governance, ict, water infrastructure, security, production & logistics, and buildings. The goal of phase I (2012 – 2013) was to gain deep insight into ongoing transformation processes of leading cities and to derive actor-specific and interdisciplinary success factors for managing the transition towards sustainable and vital cities.

Starting from a systemic analysis of six leading cities (Singapore, Copenhagen, Freiburg, New York City, Berlin and Tokyo) Fraunhofer researchers aligned and synchronized insights from all cities in one action-oriented model – called the »Morgenstadt Model for Sustainable Urban Development«. This Model helps analyze the sustainability performance of cities and points out strategic points for action and potentials for development. In combination with technology roadmaps and scenario techniques this model represents the basis for developing strategies, roadmaps and integrated measures, defining the trajectories of transition for today's cities.

INITIAL SITUATION

What is »Morgenstadt«?

A few years ago future cities were hardly a matter of broad discussion. This changed in 2007, when the United Nations illuminated the fact, that 50% of the human population (3.3 billion people) already lived in cities. According to the prognosis, in 2030 over 5 billion people will be city inhabitants. This development is not exemplary for all nations - many of the highly industrialized countries experience decreasing population statistics, due to shrinking birth rates, aging of the population, and demographic change.

The cities of tomorrow will differ essentially from today's city principles. However, this transformation will slowly happen over the upcoming decades, so that we will hardly be able to detect obvious change as contemporary witnesses. Current future topics, such as electric mobility, industry 4.0, shared economy, energy transition and the internet of things will gradually change our societies by altering value creation as well as living and working processes. The city itself will be the central point of action and testing field of our time. This is the place where people, organization forms, space and technology converge and develop in dependance on each other.

For the first time in human history, we are challenged to actively master urbanization worldwide by using the right solutions for a sustainable development. Sustainability goals are necessary for the cities of the future, but have to be complemented by additional dimensions like resilience and the ability to innovate. An increase in extreme situations and changing framework conditions require new approaches, strategies and infrastructures. What will the city look like, in which we want to spend our future in? Which products and solutions will we need to achieve this vision?

»Morgenstadt« can be considered as an innovation motor which represents the playing field we will be moving on in the future. Instruments used to stimulate innovation and insight contribute to giving an overview over current development processes and rewarding courage when using unconventional approaches to pave the path into the future.

Defining a joint vision for sustainable cities

Throughout the course of the »m:ci« research, discussions on the assessment of urban sustainability emerged. Where possible, the practice examples' impact 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.

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

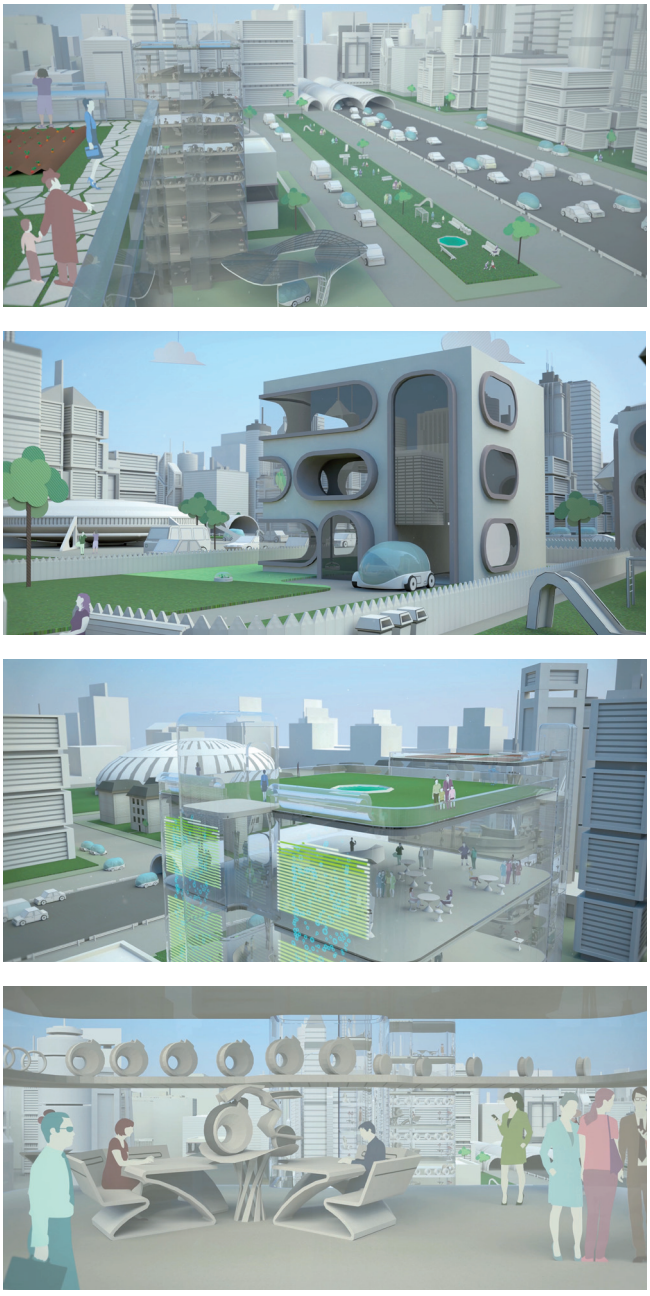


Fig. 01:
What may »Morgenstadt« look like? (Source: Fraunhofer IAO/FBB)

- The triple bottom line for urban sustainability needs to be redefined.
- Resilience has to be an integral part of sustainable development.
- Cities need individual long-term visions as guideline for socio-economic, spatial and technical development.
- Sustainability is the goal, maximizing fitness is the way

Cities need to know which goal represents their individual ideal situation. This vision has to be simple, clear and highly ambitious, representing the ideal stadium of a sustainable city. We suggest a »Morgenstadt« vision that builds upon four main development goals:

- 0% Waste
- 100% Resilience
- 100% Livability
- 100% Innovation Excellence

INNOVATION NETWORK »MORGENSTADT: CITY INSIGHTS«

Motivation

Responding to the demand for action for shaping future cities in the context of a sustainable development, the German government initiated the future oriented project »the CO_2 neutral, energy efficient and climate adapted city« wihtin the Hightech Strategy 2020. This strategy aims at developing a lead market for future sustainable city systems, foster collaboration between research and industry, and advance the framework conditions for innovation. Lead by Prof. Hans-Jörg Bullinger, President of the Fraunhofer Society until 2012, the basis for this project was developed in the advisory council to the German government: the industry-research union (Forschungsunion Wirtschaft-Wissenschaft).

In this context, the Fraunhofer-Society initiated the Morgenstadt Initiative to shape a new understanding of transforming our cities by using innovative and system-oriented solutions. One of the central measures is the joint research project »Morgenstadt: City Insights« (»m:ci«), which aims at developing and implementing socio-technical innovations and lighthouse projects to give an answer to the future cities' challenges. »m:ci« focuses on the interplay of technologies, business models, and governance approaches for sustainable urban development. The network's fundamental goal is to accelerate development that helps to reduce energy and resource consumption while enhancing the livability and prosperity of a city.

Two approaches and goals are followed in this context:

Evolutionary innovation: The »m:ci« network demonstrates and quantifies new markets and development potentials in urban systems for existing products, technologies and systems solutions.

Revolutionary innovation: The »m:ci« network identifies upcoming technology-effects and disruptive developments relevant to future cities and designs revolutionary new products, systems, and business models.

Objectives

The innovation network »m:ci« has been constituted between industry, cities and Fraunhofer institutes in order to gather innovators from cities, industry and research for an open systems research approach. The project tackles three main objectives:

- Understanding what makes sustainable urban systems successful in order to shape those systems in the future.
- Helping cities develop in a more sustainable way.
- Helping businesses understand and access sustainable cities as future markets.

The network aims as accelerating the global transition to sustainable urban systems. Network members share three important convictions:

- Sustainable cities are key to a sustainable future. To create a livable future, we must create intelligent, CO_2 neutral cities that effectively make use of energy and resources and provide a high quality living for everyone.
- Technical, organizational, and financial innovations are key to creating sustainable cities. Effective, transformational solutions for clean, efficient, and livable cities emerge where innovative technologies are combined with mindset shifts, new management and organizational structures, as well as sound creative business models.
- Interdisciplinary collaboration lies at the heart of urban innovation.

- Sustainable change innovations must be rooted in collaborative processes that facilitate out-of-the-box thinking and enable active work at interface points between sectors and disciplines.

Research approach in phase I

Phase I of the innovation network took place from May 2012 until October 2013 and completely addressed the objective to understand what makes sustainable urban systems successful. We aimed at understanding, which solutions make sustainable urban systems successful and which integration of technologies, business models, governance structures and actors lie behind them.

Over fifty researchers from twelve Fraunhofer institutes conducted a rigorous on-site analysis of six leading global cities: **Berlin, Copenhagen, Freiburg, New York City, Singapore** and **Tokyo.**

All selected cities demonstrate interesting trail-blazing projects and solution approaches for improving sustainability. Each of the cities, however, has a different strong-point in relation to the sectors studied in »m:ci«, those being: energy, building, mobility, water, productions and logistics, security, information and communications technologies (ICT) and governance. Over one hundred best practices in these eight urban sectors were analyzed with a trans-disciplinary approach.

Fraunhofer researchers systematically derived insights regarding key factors that create conditions for cities to successfully transition towards sustainable urban systems. 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 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. 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.

MORGENSTADT MODEL FOR SUSTAINABLE DEVELOPMENT

The »Morgenstadt Model for Sustainable Urban Development« originates from the first phase of »m:ci« and answers three major questions:

- What is the performance of the city?
- How does the city address sustainability?
- Why do or don't things work?

What is the performance of the city?

Over 300 indicators (input, state and output indicators) had been defined in 2012 for assessing the state of the selected cities. An evaluation process of the data assessment within those cities provided valuable insights on the availability and the comparability of data: 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 comparisons (e.g. crime rate, emissions etc.). A revision of those indicators provided a set of less than one hundred urban indicators that define a city's sustainability state.

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 were defined and compared with existing indicator systems on sustainable city development.

All indicators are put into one of the following three categories to provide a complete basis for quantitative analysis of the status quo in any city:

- »Pressure Indicators« - indicate which pressures exist on the city system from the different sectors and from the social, economic and environmental point of view.
- »State Indicators« - describe the current state of the environment, the society, the economy and the different technology sectors within the city.
- »Impact Indicators« - show which impact the city system has on the environment, the society, the economy and long-term resilience.

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 for each of the six cities. They show how the different cities are addressing their challenges and potentials and give insight into strategies and priorities of the cities.

The 83 defined key action fields for sustainable development represent the Morgenstadt Model's core. 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 allows to create 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. Those 83 fields of action were identified within these six cities on three 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 the Morgenstadt Model and served as a blueprint for structuring the sustainability profile of each city.

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 Fig. 02.

Why do or don't things work?

The third level of analysis raft Morgenstadt model is represented by individual drivers, framework conditions, local structures and systems that have a strong impact on sustainable development. These »impact factors« represent a city's individual DNA and cannot be brought into a standard model that would be applicable to different cities. The 170 identified impact factors 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.

An impact factor analysis uncovers why certain progress happens (or does not happen) in a particular way in a specific urban system. Identifying impact factors also helps to understand, why certain issues are of high priority in a city and others are not at all. Understanding the constellation of impact factors of a city means understanding external pressures, underlying forces, dynamics, socio-cultural and historic implications that are present within a city and have an impact (often unnoticed) on decisions, structures, strategies and measures taken on the city level and on the project level.

The assessment of impact factors cannot be done with a standard model. It needs a trans-disciplinary methodology for identifying and analyzing a city's local impact factors. This methodology has been developed, tested and refined throughout phase I of »Morgenstadt: City Insights«. It builds upon an on-site analysis by 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.

Using the model

The revised set of 108 Morgenstadt Indicators, the cross-impact model of 83 action fields and the methodology for assessing individual impact factors of a given city, are the elements that together form the basis of the Morgenstadt Model. They represent the DNA of sustainable urban development and are brought together in a systemic and open framework.

This »Morgenstadt Model for Sustainable development« represents a basis for future long-term collaboration between cities, research and industry. A broad variety of analytical services and consulting for sustainable urban development will be based upon it:

- Generating city profiles and benchmarking of cities.

- Conducting systems analysis of cities.
- Developing Sustainability Strategies for and with cities.
- Understanding hidden demand of cities.
- Bridging the gap between demand (municipalities) and supply (industry) by bringing available socio-technical solutions into real world city systems.
- Designing adapted solutions for individual urban systems.

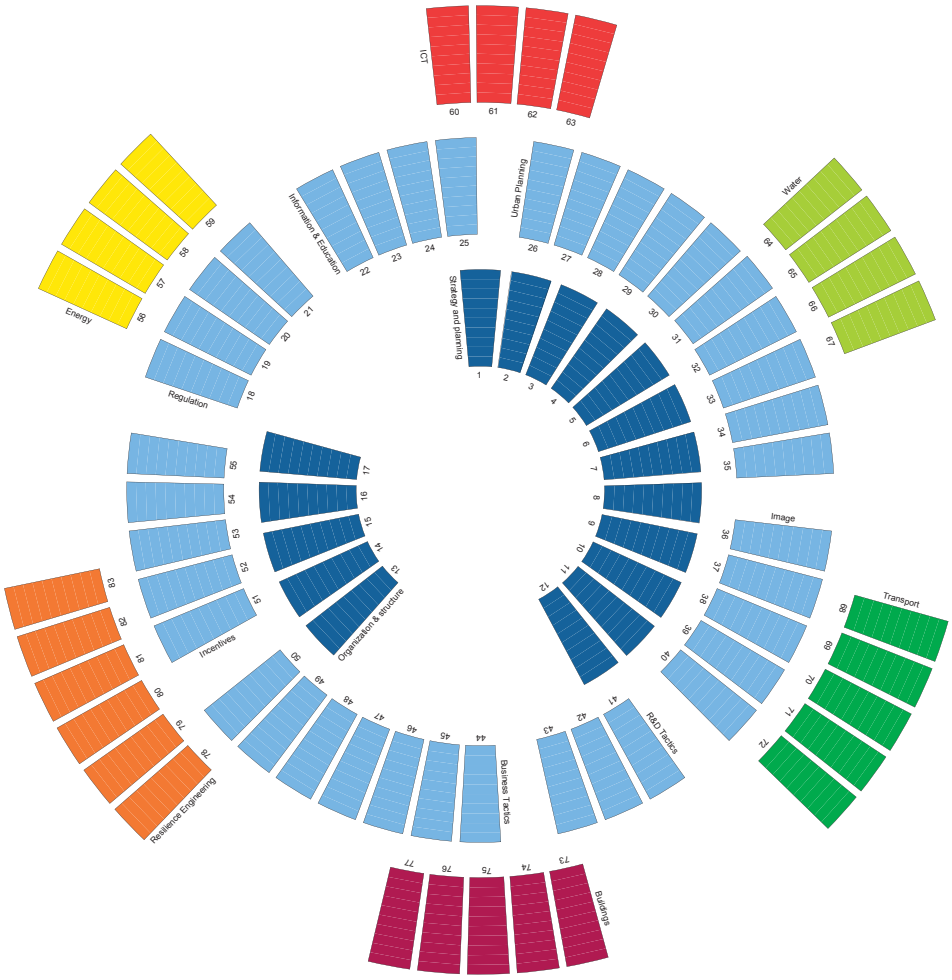


Fig. 02:
The Morgenstadt Model for Sustainable Urban Development (Source: Fraunhofer IAO)

CITY SUSTAINABILITY STRATEGIES – PROTOTYPES FOR URBAN INNOVATION

What are the individual strategies of leading cities towards fulfilling their goals for sustainability, innovation and future-proofness?

The »Morgenstadt 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 multi-layered approach for analyzing cities on their action-oriented sustainability performance and not only on their static indicators. 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 assessed by each Fraunhofer city team. 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 following 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:

BERLIN -
THE INNOVATIVE GERMAN CAPITAL

COPENHAGEN -
LIVABILITY AND GREEN GROWTH

FREIBURG -
SMALL GREEN BOTTOM-UP CITY

NEW YORK CITY -
LONG-TERM THINKING FOR RESILIENCE

SINGAPORE -
GREEN EFFICIENCY LAB FOR ASIA

TOKYO -
PPP FOR SUSTAINABLE DEVELOPMENT

BERLIN

THE INNOVATIVE GERMAN CAPITAL

Berlin struggles for sustainability. In terms of sustainability indicators the city performs quite well – mainly as a coincidence of its historic development and less because of dedicated efforts towards enhancing sustainability. Emissions are low, since industry is absent. Car-use is comparably low, since the public transport system has been improved since the 1920's and Berlin citizens share a mobility culture of bicycle use and public transport use.

Berlin's strategy towards sustainable development thus represents a mixture of a clear decision for pushing ICT-innovation, research and clean technologies for becoming a »smart city«, and a broad range of bottom-up initiatives from the citizens, converting Berlin into a test-bed for alternative concepts of housing, urban planning, urban gardening, etc.

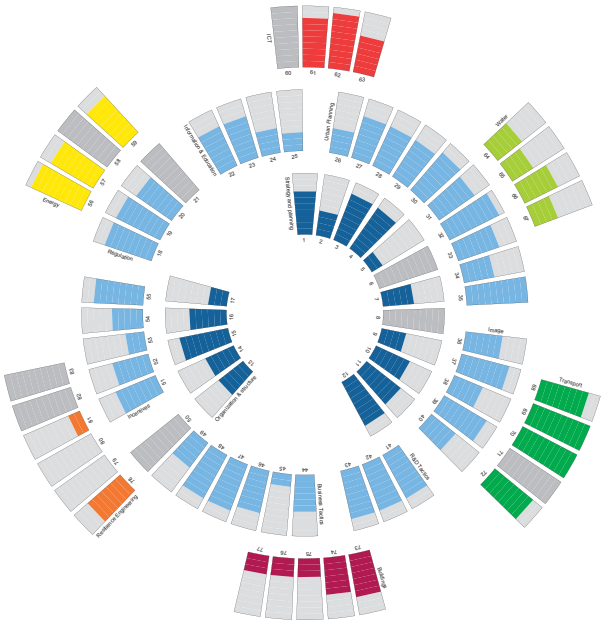
The national and international importance of Berlin helps the city attract public investments from federal and national level, but also private investments for lighthouse projects – especially in the mobility sector. Berlin is working towards becoming the German lighthouse metropolis for e-mobility with several projects bringing electric vehicles on to the streets of Berlin.

Selection of project-relevant impact factors:

- High national and international importance and visibility of city.
- Lighthouse projects/ model region.
- Alternative financing/ using instead of owing.
- Informal and semi-formal networks.
- Mobility patterns/ mobility culture.

Selection of key action fields for sustainable development and innovation:

- Establishment of sustainability advisory boards.
- Development of visions/goals together with civil society.
- Creation of administrative structures for communal sustainability management.
- Creating and maintaining a socially equitable rent level.
- District management –small-scale use-mix in local districts.

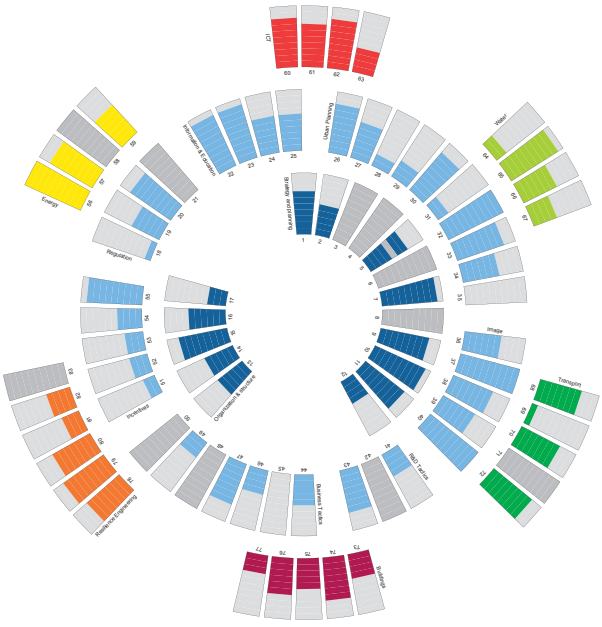


HIGH PERFORMANCE	LOW PERFORMANCE
- Low exposure to natural disasters	- Air quality: high NO_2 emissions (55 µg/m³)
- Ecological footprint (4.4 gha/ person)	- GDP/capita (29,455 €/a)
- Share of green areas (12% of the city)	- Few persons per household (1.4)
- CO_2 emissions (5.4 t per capita / year)	- High average age of population (42.9 years)
	- public confidence in government

COPENHAGEN

LIVABILITY AND GREEN GROWTH

In Copenhagen almost omnipresent, the signs of sustainable development are not only embodied in visible infrastructural elements such as the network of cycling routes or the clean water in the harbor, but also in the mindset of Copenhagen's citizens and the city administration. For example, the strategy of sustainability complies with the climate protection strategy. Coherence in sustainability action and a transition dating back to the 1990's helps the city perform high in a broad variety of indicators today.



HIGH PERFORMANCE
- Water use (104 liters per cap/day)
- CO_2 emissions (5.38 t/ capita*year)
- public confidence in government
- 228 Cars/1,000 residents
- share of local renewable energy (37.3%)

LOW PERFORMANCE
- High Tariff for water supply (2.07 €/m³)
- Production of waste (1,478,44 kg/person*year)

Copenhagen's approach towards sustainable development is rooted in a broad dispersion of action fields throughout the political and administrative realm. Copenhagen also manages to actively engage the private sector for meeting the sustainability goals of the city. It focuses on highly efficient large-scale solutions (district heating) and actively collaborates with its highly educated and aware citizens.

Selection of project-relevant impact factors:

- Marketing strategy, public relations and image of the city.
- Geographic parameters.
- Legal framework conditions from national level.
- Presence of leaders and leading figures.

Selection of key action fields for sustainable development and innovation:

- Negotiated/Voluntary agreements to higher social and environmental standards.
- Control of city over capital assets by shareholding of infrastructure providers.
- Collaboration between city and region for environmental protection and sustainability.
- Establishment of semi-formal and informal networks .
- Creation of an atmosphere open to innovation and transformation regarding sustainability.

FREIBURG

SMALL GREEN BOTTOM-UP CITY

Freiburg is well-known in Europe as green city with a cyclist culture, 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 management, efficient water use and renewable energy. Freiburg performs excellent, especially in the energy sector, but it has deficits concerning CO_2 emissions per capita, and energy demand.

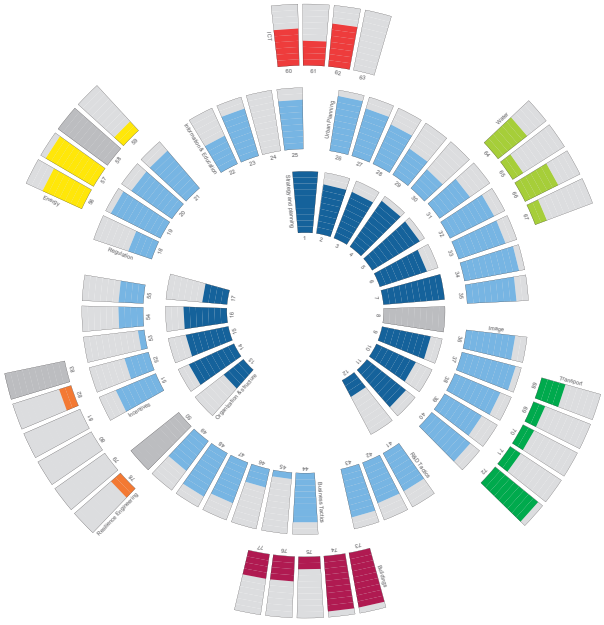
Freiburg has come a long way from the first development of a green public awareness in the 1970's to a city administration that actively pushes sustainability throughout all sectors today, backed by local policies. One third of all citizens are somehow connected to the education system (as students, teachers, employees of the institutions of higher education etc.). Consequently the educated, highly committed and critical local society represents the backbone of Freiburg's sustainable development.

Selection of project-relevant impact factors:

- Professional competence and state of knowledge of active players.
- Ecological awareness and citizen receptiveness towards sustainability policy.
- Informal and semi-formal networks.
- High involvement of the citizens representing district and thematic interests.

Selection of key action fields for sustainable development and innovation:

- Long-term political stability through planning and management approaches that exceed a single election period.
- Development of visions/goals together with civil society.
- Alignment of budgetary policy with sustainability goals.
- Negotiated agreements to higher social and environmental standards.
- Establishment of a learning organization within the city administration.



HIGH PERFORMANCE
- Production of waste: only 168 kg / person / year
- Water use per capita: 93 liters/day
- Share of local renewable energy in the grid: 11.3%
- 18.3 employees in public sector/1,000 inhabitants
- heavy trucks in total road traffic (0.51%)

LOW PERFORMANCE
- CO_2 Emissions per capita (7.97 t/person*year)
- GDP per capita (39,321 €/a)
- Total energy demand per person (22.6 MWh/year)
- 392 Cars/1,000 residents

NEW YORK CITY

LONG-TERM THINKING FOR RESILIENCE

Although New York City clearly performs best in comparison with most other North American cities, it has a large environmental footprint, when comparing it to the other cities under evaluation: bad air quality, large amounts of waste, high demand for energy, low investments into renewables etc. represent the background for a comparatively low performance. But New York City is speeding up its sustainable development – mainly by making intelligent use of a highly qualified city administration and by combining long-term thinking with clear sustainability goals and an integrated approach towards greater resilience.

HIGH PERFORMANCE	LOW PERFORMANCE
- share of employment tertiary sector (95%)	- green spaces (3.44% of city area)
- population density (10,506 inhab./km²)	- amount of waste (1,602 kg/ person*year)
- Persons/household (2.61)	- ecological footprint (7.2 gha/ cap)
- Average age (35.9 years)	- share of local renewable energy (0.01%)
- voter participation (90%)	

The rather low performance on sustainability indicators is met by a clear commitment to sustainability for future urban development. The PlaNYC 2030 and the office for long-term planning and sustainability are two great examples on how to have a Mega city embrace sustainability as long-term goal and combine strategies and measures in different sectors into one integrated approach. A strong focus on making the best use of IC-Technologies and ensuring resilience against natural disasters (Sandy) and terrorist attacks (9/11) help NYC prepare for the future.

Selection of project-relevant impact factors:

- Marketing strategy, public relations and image of the city.
- Geographic parameters.
- Legal framework conditions from national level.
- Presence of leaders and leading figures.

Selection of key action fields for sustainable development and innovation:

- Long-term political stability through planning and management approaches that exceed a single election period.
- Alignment of budgetary policy with sustainability goals.
- Establishment of semi-formal and informal networks.
- Creation and administration of platforms for citizen participation.
- Systematic long-term planning of the city structure.

SINGAPORE

GREEN EFFICIENCY LAB FOR ASIA

Singapore is a »state run enterprise« and many of Singapore's assets are difficult to copy anywhere else. Virtually all economic and political power is concentrated with the city's political elites who run it like a hierarchically structured company. This helps Singapore act with great efficiency – leading to the lowest rate of car possession of all cities under comparison, and to the most efficient and innovative system of water use worldwide.

Investments in innovations and active attraction of leading global research institutions help Singapore make the best use of innovative technologies and global knowledge for sustainable development. Presenting the city as an international showcase for cutting-edge solutions is a sound strategy that leads to the implementation of innovative clean-tech solutions by low investment costs for the city.

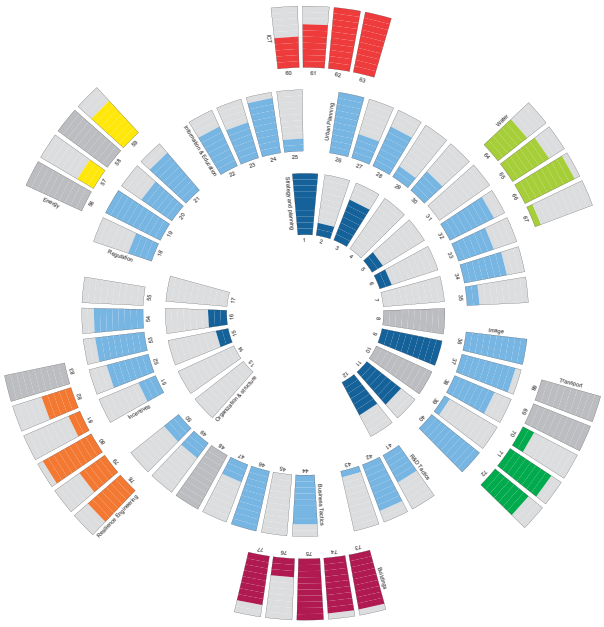
Singapore has the chance to demonstrate how an island-situation with very limited natural resources can lead to a highly sustainable system. Water and traffic management, and the green buildings approach are already leading the way. Reduction of waste and the increase of renewable energies are issues that the city will have to deal with throughout the upcoming years.

Selection of project-relevant impact factors:

- Geographic parameters.
- Limited land and water resources.
- Population growth (mainly by in-migration).
- City as a state with high environmental taxes.

Selection of key action fields for sustainable development and innovation:

- Long-term political stability through planning and management approaches that exceed a single election period.
- Control of city over capital assets by shareholding of infrastructure providers.
- Creating and maintaining a socially equitable rent level.
- Systematic long-term planning of the city structure.
- Low barriers for attraction of skilled persons, investors and businesses.



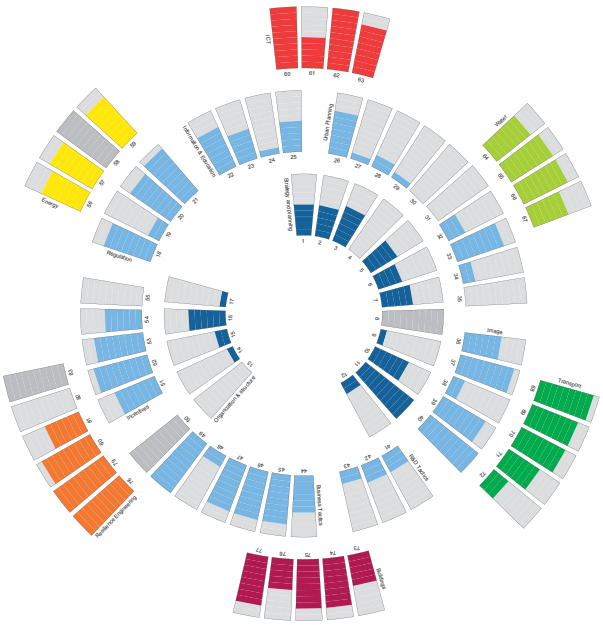
HIGH PERFORMANCE
- Unemployment rate (2.1%)
- Population density (7,163 inhab./km²)
- 117 cars/1,000 residents
- public confidence in government
- water tariff despite water scarcity (1.17 €/m³)

LOW PERFORMANCE
- Air quality: high PM10 emissions
- amount of waste (1,198 kg/person*year)
- public sector (38.7 city employees per 1,000 inhabitants)

TOKYO

PPP FOR SUSTAINABLE DEVELOPMENT

Tokyo's high density helps this mega city to be highly efficient in energy use, mass-transport, CO_2 emissions and resource consumption. Tokyo has come a long way in improving its air quality (which is still low) and reducing its environmental footprint. However, Tokyo is far from being a sustainable city. Due to its geographic situation Japan's capital is highly prone to natural disasters and thus, city officials channel investments into resilient infrastructures, security and emergency solutions. The mere size of the city forces Tokyo to apply some of the most innovative and efficient concepts of city logistics. A powerful local government steers the city's transition and aims at pushing Tokyo towards becoming more sustainable and green with the »Vision 2020«.



HIGH PERFORMANCE	LOW PERFORMANCE
- CO_2 emissions (4.8 t / year / cap)	- PM10 + NO_2 emissions
- size of public sector (12.5 city employees per 1,000)	- High exposure to natural disasters
- amount of waste (342 kg / person / year)	- voter participation in last elections (54.35%)
- unemployment rate (5%)	- water use efficiency (249 l / person / day)
- total energy demand per cap (15.3 MWh/ year)	- average age (Ø 41.8 years)

Tokyo is applying important levers to bring private actors into the game. The cap-and-trade program represents one of the main measures that help Tokyo create a green real-estate market to activate private investments into sustainable building technologies. This strategy is typical for the relationship between the Tokyo Metropolitan Government and the private sector.

Selection of project-relevant impact factors:

- Specific cultural memes (e.g. Meiwaku = avoid causing stir; Tokushita = get something for free; Machizukuri = bottom up urban development; muda = avoidance of waste; Mentsu o tateru = save face).
- Regulations for buildings and building processes.
- Public Private Partnerships & penetration of political/economic system.
- Geographic parameters.
- High population density and limited space.

Selection of key action fields for sustainable development and innovation:

- Establishment of semi-formal and informal networks.
- Enforcement of sustainable behavior and investments by regulation (e.g. thresholds).
- Active partnership between city and private sector for sustainability (PPP).
- Interoperable electronic ticketing systems in public transport.
- Use of Urban big data systems for urban management.

URBAN SECTORS

How do urban systems evolve? What solutions and strategies do exist in leading cities worldwide?

Research and innovation within »m:ci« is driven by a new approach that enables to assess, monitor, and shape sustainable urban development from a systemic point of view. The »Morgenstadt Model for Sustainable Development« combines insights from the most important urban sectors into an action-oriented analytical framework.

The m:ci Innovation Network focused on eight key technology sectors with a systemic, integrated approach. Governance structures and the economic dynamics within urban systems facilitate progress in these technical sectors and thus represent additional arenas for analysis and implementation. Each of these urban sectors displays different impact factors as frame conditions to be successful, need different implementation strategies and are more or less connected in the urban system:







Energy and Resources

Mobility and Transport

Information and Communications Technologies

Production and Logistics

Water Infrastructure

Buildings

Governance

Security and Resilience

Energy and Resources

Energy production and consumption of urban processes account for a great deal of resource use and emissions. Indicators not only reflect the level of efficiency, they are also influenced by the climatic conditions and the size and type and industry located in a city.

In general three types of energy-related projects were distinguished in the cities under evaluation:

- Citizen oriented projects, where a high acceptance and interest of the citizens is necessary to implement projects. The availability of private funding is also crucial for such projects.
- Technically oriented projects, which improve the energy system's efficiency as well as the share of renewable energy, without involving the energy user to a great extent.
- Research oriented energy projects, which are aiming at identifying possibilities to increase the sustainability of the energy system. A Public-private partnership is an important impact factor, since pilot installations are usually realized in cooperation between cities and industry.

Selection of Key Action Fields:

- High-efficient centralized energy supply.
- Promotion of renewable energies.
- Communal energy management.
- Use of smart grid technologies.

Mobility and Transport

The need for sustainable mobility concepts becomes obvious when looking at global carbon dioxide emissions caused by transport. Due to its importance and the presence of innovative practice examples, the mobility sector was analyzed in all of the six cities. It has proven that successful measures are mostly connected to large infrastructure projects, which are shaped by decades of development, policies and local framework conditions. In terms of transferability, technological and infrastructural solutions are usually applicable to multiple situations and should be integrated into a city's holistic sustainability strategy. Certain patterns could be identified across all six cities, here's a selection:

- Green mobility has a strong marketing value and becomes a major locational factor for cities.
- Transition towards public transport instead of private mobility concepts.
- Promoting interconnected inter- and multimodal mobility by creating intermodal hubs that offer alternative transport options.
- Introducing car-free living quarter concepts.

Selection of Key Action Fields:

- Targeted combination of different modes of transport.
- Public-transport oriented development.
- Linking multimodal mobility to financial services.
- Enhancing efficiency of urban transport by smart multimodal transport integration.
- Nonmotorized transport.

Information and Communications Technologies (ICT)

The city of tomorrow will be data driven and thus, it needs to adapt to this trend by analyzing the various existing data sets with urban context and using the gained knowledge in order to optimize municipal processes.

A total of thirteen practice examples were analyzed in New York City, Berlin, Tokyo and Freiburg, not one of them being limited exclusively to the ICT sector. Thus, ICT solutions contribute to the sustainability development across sectors. This overlap occurs due to efficiency, promising opportunities of new technologies and emerging demands. The analyzed ICT solutions can mostly be considered transferrable, although dependent on basic societal approval and financial resources. Successfull ICT solutions need, amongst others:

- Jointly developed ICT strategies.
- (Big) Data analysis with high performance analysis tools.
- Defined transfer of knowledge processes.
- Dissemination processes for public information.

Selection of Key Action Fields:

- Open data systems.
- Urban Big Data systems.
- Intelligent traffic management based on real-time information.
- Interoperable electronic ticketing systems in public transport.
- Digital self-helping structures.

Production and Logistics

In the urban context, basic system conditions are changing due to the growing population and density of metropolitan areas, new production and consumption patterns and demographic change. Customized products and e-commerce lead to more individual manufacturing and smaller quantities of goods resulting in higher delivery frequencies and atomization of shipments. It is crucial to not just optimize individual technologies or product components, but also analyze value chains in a systematic and holistic way.

Analyzed best practices in Berlin, Copenhagen and Tokyo dealt with urban delivery concepts, cluster strategies and infrastructure development. Transferrable results include the integration of decentralized delivery solutions into city quarters; separation of infrastructure and service as well as utilization of communication and planning tools.

Selection of Key Action Fields:

- Establish flexible and local solutions for delivery services and freight logistics in urban areas.
- Intermodality.
- Quality and optimization of the street network.
- City-compatible noise- and emission-reduced operations must be enforced.
- Network-management, marketing and the provision of necessary infrastructure.
- Urban logistics monitoring and information board (logistics-cockpit).
- Intelligent urban supply network.

Water Infrastructure

This sector includes the fields of water supply, sanitation/wastewater treatment, stormwater management and flood protection/prevention. A total of nine inspiring practices were analyzed in Copenhagen, New York City and Singapore. Most of them were based on specific framework conditions and demands (e.g. limited water resources or frequent flooding). It became clear, that the sustainable development of a city is not only about technology, but also city strategy and interlinking different sectors. To generate truly innovative sustainable solutions, the challenge lies in the integrated view and process development both within and beyond the one single sector.

While solutions targeting the reduction of water consumption by strategic processes (e.g. awareness-raising campaigns) can easily e.g. be transferred to any city with scarce potable water resources, technological measures need to be further developed, e.g. to prevent pollution infiltration into the environment when increasing the infiltration capacities of stormwater into the ground.

Selection of Key Action Fields:

- Water conservation/water saving programs.
- Stormwater management – strategic planning and implementation of measures.
- Active management of the Water-energy nexus.
- Smart water grid.
- Decentralized water treatment.
- Resource management.

Buildings

In Freiburg, Copenhagen, Berlin, New York City, Singapore, and Tokyo 18 practice examples were analyzed, dealing with energy efficient renovation of existing city quarters, urban development plans towards high performance city quarters with a focus on livability, innovative technologies tested in cutting-edge projects, voluntary certification systems, approaches to influence high energy consumers and big buildings, increasing building renovation as a goal, affordable rent and adapting to changing numbers of inhabitants.

Sustainability roadmap concepts or regulations for cities are necessary and role models for sustainable buildings are important for raising awareness and garnering wide acceptance for innovative solutions from all city stakeholders. Acceptance can also be improved by lessening the time and effort necessary for building applications, e.g. by simplified and alternative approaches within a city's regulatory structures. Furthermore, passive consumers (e.g. building occupants) need to be integrated more strongly in the future.

Selection of Key Action Fields:

- Regulation for construction processes and building activities.
- Prefabrication of buildings for efficient city transformation and use of resources.
- Energetic retrofit.
- Increased energy building standards for new construction and building retrofit.
- Sustainable certification.
- Material flows.
- Socially acceptable rent levels.

Governance

Steering cities towards sustainability is a complex task involving stakeholders from different levels of politics, civil society, research and industry. The mayor as political head of the city and the directors of important sections within the city administration prove to have the most important position in fulfilling this task. However, engaged citizens, innovative enterprises and forward-looking individuals in cross-cutting positions have the possibility of bringing important issues to the agenda or pushing for sustainability in single projects.

Successful cities in terms of sustainability have in common, that they follow a systematic and well-structured management approach towards integrating sustainability into the political and administrative aims and structures of the city. The main elements of an urban management approach towards sustainability include: First, creating a cross-sectoral management unit for sustainability within the city administration related directly to the city's highest political body and creating Sustainability Advisory Boards with local experts. Second, defining sustainability goals together with civil society and integrating the city's inhabitants in an urban management process. Third, rooting sustainable development within local economic structures and sustainability within the cities' budgetary system.

Selection of Key Action Fields:

- Cross-Sectoral forms of organization.
- Urban Leadership.
- Long-term planning.
- Pubilicly available data / collection of data.

Security and Resilience

Urban systems will be facing two major challenges in the 21st century: First, the absolute and relative number of severe shocks and stress fractures (either man-made or naturally-caused) is going to rise. Second, our increasingly heavy on ICT and interconnected infrastructures and social networks need to be able to rapidly absorb such disturbances without jeopardizing or surrendering the sustainability imperative. Still, pay-off for investments in security and resilience is seen as low, since the occurrence of so-called low-probability high-impact events is rare.

The practice examples analyzed in Copenhagen, New York City, Berlin and Singapore have shown, that natural disasters do have great potential to be game changers for large-scale investments in urban security and resilience. Besides lighthouse projects, cities need real-world test beds in urban environments to prove feasibility, acceptance and business case for new solutions.

Future resilient urban systems and their individual components will need good design and construction, good management and good governance.

Selection of Key Action Fields:

- Resilience-by-Design Approaches.
- Network Security Solutions.
- Business Continuity Management and Planning.
- Flood Protection.
- Integrated Risk Management.

OUTLOOK ON RESEARCH PHASE II (M:CI²)

Starting in January 2014, the second 2-year research phase of the innovation network will be rolled out. »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.

Key focus of phase II will be the establishment of strategic cooperations with at least three cities (Morgenstadt City Labs) on German, European and International level. Within these labs the objective lies on the identification and validation of future demands and possible development paths of cities over the next fifteen to twenty years. The labs will act as kind of test-bed to understand the challenges and the consequences from the expected shifts on a social, economical and technical dimension. In order to do so, the Morgenstadt model will be converted into a tool-kit for the collaboration between cities, industries and research. In addition, a global city survey "What cities need?" will be conducted to gain insights in tomorrow´s challenges and potentials.

The network's primary mission in phase II is to identify, conceive, initiate and implement pilot and demonstration projects for sustainable urban solutions in cities in Germany and around the world. Projects are to 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 face challenges 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.
- Fitting solutions to pressing problems are often not implemented either because of lacking evidence-based long-term planning and scenario analyses or because of possible economic risks when considering innovative solutions.

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 at becoming the first global alliance for planning and implementing large-scale sustainable urban solutions in a range of cities around the world.

»It is not the strongest or the most intelligent species who will survive but those who can best manage change.« (Charles Darwin)

PARTNER NETWORK

The innovation network »Morgenstadt: City Insights« represents an long-term 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 the final project report thus have to be seen as results of an intensive and open collaboration of many actors and stakeholders.

»Morgenstadt: City Insights« has been supported by the following city and industry partners in research phase I:

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