Fraunhofer

MorgenStadt
City of the Future

MORGENSTADT – CITY OF THE FUTURE

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DISCOVERING THE CHANCES OF TOMORROW

Challenges for urban environments of the future

The consumption of energy and resources in Germany is primarily concentrated in cities. Urban living environments therefore play a major role in efforts to tackle the key challenges of the 21st century. Municipalities, cities and regions must take timely measures to ensure they are properly equipped to face these future challenges. In response to trends and developments that are already emerging, countries all over the world will soon be required to fundamentally re-think existing city concepts and to adopt a different approach to planning and implementing future projects. These trends include increasing urbanization, demographic change, the ever-increasing consumption of resources, a clearly visible structural shift in the existing system of value creation, increasing climate variability, and the transition towards a cleaner, more sustainable energy economy, together with the changes in mobility this implies. At the same time, new opportunities are emerging as a result of increasing digitization and the growing need for citizens to participate in the planning and development processes which shape their living environments.

One of the biggest challenges to creating livable, sustainable cities and urban environments in the future will be the task of defining strategic, long-term guiding principles that take into account visible trends while retaining the flexibility to anticipate potential changes. This will require us to view each city as an overall system, because carrying out isolated interventions and executing myriad separate plans cannot offer an adequate solution to the challenges that lie ahead. In view of the multiple paradigm changes we face in so many different areas – changes that affect cities and their surroundings to an equal extent – conventional planning instruments and planning powers are unlikely to be very effective in the future. The ability to pursue long-term sustainability strategies depends on achieving demand-oriented synchronization of short-term and long-term innovation cycles – processes which have previously evolved completely separately in today's cities. In Germany and elsewhere in the world, the city of the future currently lacks uniform guiding principles or models which could serve as maxims for future action.

So what does that mean for the cities of the future? There is certainly a pressing need to take numerous aspects arising from a variety of considerations into account at the planning, construction and building operation stages – something that will only be feasible in the future through a synergetic interplay of architecture, structural engineering, building services and urban planning. The future vision of a 'CO2-neutral, energy-efficient and climate-adapted city' can only be achieved by simultaneously pushing ahead with three key approaches: modernizing buildings and production plants to make them more energy-efficient, promoting innovative and sustainable mobility concepts, and expanding and developing intelligent energy networks. Cities must adapt to climate change – and that means they must take into account their regional surroundings and the broad variety of relationships between urban and rural areas.

A great deal of research is currently still needed in this field. The Fraunhofer-Gesellschaft has risen to this challenge by developing its 'Morgenstadt – City of the Future' initiative. The city's complexity as a research topic, with all the technical, process-related, demand-oriented and systemic issues it involves, is one of the biggest challenges on the path towards a sustainable society. Fortunately, the Fraunhofer-Gesellschaft's broad scope of research and development expertise enables it to make an outstanding contribution to transforming the 'Morgenstadt – City of the Future' vision into reality. Specifically, this means tackling the numerous challenges that face tomorrow's cities in order to help them evolve into sustainable, livable and viable cities of the future.

RESEARCH INTO THE CITY OF THE FUTURE – THE MORGENSTADT

Key areas of research to help achieve sustainable, livable and future-oriented cities

How might Morgenstadt look as a vision of a sustainable, livable and innovative city of the future? To answer this question, the Fraunhofer-Gesellschaft embarked on an extensive, multidisciplinary process aimed at producing a comprehensive and scientifically validated future scenario as a guiding principle for demand-oriented and implementation-focused research initiatives. The current process has already yielded the definitions of seven core research topics which form the basis of the 'Morgenstadt – City of the Future' vision:

ENERGY:

The majority of the processes in Morgenstadt will be CO2-neutral, and the city will require virtually no external energy supplies. Multi-energy smart grids will intelligently link energy generation with consumption, drawing on a variety of energy sources and carefully tailoring power supplies to meet changing requirements. Morgenstadt will be a hybrid energy storage system capable of creating a virtual, balanced network of all available storage media. Heat will be recovered from waste water and biogas will be generated as an energy source in decentralized sewage treatment plants.

BUILDINGS:

Morgenstadt will be an organic complex of interacting buildings and infrastructures which will maintain high levels of efficiency even as the climate becomes increasingly variable. Its development concept allows for a self-sufficient power supply system thanks to the full-scale utilization of energy sources – primarily solar energy – and the adaptation of building envelopes to reflect intermittent energy yield requirements. Aspects that previously served a single purpose gain added value through the adaptive design process – for example, building envelopes can take on additional roles such as reducing noise and reducing emissions of chemical and biological pollutants in addition to their protective function. Innovative and flexible planning and construction processes can be used to create life-cycle-oriented designs.

PRODUCTION AND LOGISTICS:

Morgenstadt will be designed to ensure the smooth operation of goods transportation and handling, trade and commerce, service provision and production. At the same time, its inhabitants will be able to rely on a constant supply of key goods and services. By providing, planning and monitoring specific urban infrastructures and essential components of critical services, the cities of the future will be far more heavily involved than today's cities in furnishing production and logistics services.

MOBILITY AND TRANSPORTATION:

Transportation in Morgenstadt will be entirely oriented towards the needs of its inhabitants and offer high levels of efficiency in regard to sustainability and quality of life. Thanks to intelligent communication architectures, all mobility systems will be in constant communication with each other, thereby reducing the number of traffic accidents to virtually zero. Semi or fully autonomous vehicle systems will be available to the general public to take on the task of performing tedious, routine journeys, leaving people with more time for other activities. The individual transport systems in Morgenstadt will be emissions-neutral and will form part of a city-wide, integrated mobility system offering maximum comfort.

INFORMATION AND COMMUNICATION:

All the core issues of Morgenstadt – energy supplies, mobility and public safety – rely on information, communication, data exchange and networking in real time. Morgenstadt will be based on a new concept of communication which will meld together conventional communication infrastructures which were previously separate, ranging from adaptive sensor networks and information networks to mobile communications.

URBAN PROCESSES AND ORGANIZATION:

People living and working in Morgenstadt can expect to travel short distances and have a considerable degree of freedom in choosing and achieving their own personal styles of daily life and work. At the same time, the inhabitants will have numerous opportunities to participate in and co-determine their city's ongoing development. Instead of traditional, rigid approaches to value creation, the city will be dominated by innovative and agile value-added models. In regard to consumer behavior and the economy, ownership will cease to be the only option in the spotlight; instead, there will be more of a focus on using things in sustainable ways. Thus, the inhabitants of Morgenstadt will no longer exclusively be consumers, but rather what are known as 'prosumers' – in other words producing consumers.

SAFETY AND SECURITY:

The citizens of Morgenstadt will take safety and security for granted in their everyday lives. They will enjoy complete freedom, children will play on the busy squares, railway stations and airports will be multifunctional building complexes that form an integral part of public life, and the city's parks and transit routes will be busy and lively even when the sun goes down. Responsibility for public safety will not solely be confined to the forces of law and order: every individual and every public building will form part of a comprehensive concept of resilience against all kinds of safety and security risks. This concept will enable the city to create an integrated risk management strategy to ensure it is constantly prepared to respond to hazardous situations.

THE FRAUNHOFER-GESELLSCHAFT AND THE CITY OF THE FUTURE

Fraunhofer is the largest organization for applied research in Europe and is a key player in the Morgenstadt initiative. Our research focuses on people's needs in the fields of health, safety and security, communication, mobility, energy, and the environment. This is why the work performed by our researchers and developers will have such a major impact on people's lives in the future. We are creative, we shape technology, we design products, we improve processes, and we open up new avenues. We invent the future.

THE INNOVATIVE MORGENSTADT PROJECT – PART OF THE HIGH-TECH STRATEGY 2020

Under the leadership of Prof. Dr. Hans-Jörg Bullinger, President of the Fraunhofer-Gesellschaft, the Industry-Science Research Alliance rapidly developed the foundations for an innovative project entitled 'The CO2-neutral, energy-efficient and climate-adapted city (Morgenstadt – City of the Future)'. The Industry-Science Research Alliance is the German federal government's central advisory committee for innovation policy in relation to the pursuance of its 'High-Tech Strategy 2020 for Germany'. In late March 2012, the German government published its action plan for the High-Tech Strategy 2020, paving the way for the implementation of ten forward-looking projects. The goal of the High-Tech Strategy is to make Germany the leading provider of solutions to key global challenges and to offer compelling answers to the most pressing questions of the 21st century. The action plan has shifted selected missions firmly to the center of future research and innovation policy. One of the most important future policies is to seek solutions to the key challenges facing a system that represents one of our society's central living environments – the city.

FRAUNHOFER'S MORGENSTADT INITIATIVE

Currently, 15 Fraunhofer institutes are collaborating on a series of interdisciplinary projects to prepare the Morgenstadt initiative. Seven of these institutes have been designated as core institutes which are responsible for configuring the required fields of research. These include the Fraunhofer Institutes for Industrial Engineering IAO and Building Physics IBP, which also share responsibility for project management, and the Fraunhofer Institutes for Solar Energy Systems ISE, for High-Speed Dynamics, Ernst-Mach-Institut, EMI, for Environmental, Safety and Energy Technology UMSICHT, for Open Communication Systems FOKUS, and for Material Flow and Logistics IML. A number of other Fraunhofer research institutes are also channeling their specialist expertise into specific research topics, including the Fraunhofer Institutes for Integrated Systems and Device Technology IISB, for Wind Energy and Energy System Technology IWES, for Optronics, System Technologies and Image Exploitation IOSB through

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its Application Center System Technology, for Interfacial Engineering and Biotechnology IGB, for Microelectronic Circuits and Systems IMS, for Factory Operation and Automation IFF, for Manufacturing Engineering and Automation IPA, and Fraunhofer Portugal through the Fraunhofer Center for Assistive Information and Communication Solutions AICOS..

IMPLEMENTING CONCEPTS FOR TOMORROW'S CITIES TODAY – TECHNOLOGY MANAGEMENT AND URBAN INTEGRATION

Each of the areas of research included in the Morgenstadt initiative is already a world in its own right, yet the basic structures and functions required for Morgenstadt only emerge when these varied research topics are consolidated and synchronized. The primary focus is always the harmonious triad of economic, ecological and social targets. A long-term sustainability strategy requires us to synchronize short-term cycles – such as those that apply to information and communication technologies – and long-term cycles, such as those that apply to buildings and transport infrastructures. Yet these cycles currently tend to run in their own separate grooves. To address this issue, the Fraunhofer initiative Morgenstadt has developed a strategic model which is designed to align systems that were previously unconnected to each other while simultaneously investigating complementary key technologies. The goal is to establish an integrated and multidisciplinary system of technology management in the city of the future. But this involves far more than just technical implementation – other factors that play a key role include the needs of citizens, administrative functions and participating companies. Transformation processes can only be quickly and effectively put into practice through targeted cooperation and interaction and a self-stabilizing overall system. In Fraunhofer's Morgenstadt initiative, numerous institutes have combined their skills to help complete a wide variety of urban development projects in Germany and worldwide – projects that focus in particular on future needs and sustainable solutions. Thanks to the broad scope of research activities performed by the Fraunhofer-Gesellschaft's 60 institutes and the systemic integration of multiple research topics, Fraunhofer is able to support public-sector institutions, private investors and developers in the planning, development and creation of innovative urban areas. The earlier Fraunhofer researchers get involved in the process, the easier it is to identify and implement specific success factors and development strategies and to use these as a basis for developing long-term innovation strategies and processes that can be transferred to further projects.

FRAUNHOFER TECHNOLOGY

CITIES AND MUNICIPALITIES AS 'LIVING LABS'

The Fraunhofer institutes participating in the Morgenstadt initiative are already busy developing solutions for the cities of the future in close collaboration with industry and municipal authorities. Encompassing areas such as energy, mobility, production, logistics, information/communication, and safety and security, many of these solutions have already been the subject of extensive ongoing research in existing Fraunhofer innovation clusters. The services offered by Fraunhofer cover the entire value-creation process for urban development: from future scenarios and technology roadmaps to development concepts and new planning and management tools; and from innovative process and system integration all the way through to the development of needs-based products, solutions and business models in the form of demonstration prototypes and their successful implementation in new or existing urban structures.

DEMAND-ORIENTED TECHNOLOGY MANAGEMENT

The challenge that arises when planning and building new cities, districts and neighborhoods is to develop an urban technology and implementation roadmap that records the future requirements for residents, their living and working processes, business models and services as a basis for the total value added and technologies/infrastructures. This basis is then used to derive the measures that are required to shape and configure future urban and living environments. Fraunhofer can provide substantial support in this process, helping to ensure the correct decisions are taken at an early stage of planning and constructing future cities. By working together with users and planners, Fraunhofer can help achieve sustainable, livable and forward-looking results in a wide array of urban development projects.

CITY PROJECTS SUPPORTED BY FRAUNHOFER

MASDAR CITY, ABU DHABI, UNITED ARAB EMIRATES – COMPETENCE CENTER FOR BUILDING MATERIALS AND FAÇADES

The Fraunhofer Gesellschaft recently signed a framework agreement with the organizers of the United Arab Emirates' Masdar Initiative to advance the development, commercialization and deployment of renewable and alternative energy technologies and solutions in the UAE. An initial contract has already been secured under this agreement: the Fraunhofer Institutes for Building Physics IBP and for Solar Energy Systems ISE have been commissioned to take charge of designing and supervising the Façade Test Center (FTC) which will be created as part of the world's first city with low CO2 emissions and energy consumption. The aim is to develop a competence center for building materials and façades in the region on the basis of Fraunhofer expertise. The experience acquired in the FTC will enable teams from Masdar City and Fraunhofer to support industry in choosing high-performance building materials and façades. The primary focus is on reducing energy losses in the United Arab Emirates and the entire MENA region. Masdar is hoping to cut energy demand by carrying out tests and measurements of the energy profiles of integrated building façades – in particular in the context of strategic partnerships and cooperation projects in the fields of renewable energy and sustainability

KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY KACST, RIYADH, SAUDI ARABIA

As part of the ongoing development of the KACST research campus for approximately 12,000 researchers and scientists in Riyadh, Saudi Arabia, the Fraunhofer Institute for Industrial Engineering IAO is supporting the development of an integrated technology and implementation concept for the innovative building project as a prototype of a sustainable research campus of the future. It is also providing assistance to a number of different research clusters in efforts to integrate a modular lab concept.

GARE DU NORD, FREIBURG

FIn collaboration with planners, project developers and other protagonists involved in converting the site of the former Gare Du Nord freight depot in Freiburg, Fraunhofer IAO has developed an innovation concept for the forward-looking, sustainable redevelopment of the area. The goal is to create a remarkable combination of uses including logistics, residential areas and work spaces (offices, services, science, research, media and communication). The challenge

is to synchronize the site's existing potential with efforts to tap into new technical potential in the fields of networked mobility, urban production and sustainable construction.

BÖBLINGEN/SINDELFINGEN AIRFIELD

Over the last few years, a high-quality commercial and services district has been developed on an approx. 80 hectare site between the towns of Böblingen and Sindelfingen. The site features a mixture of production, services, research, training, residential areas and green space, all in close proximity to the city. Right from the beginning of the planning phase, Fraunhofer IAO has provided support in the implementation process by helping to develop an integrated and forward-looking model focused on the potential offered by the site in three key fields: urban transport telematics, integration of electric vehicles in the urban landscape, and the innovation value stream.

SEE STUTTGART – CITY WITH ENERGY EFFICIENCY

The 'City with Energy Efficiency – SEE Stuttgart' concept from Fraunhofer IBP was developed in collaboration with the City of Stuttgart, the company EnBW Energie Baden-Württemberg AG and the University of Stuttgart. Its strength lies in a strategy that considers all aspects of energy efficiency, leading to measures which draw on the interests and behavioral patterns of the private households involved to define energy and economic priorities. The project is based on a macroscopic and microscopic energy efficiency and strategy model which prioritizes the effectiveness of the proposed energy-saving measures under realistic conditions. An 'Energy' roadmap details the actions that can be taken to save approximately 3000 GWh per year, thereby increasing energy efficiency by 20 percent by the year 2020. In order to speed up implementation of the roadmap, services are being initiated for the private sector and these are now ready to be brought to market. The strategy developed on behalf of the City of Stuttgart integrates all the different protagonists and levels of action, and its model calculations have been validated by a comprehensive survey of 1,000 households.

WOLFHAGEN – AN ENERGY-EFFICIENT CITY

With some 14,000 inhabitants and 11 different districts, the town of Wolfhagen faces the typical challenges of a largely rural municipality in the structurally disadvantaged region of North Hessen. Moving a small town to a renewables-based energy supply within a medium-term time frame

1 *Prototype of the Façade Test Center (FTC) in Masdar City, the Modular Test Facility for Energy and Indoor Environments (VERU) developed by Fraunhofer IBP in Holzkirchen.*

2 *View of the town of Wolfhagen which – together with Fraunhofer IBP – was the joint winner of the Energy-Efficient City initiative run by Germany's Federal Ministry of Education and Research (BMBF).*

3 *A house that acts as a micro power plant and refueling station – the house of the future developed by Germany's Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and Fraunhofer IBP.*

first requires all levels of society to embark on a major shift in thinking. The goal is to develop not only measures that will have a broad impact but also a range of new services. One of the keys to this process is to incorporate citizens and local protagonists such as municipal utilities, the skilled trades and banks. Communication and information therefore form a critical part of the project. One of the main contributions that building physics can make to analyzing and shaping a town as an energy system is to calculate energy demand figures and develop strategies to reduce energy consumption levels in existing buildings. Fraunhofer IBP is working on innovative solutions for building envelopes and for new approaches in the provision of heating and cooling. Since the inherent fluctuations in renewable energy production often run counter to the times of peak demand, new control strategies and storage media are required to bring energy supply and consumption into a sustainable balance, including solutions that can provide energy for electric vehicles among other aspects. A further key area of research at Fraunhofer IBP is the development of high-time-resolution methods for determining energy consumption densities and for calculating the potential of renewable energy using geographic information systems.

EFFICIENCY HOUSE PLUS WITH ELECTROMOBILITY – HOUSES AS POWER PLANTS IN DECENTRALIZED ENERGY SYSTEMS

After just one year of planning and construction, the 'Efficiency house plus' was officially unveiled by German Chancellor Angela Merkel on December 7, 2011. Thanks to its central location at Fasanenstrasse 87 in Berlin, just around the corner from the Kurfürstendamm, the house of the future can be visited before the test family moves in and after they move out. As well as drawing up the technical criteria for the building, the Fraunhofer IBP researchers also carried out validation of the measuring systems used in the project.

The 130-square-meter house features the very latest technical innovations in the field of energy efficiency. With its heat pump and state-of-the-art photovoltaic panels on the roof and outside walls, the house produces more electricity than its residents need. The energy generated by the house is stored in high-performance batteries and used for various purposes, including charging electric vehicles at the house's own charging station – a concept that brings the filling station to where the car owner lives! Insulation of the building envelope and optimized building services technologies minimize the heat losses which are responsible for significant energy wastage in conventional building designs. All this makes the single-family home into something of a 'micro power plant' which can feed the surplus energy it produces into the public grid. It is intended to provide a model for future decentralized energy supply systems, especially for rural residential structures.

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