

**BUILDING FOR THE FUTURE –  
THE FUTURE FOR BUILDING**



PREFACE	3
FRAUNHOFER BUILDING INNOVATION ALLIANCE – WHO WE ARE	4
FRAUNHOFER BUILDING INNOVATION ALLIANCE – KEY TOPICS	6
SOFTWARE FOR BUILDINGS	8
NANOTECHNOLOGY FOR BUILDINGS	10
BUILDING MATERIALS	12
BUILDING WITH MEMBRANES	14
PEOPLE IN BUILDINGS	16
BUILDING AUTOMATION	18
SAFETY AND SECURITY	20
ENERGY SUPPLY SYSTEMS	22
SUSTAINABLE QUARTERS	24
INTERNATIONALIZATION	26
SPECIALIST BUILDING INFORMATION AND DATABASES	28
ADDRESSES	30

# BUILDING TOMORROW'S WORLD TODAY

'Resource scarcity and demographic change are the key challenges of the 21st century. Important questions on the future character of buildings, infrastructure and settlements must be addressed to ensure we are ready to face the changes that lie ahead. When it comes to creating the city of tomorrow, far-sighted planning is just as crucial as the use of innovative materials and processes.'

*Prof. Dr. Hans-Jörg Bullinger, President of the Fraunhofer-Gesellschaft*



The growth and transformation of cities will significantly influence development in the 21st century because the race toward an environmentally sustainable future is primarily taking place in urban centers. By the year 2050, the earth's population will have increased by a further 3 billion people, all of whom will need somewhere to call home. By 2025, some two thirds of the world's population will be living in cities. At the same time, current extrapolations suggest that primary energy demand will increase by some 50 percent – a development that will go hand-in-hand with a corresponding rise in CO<sub>2</sub> emissions.

The city of the future will no longer be comparable to today's cities, largely because the technological challenges we face are so immense. As a result of increasing climate variability, extreme weather phenomena are likely to occur with greater frequency, even in areas that have so far remained virtually unscathed. New materials and processes will open up huge opportunities to design and configure building structures to cope with these challenges.

Even in the not so distant future, people in the industrialized world will be spending an average of 90 percent of their lives indoors. For people living as part of a steadily growing population, in an increasingly ageing society, in ever larger cities, yet with dwindling resources, the comforts and amenities of the buildings and settlement structures they inhabit will become increasingly significant.

What does that mean for the cities of tomorrow? There is certainly a pressing need to take multiple and varied aspects 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. As an interdisciplinary organization, the Fraunhofer Building Innovation Alliance already acts as an interface between the realms of business, research and politics. It embodies the Fraunhofer-Gesellschaft's commitment to providing the market with a central systems integrator in the field of building research.

The research institutes involved in the Fraunhofer Building Innovation Alliance develop solutions for the urban future in close collaboration with industry and municipal authorities. These solutions, many of which have been the subject of long-term research, encompass fields such as materials, supply technologies, production, building automation, safety and security, and planning processes. Together, these solutions cover the entire life cycle from planning and construction to building usage, change of usage, and the recycling of buildings and settlement structures. Very best regards,

Prof. Dr. Klaus Sedlbauer  
Chairman of the Fraunhofer Building Innovation Alliance and director of the Fraunhofer Institute for Building Physics IBP



# FRAUNHOFER BUILDING INNOVATION ALLIANCE

## KEY AREAS OF EXPERTISE OF THE FRAUNHOFER BUILDING INNOVATION ALLIANCE

- PRODUCT AND SYSTEM DEVELOPMENT
- STRUCTURAL COMPONENTS, CONSTRUCTION SYSTEMS, BUILDINGS AS INTEGRATED SYSTEMS
- SOFTWARE, SIMULATIONS
- CONSTRUCTION PLANNING, CONSTRUCTION SEQUENCE, LIFE CYCLE ASSESSMENT (LCA)
- CONSTRUCTION PROJECTS IN DIFFERENT CLIMATIC ZONES
- SUSTAINABILITY AND ENERGY EFFICIENCY
- COMFORT AND AMENITIES OF BUILDING INTERIORS

### Background and current situation

Employing some 700,000 people, the construction industry is one of the mainstays of the German economy. Its ability to innovate will determine whether we can meet our CO<sub>2</sub> reduction and energy saving goals through continuing improvements to energy efficiency and sustainability and, at the same time, whether we can respond to people's changing expectations regarding their standard of living and comfort. Modern buildings are increasingly developing into complex, high-tech systems: In the future, we will be building energy-plus-houses that will also charge up our electric cars; houses will be flexible and multifunctional, capable of adapting to the climate based on weather forecasts and supporting users with intelligent systems and building control technologies. Yet transforming this vision into reality will require significant further research and development work.

### The Fraunhofer Building Innovation Alliance

Many of the challenges facing the construction industry today are so complex that they can only be tackled by combining multiple different disciplines. The Building Innovation Alliance pools the construction-related resources and expertise of 17 Fraunhofer research institutes. Drawing on the skills of more than 4,000 staff members, this highly efficient research association was established with the aim of developing application-oriented system solutions in collaboration with industry in order to surmount the new challenges facing the building industry. The breadth of the topics addressed by the Fraunhofer Building Innovation Alliance makes it unique within the research landscape.

### Research portfolio

At a time of rocketing energy prices, improving the energy efficiency of buildings is a key issue for both residential and commercial properties. Yet the work of the Building Innovation Alliance goes a great deal deeper than this. It also seeks to promote sustainability and resource conservation and ensure that construction methods and residential buildings pose the least possible risk to human health, as well as addressing the issue of how to optimize building materials, systems and processes. Construction research shares common ground with Fraunhofer expertise in the fields of energy, information and communications technology, materials and components, life sciences, production, microelectronics, and defense and security, all of which are included in the Building Innovation Alliance. Its portfolio covers the systematic consideration of buildings on all levels from materials and components to rooms, buildings and entire residential developments. It also encompasses a chronological assessment of buildings – the potential for innovation and optimization can be found throughout the entire construction process chain, from construction, building materials and systems all the way through to the renovation and dismantling of existing buildings.

### Cooperation

The main office of the Fraunhofer Building Innovation Alliance is located at the Fraunhofer Institute for Building Physics IBP in Holzkirchen. This is where the Alliance coordinates its activities and forwards customer queries to the relevant member institutes. But its greatest strength lies in the broad scope of scientific expertise which the participating institutes of the Fraunhofer Building Innovation Alliance inject into interdisciplinary research projects – expertise which enables the development of commercially viable processes and products in collaboration with industry partners. Thanks to its network of international contacts and partnerships, the Building Innovation Alliance is able to provide support and assistance to global businesses outside Germany. Its research activities primarily center on the 11 topics outlined below.

# FRAUNHOFER BUILDING INNOVATION ALLIANCE

## SOFTWARE FOR BUILDINGS



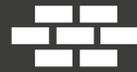
Improving the flow of digital information in the planning process • Software for analyzing the indoor climate • Building information modeling

## NANOTECHNOLOGY FOR BUILDINGS



Nanomaterials in the construction industry • 'Self-cleaning' surfaces • Antimicrobial paints • Improving indoor air • Nanotechnology on photovoltaic modules • Development of manufacturing and production processes

## BUILDING MATERIALS



Testing the durability of building materials • Outdoor testing of full-scale structures • Bonding building materials • Environmentally friendly insulating materials and flame retardants • Multifunctional materials

## BUILDING WITH MEMBRANES



Advantages and challenges of membrane construction • Coating of membranes • Mechanical properties of membranes • New joining techniques for membranes

## PEOPLE IN BUILDINGS



Indoor climate and its effects • Performance-boosting environments • Healthy indoor spaces • Climate simulation

## BUILDING AUTOMATION



Improving the physical properties of buildings • Structural monitoring • Assistance systems • Planning and updating electronic infrastructures • Frontline themes

## SAFETY AND SECURITY



Safe building materials • Membrane façades • Multifunctional modules • Low-cost shelters

## ENERGY SUPPLY SYSTEMS



Energy savings in buildings • Photovoltaic and solar thermal technologies • Combined heat and power

## SUSTAINABLE QUARTERS



Description and evaluation of sustainability in urban development • Criteria for making Sustainable Quarters more livable in social and environmental terms • Life cycle assessment software • Concept of the electromobile city • Urban innovation management

## INTERNATIONALIZATION



Megatrend of urbanization • Consulting on international construction projects • Building in different climate zones • International contacts

## FRAUNHOFER IRB



Expert information on planning and building • Three specialist portals • Building and construction databases • Publishing: Fraunhofer IRB Verlag and Fraunhofer Verlag

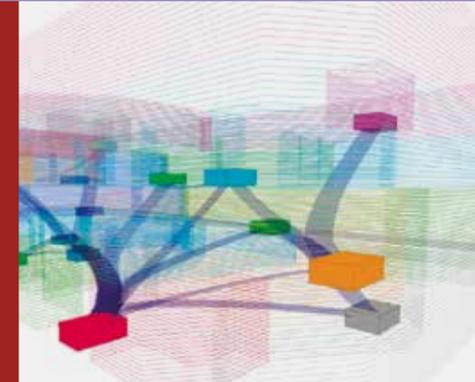


# SOFTWARE FOR BUILDINGS



## SOFTWARE FOR BUILDINGS – DIGITAL INNOVATION INCUBATOR

- IMPROVING THE FLOW OF DIGITAL INFORMATION IN THE PLANNING PROCESS
- SOFTWARE FOR ANALYZING INDOOR CLIMATE
- BUILDING INFORMATION MODELING



Software programs are the key tools in the construction planning process. New solutions are constantly being produced to reflect changes in energy efficiency and indoor climate requirements as well as safety and building management issues. The 'Software for Buildings' project group draws on its many years of experience and research skills to find new ways of facilitating the flow of digital information.

### Background

Constructing a building is a complex process that can be seriously hindered by the failure to ensure that all the relevant data is constantly in the hands of the architect, civil engineer, structural engineer and building services engineer. One of the reasons it is so difficult to share information is that the various planners involved tend to work with different software packages. Since the industry still lacks a binding, standardized data exchange format, it is almost inevitable that some information will go missing – and that causes unnecessary delays in project planning and implementation. That's why the Fraunhofer Building Innovation Alliance is working towards the goal of developing and implementing a neutral data exchange format.

### An integrated approach

The sustainability standards that apply to the construction and renovation of buildings are constantly being tightened. The only way to satisfy these requirements over the long term is to take a holistic, integrated approach. The 'Software for Buildings' project group of the Fraunhofer Building Innovation Alliance covers all areas of the construction process using its own application-specific simulation and calculation methods – from planning and construction to building operation and decommissioning.

### Simulations of indoor climates

The WUFI family of software has already established a strong reputation in the marketplace. It enables users to quantify and interpret the temperature and moisture conditions of a building's

structure and external envelope. This provides building contractors with valuable information on issues such as potential energy wastage resulting from cold spots, evaporation and air conditioning. The software program can help to reduce energy consumption and cut costs. It also enables users to pinpoint connections between indoor climate aspects and the building occupants' sense of comfort.

### Looking to the future

Building information models (BIMs) are digital models of existing buildings or planned construction projects. Depending on how they are programmed, they can also be used to model the entire life cycle of a building. Three-dimensional modeling makes it possible to derive consistent plans, and the building's construction is based on building-specific objects. BIMs offer a means of ensuring that everyone involved is immediately made aware of any changes to plans or building features. This simplifies the planning process and makes it easier to maintain buildings and assess their current condition. The 'Software for Buildings' group's services also include test planning and BIM training sessions.

### From simulation to reality

In today's world, it is virtually impossible to plan, build and operate buildings without the help of powerful software tools. And the drive toward sustainability is pushing standards even higher: The only way to save the required amounts of energy is to ensure that buildings are able to respond actively to environmental factors. The 'Software for Buildings' group supports the building industry by performing targeted basic research and offering consulting services in all key areas.

### Participating Institutes

#### Fraunhofer IBP

Fraunhofer EMI

Fraunhofer IAQ

Fraunhofer ISE

Fraunhofer Italia –  
Fraunhofer IEC

Fraunhofer IZFP

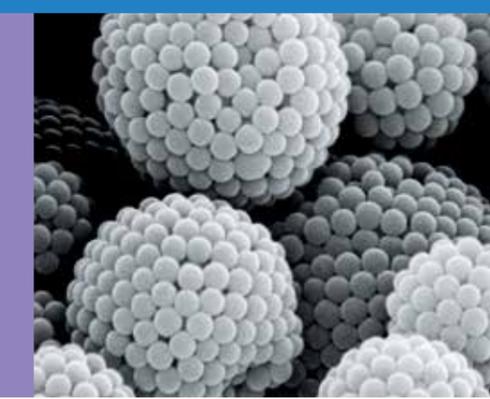
Fraunhofer UMSICHT



# NANOTECHNOLOGY FOR BUILDINGS

## NANOTECHNOLOGY FOR BUILDINGS – TINY STRUCTURES THAT MAKE A HUGE DIFFERENCE

- NANOMATERIALS IN THE CONSTRUCTION INDUSTRY
- 'SELF-CLEANING' SURFACES
- ANTIMICROBIAL PAINTS
- IMPROVING INDOOR AIR
- NANOTECHNOLOGY ON PHOTOVOLTAIC MODULES
- DEVELOPMENT OF MANUFACTURING AND PRODUCTION PROCESSES



Surface modification of nanoparticles leads to targeted and reversible agglomeration. This facilitates powder handling and ensures full dispersion in the matrix material. (© Fraunhofer ISC)

The application of nanotechnologies can help us improve the properties of existing building materials, develop entirely new materials, and create innovative building concepts. The 'Nanotechnology for Buildings' project group brings together the full range of skills of the Fraunhofer Building Innovation Alliance in producing, modifying, analyzing and processing nanomaterials.

### Nanotechnology in the building industry

Nanomaterials are substances or materials that have been engineered to have one or more dimensions in the range of 1-100 nm, thereby giving them unique characteristics. Because nanomaterials have such a large surface area in relation to their tiny mass, they frequently demonstrate altered physical and chemical properties. Nanotechnologies have already been successfully introduced in the building industry to improve the mechanical, hygienic, aesthetic and energy-related properties of building materials. Research carried out by the 'Nanotechnology for Buildings' project group focuses on the issue of how nanomaterials can be integrated in existing production processes and value chains. This includes adding them to existing building materials as well as applying nanomaterials as coatings.

### Clean, antimicrobial surfaces

Researchers have achieved particular success using nanotechnology to construct façades, roofs and windows. For example, coatings of nanoscale titanium dioxide draw on the principle of photocatalysis to form a surface that actively breaks down dirt. Applied to a PVC window frame or glazing, this coating has a 'self-cleaning' effect while simultaneously increasing the building's aesthetic appeal. This method can also be used to keep roof tiles clean. Nanotechnology can even be used to improve hygiene: Adding silver nanoparticles to paint provides the painted surfaces with lasting antimicrobial properties. The biocidal effect of the released silver ions prevents the growth of mold, algae and bacteria, thereby eliminating the need for biocides.

### Better indoor air

Nanoporous materials can help to reduce or even eliminate unpleasant odors and contaminants. For example, zeolites (natural or synthetic crystalline aluminosilicates) with functionalized nanopores have the ability to absorb molecules. The quality of indoor air can be improved by incorporating them in plasterboard or chipboard.

### Greater energy yield

Nanotechnology also offers significant market potential in the field of solar energy generation: The reflection of the sun's rays from the glass covers of photovoltaic modules causes up to four percent of the energy to be lost. Nanoporous coatings largely eliminate this undesirable effect, thereby increasing the energy efficiency of the solar installations.

### Market readiness through teamwork

The 'Nanotechnology for Buildings' project group focuses on the development of nanomaterial manufacturing and processing methods. Its goal is to provide industry with simple, safe and cost-effective techniques for producing and processing nanomaterials while observing all safety issues that apply to the handling of nanomaterials.

The group also works on joint projects with industry partners to ensure its research is applicable to real-life situations.

### Participating Institutes

- Fraunhofer ISC
- Fraunhofer EMI
- Fraunhofer IBP
- Fraunhofer ICT
- Fraunhofer IVV
- Fraunhofer IZFP
- Fraunhofer WKI



# BUILDING MATERIALS

## BUILDING MATERIALS – THE BASIS FOR INNOVATIVE BUILDINGS

- TESTING THE DURABILITY OF BUILDING MATERIALS
- OUTDOOR TESTING OF FULL-SCALE STRUCTURES
- BONDING BUILDING MATERIALS
- ENVIRONMENTALLY FRIENDLY INSULATING MATERIALS AND FLAME RETARDANTS
- MULTIFUNCTIONAL MATERIALS (PCM)



The quality of a building is directly dependent on the properties of the building materials used. The 'Building Materials' project group of the Fraunhofer Building Innovation Alliance focuses on the ongoing development of traditional materials and conducts research into innovative building materials and surface coatings. It also develops and tests suitable manufacturing and processing technologies.

### Focus

Key topics addressed by the project group include the efficient use of materials and energy and the development of environmentally friendly building materials that are non-injurious to health. In the field of quality assurance, the 'Building Materials' project group specializes in non-destructive testing methods. In addition, it develops test systems and performs system analyses and needs analyses, and it can also develop strategies for carrying out life cycle assessments of building materials. The project group's work ensures that the Building Innovation Alliance covers the entire value chain of building material development – from design and production to processing and recycling.

### Outdoor testing

For long-term field trials, the Building Innovation Alliance is fortunate to have access to a state-of-the-art outdoor testing site, the largest of its kind in Europe. The facility enables researchers to run full-scale tests to determine the durability of building materials under real-life conditions.

### New connections for new building designs

Constructive adhesive bonding provides a durable solution for joining virtually all combinations of materials. The advantage of this technology is that the adhesive process can be performed at lower temperatures than welding or soldering. This prevents damage to the parts being joined and allows them to maintain their original material properties, thereby

opening up new building methods such as lightweight structures. Constructive bonding also enables additional functions to be integrated in the building component. For example, color indicators can be incorporated to make cracks and other damage to building components visible at an early stage.

### Sustainable materials

As well as investigating how to improve the insulating properties of traditional insulating materials such as polystyrene, the project group also conducts research into developing recyclable biofoam materials from renewable resources. Another area of research is the development of environmentally friendly flame retardants and novel coating materials designed to protect a wide range of components against fire.

### Value-added building materials

Sustainable construction requires sustainable building materials. The goal is to carry out targeted further development of traditional building materials in order to supplement their tried-and-tested properties with additional features. One example is the use of phase change materials (PCM) to store heat in plaster systems and façades. As well as conducting basic research, the 'Building Materials' project group also works with industry partners on the development and marketing of innovative materials.

### Participating Institutes

#### Fraunhofer ISC

Fraunhofer EMI

Fraunhofer IBP

Fraunhofer ICT

Fraunhofer IFAM

Fraunhofer IZFP

Fraunhofer UMSICHT

Fraunhofer USA –

Fraunhofer CSE

Fraunhofer WKI



# BUILDING WITH MEMBRANES

## BUILDING WITH MEMBRANES – THE FLEXIBLE BUILDING ENVELOPE

- ADVANTAGES AND CHALLENGES OF MEMBRANE CONSTRUCTION
- COATING OF MEMBRANES
- MECHANICAL PROPERTIES OF MEMBRANES
- NEW JOINING TECHNIQUES FOR MEMBRANES



Bonded membrane cushions in free-form shapes made from ETFE films – shaded and transparent (@ Fraunhofer IFAM)

Membranes are a building material with a bright future. They can be used to create lightweight, self-supporting structures which are superior to glass designs in terms of both their price and flexibility. Examples such as the Allianz Arena in Munich and the National Aquatics Center (aka the 'Water Cube') in Beijing are particularly well-known examples. The 'Building with Membranes' project group brings together seven research institutes from the Fraunhofer Building Innovation Alliance to find ways of developing this fledgling technology.

### Need for research

Pneumatically stabilized membrane cushions made from ethylene tetrafluoroethylene (ETFE) film are one of the best known types of membrane material. However, this relatively recent building material can be challenging to use unless proper attention is paid to its unique characteristics. Solar radiation can cause sealed membrane structures to overheat rapidly in the summer, while their low mass can cause them to lose heat just as quickly in the winter. The Fraunhofer Building Innovation Alliance uses a multifunctional roof test facility to collect standardized data on the thermal performance of membranes and their physical characteristics in construction applications. It also conducts research into mechanical aspects of membrane materials and issues related to further processing of these materials (e.g. joining).

### Modifying membrane properties

The 'Building with Membranes' project group of the Building Innovation Alliance has successfully completed an in-house research project to formulate a scientific basis which can now be incorporated in broader research and development work in industry. One of the topics investigated in the research project was the development of ceramic coating materials with antimicrobial effects. The researchers also succeeded in solving the problem of how to apply infrared-reflective coatings to ETFE films and provide them with lasting protection against corrosion. Their solution reduces overheating in summer and heat loss in winter. The research project also involved the development of prototype gasochromic cushions which can be used to actively modulate the light and heat transmittance of ETFE films from around 80 percent to below 10 percent.

### Tensile test

Membrane structures are exposed to heavy mechanical loads such as wind, snow and the pressure inside membrane cushions. In order to record and test the mechanical properties of membrane materials under real-life conditions, the researchers developed a biaxial test facility which is now available at the testing, monitoring and certification center for membrane materials in Halle. This center has been certified by the German Institute for Building Technology (DIBt).

### Flexible geometries

The Building Innovation Alliance researchers have also developed novel joining techniques which have opened up new ways of using ETFE membranes in construction projects. In addition to a laser welding technique, which can also be used to carry out repairs on the construction site, the films can now also be joined using an adhesive bonding technique. In the future, these new methods will make it possible to create membrane cushions in virtually any shape and form.

### Membranes: The fifth building material

As well as focusing on comfort and indoor climate, researchers working on membrane structures also need to improve processing quality and durability. The Building Innovation Alliance hopes that its activities will help to enhance the practical usability and acceptance of membranes within the construction industry.

### Participating Institutes

#### Fraunhofer IBP

Fraunhofer IFAM

Fraunhofer ISC

Fraunhofer ISE

Fraunhofer IVV

Fraunhofer IWM (Halle)

Fraunhofer UMSICHT



# PEOPLE IN BUILDINGS



## PEOPLE IN BUILDINGS – GREATER COMFORT BOOSTS PERFORMANCE

- INDOOR CLIMATE AND ITS EFFECTS
- PERFORMANCE-BOOSTING ENVIRONMENTS
- HEALTHY INDOOR SPACES
- CLIMATE SIMULATION



Indoor climate measurements to develop ventilation strategies in classrooms using person simulators (© Fraunhofer IBP)

People in the industrialized world spend up to 90 percent of their lives indoors. To ensure building occupants remain healthy and perform to the best of their abilities, the climate and comfort of indoor spaces must be tailored to meet specific requirements. The goal of the 'People in Buildings' project group is to investigate the relevant aspects of indoor spaces and develop suitable solutions.

### The effects of being indoors

People in buildings are exposed to a range of influences including temperature, humidity and air circulation. Together with acoustics and lighting, these factors affect the building occupants' comfort as well as their health and performance. Of particular concern are the possible effects on people's health of emissions from wood preservatives, paints and floor coverings.

### How people affect indoor spaces

Indoor environments are also affected by the occupants' activities, the number of people in a room, and the outdoor climate. For example, in open-plan offices the amount of oxygen in the air decreases over the course of the day – simply due to people breathing – and people's ability to concentrate steadily diminishes as a result. Poor acoustics and sources of visual interference also decrease employees' performance and can ultimately cause companies to suffer economic losses.

### Research of practical utility

The research institutes involved in the Fraunhofer Building Innovation Alliance use experimental set-ups and test equipment to investigate how different façade systems affect indoor climate conditions in school rooms and open plan offices. The group also conducts research into climate simulation and the monitoring of building user behavior, always maintaining a primary focus on the users' individual needs in addition to the physical factors of the building itself. The researchers also investigate user acceptance of new air-conditioning technologies

and the use of renewable energies. The goal is to achieve optimum comfort in buildings while consuming minimal amounts of energy and resources.

### Creating a good atmosphere

Outdoor climate has a significant impact on indoor climate. That's why it is essential to take a holistic, integrated approach toward planning new buildings and renovating existing buildings. The member institutes of the Fraunhofer Building Innovation Alliance work on strategies for configuring the indoor climate to reflect changes in the outdoor climate and to cater to the building's function, form, location and design. Examples include the passive use of solar energy, passive cooling and natural ventilation. Intelligent shading systems and well-chosen building insulation can also help to improve the indoor climate.

### New building designs require adapted climate designs

Creating innovative indoor spaces with maximum comfort and minimum energy consumption is a challenging task for planners. The objective of the 'People in Buildings' project group is to analyze the complex interplay between indoor climate and comfort in order to develop solutions that are fit for practical use. Its tasks also include the creation of performance-boosting work environments and healthy indoor spaces. In addition to their research in the field of buildings, the member institutes of the Fraunhofer Building Innovation Alliance also conduct research into different types of enclosed spaces such as vehicle passenger compartments and aircraft cabins.

### Participating Institutes

#### Fraunhofer IBP

Fraunhofer IAO

Fraunhofer ICT

Fraunhofer ISE

Fraunhofer Italia –  
Fraunhofer IEC

Fraunhofer UMSICHT

Fraunhofer WKI



# BUILDING AUTOMATION



## BUILDING AUTOMATION – IMPROVED QUALITY OF LIFE THROUGH SENSOR TECHNOLOGY

- IMPROVING THE PHYSICAL PROPERTIES OF BUILDINGS
- STRUCTURAL MONITORING
- ASSISTANCE SYSTEMS
- PLANNING AND UPDATING ELECTRONIC INFRASTRUCTURES
- FRONTLINE THEMES



Buildings and other structures need to be safe, energy-efficient and comfortable. These criteria – and many others besides – can be met using modern automation technologies. However, building automation systems require a dedicated infrastructure that must be taken into account right from the beginning of the planning phase. The ‘Building Automation’ project group carries out research and development activities which are designed to bridge the gap between architects and building engineers.

### Microprocessors continuing to gain ground

In the field of building automation, microprocessors are increasingly edging out traditional analog control systems. These are being replaced by integrated control and monitoring systems offering a much broader scope of functions. Although automation technologies offer clear benefits, it is not yet possible to include them in all projects since many clients are still put off by the high capital costs and comparatively complex planning requirements. The Fraunhofer Building Innovation Alliance actively promotes the exchange of information between architects and building engineers as part of its efforts to overcome the obstacles that exist in this area.

### Reducing energy consumption

The aim of building automation is to improve a building’s physical properties by using suitable technologies and by incorporating integrated control concepts. The goal is to reduce energy consumption and costs by intelligently controlling and monitoring the installed building services. Automated solutions that regulate heating, air conditioning systems and lighting based on demand are already in widespread use. Intelligent ventilation and shading solutions are a particularly energy-efficient option. For example, window monitoring systems can reduce the amount of heating and cooling energy consumed by up to 10 percent.

### New fields of application

Miniaturized sensor systems are steadily opening up new fields of application for building automation – for example in the area of structural monitoring. There are also plenty of new developments in the market segment for assistance systems, generally aimed at enabling the elderly and people in need of care to live independent, safe and comfortable lives for longer.

### Planning ahead

Since all automation systems operate on electricity and some are controlled via data cables, it is imperative to have the right infrastructure in place. Most new building projects still fail to take this aspect into account. By cooperating with everyone involved in the construction project and planning ahead, it is possible to avoid the expense and complexity of having to retrofit this infrastructure at a later point in time. In refurbishment projects aimed at improving energy efficiency, the power and network connections required for building automation can be included at minimal additional cost.

### The buildings of the future are intelligent

Most of the systems that have reached market maturity to date are automated control and monitoring systems for building services. However, there is also a huge amount of market potential in intelligent solutions from the fields of entertainment, security and comfort. The ‘Building Automation’ group conducts intensive research into the interactions between active and passive indoor environments. It also aims to combine innovative building materials with microelectronic components in order to create new functions.

### Participating Institutes

#### Fraunhofer IMS

Fraunhofer IBP

Fraunhofer ISE

Fraunhofer Italia –  
Fraunhofer IEC

Fraunhofer IZFP

Fraunhofer USA –  
Fraunhofer CSE



# SAFETY AND SECURITY

## SAFETY AND SECURITY BY DESIGN

- SAFE BUILDING MATERIALS
- MEMBRANE FAÇADES
- MULTIFUNCTIONAL MODULES
- LOW-COST SHELTERS



Natural disasters and terrorist attacks often cause buildings to collapse. The risk of collapse can be significantly reduced by forward-looking building planning and the use of innovative building materials. With this aim in mind, seven member institutes of the Fraunhofer Building Innovation Alliance came together to form the 'Safety and Security' project group. In addition to issues of disaster prevention (security) the group also investigates normal loading as it applies to buildings (safety).

### Safety starts with materials

Researchers are particularly interested in building materials that are capable of absorbing the shockwaves of an earthquake or explosion thanks to their high energy absorbing capacities. One such material is polymer concrete, which contains porous organic filler reinforced with fibers. Its high pore volume enables this building material to significantly reduce the destructive effects of detonations.

### Protective second skin for buildings

With the aim of providing buildings with more reliable protection against damage caused by short-duration dynamic events, researchers are also working on the development of membrane façades which are designed to be placed in front of a building's actual façade. As well as providing a climate-regulating envelope around the building that can be used to fulfill building physics requirements, these kinds of membrane façades also dampen the effect of impact and pressure loads. They are designed to allow partial perforation during a dynamic event in order to reduce the extreme force of a blast on the supporting structure. Textile outer façades can be used as explosion and splinter shields for buildings considered to be at particular risk such as embassies, government buildings and police stations.

### Versatile solutions

The group also conducts research into modular systems solutions which can be tailored or retrofitted for a wide range of different applications. Examples include mobile sound insulation

units which can be converted into what are known as blast protection systems. Originally conceived as soundproofing solutions for temporary sources of noise, these components can be filled with water or heavy materials and transformed into safety barriers to combat the risk of explosions. Specially developed support structures keep the barriers firmly in place in the event of a detonation. Researchers are also investigating ways of combining blast protection systems with bullet-proof fiber composite materials.

### Mobile shelters for disaster areas

The project group has been commissioned to develop low-cost shelters designed to ensure the safety of military and civilian personnel on national and international deployments. Thanks to their modular design, these can be assembled into a shell from a small number of lightweight, air-transportable components and filled with locally available materials such as soil, thereby creating a robust and durable building envelope.

### Protection that offers additional design options

The 'Safety and Security' project group aims to combine safety and security aspects with building insulation solutions and architectural design in order to create multifunctional building components. Currently, researchers are working on printable membrane façades which protect and insulate the building as well as having a design function.

### Participating Institutes

#### Fraunhofer EMI

Fraunhofer IBP

Fraunhofer ICT

Fraunhofer IFAM

Fraunhofer IWM (Halle)

Fraunhofer IZFP

Fraunhofer WKI



# ENERGY SUPPLY SYSTEMS

## ENERGY SUPPLY SYSTEMS – EFFICIENT, ENVIRONMENTALLY FRIENDLY, SUSTAINABLE

- ENERGY SAVINGS IN BUILDINGS
- PHOTOVOLTAIC AND SOLAR THERMAL TECHNOLOGIES
- COMBINED HEAT AND POWER



Buildings are one of the biggest consumers of energy worldwide. Any efforts to decrease the use of fossil fuels over the long term and reduce environmental pollution must therefore include solutions that address the supply of energy to buildings. In collaboration with industry partners, the 'Energy Supply Systems' project group develops innovative technologies and concepts to help achieve these objectives, focusing in particular on energy efficiency, economic efficiency and user comfort.

### Areas of research

Key areas of research include solar power using photovoltaic and solar thermal systems, solar heating and cooling, cogeneration (combined heat and power) and trigeneration (combined cooling, heat and power), cooling and thermal energy storage, sorptive systems and building-integrated solar and air-conditioning technologies. The participating Fraunhofer institutes also conduct research in the fields of energy management, building management, and energy supply strategies for cities and residential quarters.

### Foundations for intelligent energy concepts

As a general rule, the only way to fully exploit potential energy savings is to develop a suitable energy concept right from the planning stage. This applies to new buildings as well as to projects aimed at improving the energy efficiency of existing buildings. In the case of existing building stocks, it is essential to carry out an efficient and accurate assessment of the building's current situation in order to plan and implement the necessary measures as precisely and efficiently as possible. Particular attention must be paid to the complex interactions between the physically determined energy requirements of the building and the energy efficiency of the installed building services in order to find the optimum combination of passive and active technologies.

### Renewable technologies

A number of different photovoltaic and solar thermal technologies may be worth considering for a building's heat and power supply. High efficiencies can be achieved by generating energy with cogeneration or trigeneration systems in combination with thermally driven heat pumps. By incorporating small Stirling engines, gas turbines or fuel cells, it is even possible to set up the heating systems of particularly efficient buildings without requiring a costly reserve heating system. The use of biomass to generate heat is also becoming increasingly widespread and offers a useful means of improving a building's CO<sub>2</sub> footprint. Another technology that offers the potential to improve energy efficiency is the monoenergetic operation of a heat pump together with auxiliary electrical heating. In combination with a solar thermal system, it is possible to achieve a high degree of sustainability for building services.

### Sustainable energy concepts require planning and cooperation

Using existing technologies and products, it is already possible to achieve cost and resource efficient implementation of renewable energy systems. Nonetheless, the system's efficiency is influenced by many different factors. The 'Energy Supply Systems' project group therefore takes an integrated approach in which all the different aspects are viewed in the context of the entire value chain – from basic research to market launch and from material development to building operation. It also places a strong emphasis on the interdisciplinary transfer of knowledge between developers, building engineers, architects and construction firms.

### Participating Institutes

#### Fraunhofer ISE

Fraunhofer IBP

Fraunhofer ISC

Fraunhofer Italia –  
Fraunhofer IEC

Fraunhofer IVV

Fraunhofer IZFP

Fraunhofer UMSICHT

Fraunhofer USA –  
Fraunhofer CSE



# SUSTAINABLE QUARTERS

## SUSTAINABLE QUARTERS – ENERGY EFFICIENT AND LIVABLE

- DESCRIPTION AND EVALUATION OF SUSTAINABILITY IN URBAN DEVELOPMENT
- CRITERIA FOR MAKING SUSTAINABLE QUARTERS MORE LIVABLE IN SOCIAL AND ENVIRONMENTAL TERMS
- LIFE CYCLE ASSESSMENT SOFTWARE
- CONCEPT OF THE ELECTROMOBILE CITY
- URBAN INNOVATION MANAGEMENT



Sustainable quarters require us to take a holistic, integrated view – from planning to demolition.

Sustainably built residential developments are superior to conventional residential construction projects over the long term in regard to environmental, economic and socio-cultural criteria. The 'sustainable quarters' project group draws together all the key topics from the building sector in order to provide support to urban planners and the building industry in all areas of sustainable residential construction.

### Holistic view

The participating Fraunhofer institutes develop models, methods and tools which can be used to describe and assess the sustainability of urban development projects. The group's research topics cover the entire building life cycle from construction and usage to demolition and disposal. The researchers take a holistic, integrated view of all the different levels of the building sector, i.e. products, buildings and settlement structures. Their findings are used as a basis for designing sustainable quarters that are more livable in both social and environmental terms.

### Areas of research

Key fields of research include the intelligent use of space and energy-efficient, low-emission construction. Other important topics include the utilization of renewable energies and recycled materials. The project group's researchers are also engaged in work on the integrated management of fresh water and water for domestic use on a quarter level, the implementation of innovative mobility concepts, and the creation of eco-niches that benefit both people and nature.

### Making savings through sustainable building

Integrated planning processes pay for themselves: For example, the integrated use of life cycle assessment software makes it possible to identify energy weak points at a much earlier stage. It also facilitates comparisons of different building designs and materials. That improves the building's life cycle and helps to cut costs.

*Distributed energy storage is a key component of sustainable residential developments.*

### A great point of contact for new urban systems

The creation of sustainable quarters is typically thwarted by time and cost pressures, insufficient information and a lack of communication between the people involved. By publishing its research results and developing suitable tools and instruments, the Fraunhofer Building Innovation Alliance has established itself as an expert partner for sustainable construction. It works together with industry partners to implement comprehensive assessment and solution models. Examples include the concepts developed by its researchers for the 'electromobile city'. Its portfolio also includes urban innovation management for the integration of a range of urban systems as well as user analyses and behavioral studies in relation to urban processes.

### Building better cities together

The buildings of the future will no longer be independent, isolated structures. Instead, they will be closely integrated with their environment in terms of their design, function and infrastructure. The Fraunhofer Building Innovation Alliance is driving this process forward with its continuing commitment to basic research and the development of practical design concepts for urban planners and the building industry.

### Participating Institutes

#### Fraunhofer IBP

Fraunhofer IAO

Fraunhofer IGB

Fraunhofer ISE

Fraunhofer Italia –  
Fraunhofer IEC

Fraunhofer UMSICHT

Fraunhofer WKI



# INTERNATIONALIZATION



## INTERNATIONALIZATION – TEAMWORK FOR GLOBAL SUCCESS

- MEGATREND URBANIZATION
- CONSULTING ON INTERNATIONAL CONSTRUCTION PROJECTS
- BUILDING IN DIFFERENT CLIMATE ZONES
- INTERNATIONAL CONTACTS



Continuing population growth and urbanization are leading to an increase in worldwide building activity. This poses a dilemma for urban planners who are expected to quickly and cheaply produce enough infrastructure while simultaneously making careful use of scarce resources such as development areas, water and energy. The 'Internationalization' project group coordinates the Fraunhofer Building Innovation Alliance's international research and development activities to help find solutions to these complex issues.

### Growing cities

The world's population is predicted to increase from the current figure of 6 billion to somewhere around 9 billion by 2050. In just 15 years time, it is expected that some two thirds of the global population will be living in cities. To keep pace with these developments, approximately two thirds of the world's cities will need to be replanned and rebuilt over the next 20 years. This will throw up many challenges for urban planners, some of which are mutually incompatible. For example, new buildings need to be as energy-efficient, environmentally friendly and safe as possible – but, at the same time, the decision-making processes are increasingly being affected by the pressure of tight deadlines and limited budgets.

### Customized solutions

The only way to satisfy all the requirements of modern urban development is to integrate all aspects of sustainable and resource-oriented construction right from the planning phase. To help achieve this, the 'Internationalization' project group of the Building Innovation Alliance has clustered all the relevant skills required for this process with the goal of facilitating a holistic, fully integrated approach. Instead of restricting itself solely to German expertise, the Building Innovation Alliance has consciously committed itself to exchanging knowledge with international partners and its own research institutes in other countries. This paves the way for customized solutions tailored to specific local situations while continuing to provide access to tried-and-tested analysis methods and tools.

### Conditions vary from country to country

The fastest-growing and most innovative markets of the future are not in Europe, but, predominantly, in Asia. This means that European companies embarking on projects further afield will increasingly be faced with a range of unfamiliar conditions and constraints. By collaborating with the Fraunhofer Building Innovation Alliance – for example by conducting simulations and field trials – these companies can prepare themselves thoroughly for the climatic conditions and effects they will encounter on the construction project. This gives companies a decisive competitive edge which can help them to establish a successful presence in new markets.

### Tapping into new markets together

As well as its expertise in the field of research and development, the Fraunhofer Building Innovation Alliance is also determined to continue expanding its global presence and portfolio of services. To achieve this, it is increasingly striving to strengthen its ties with public and private decision-makers and investors on an international level. At the same time, the Alliance is continuing to provide targeted support to its customers in entering new markets and acquiring new projects. It offers a broad range of services, including identifying future markets, conducting studies and market analyses, carrying out research contracts, and establishing links to project partners abroad.

### Participating Institutes

#### Fraunhofer-Gesellschaft

Fraunhofer IAO

Fraunhofer IBP

Fraunhofer ISE

Fraunhofer Italia –  
Fraunhofer IEC

Fraunhofer IZFP

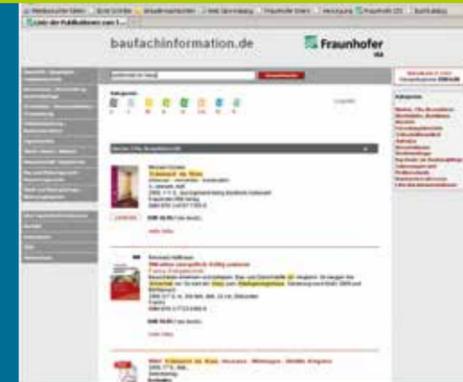
Fraunhofer USA –  
Fraunhofer CSE



# FRAUNHOFER IRB

## FRAUNHOFER IRB – ACCUMULATED KNOWLEDGE FOR THE BUILDING INDUSTRY

- EXPERT INFORMATION ON PLANNING AND BUILDING
- THREE SPECIALIST PORTALS
- BUILDING AND CONSTRUCTION DATABASES
- PUBLISHING: FRAUNHOFER IRB VERLAG AND FRAUNHOFER VERLAG



Research results are only useful if they are made easily available within a short time frame. The Fraunhofer Information Center for Planning and Building IRB collects relevant information on building and construction and makes it available to a broad range of experts and specialists. By helping to avoid parallel and redundant developments in the areas of both research and professional practice, the Fraunhofer IRB offers valuable support in improving building and planning services.

### Fraunhofer IRB knowledge pool

The key mission of the Fraunhofer IRB is to compile and provide access to scientific and practical specialist information from all fields of planning and building. To achieve this, it draws on its numerous partnerships with relevant expert institutions and associations, research institutes and specialist publishing houses. The information can either be accessed by conducting a search in one of the numerous databases or can be acquired as a print version from the institute's own publishing house. Many publications can also be downloaded as digital documents.

### Easy to find

The Fraunhofer IRB offers three specialist portals which cover the topics of urban and spatial planning, historic monument conservation and construction research. In addition, the Fraunhofer IRB runs its own building and construction databases and hosts additional databases belonging to its partners. These include full text, reference, research and address databases. Two bibliographic databases that are particularly important in this field are the RSWB® and ICONDA® databases, which provide access to national and international specialist literature. In addition, the Fraunhofer IRB full-text database SCHADIS® offers up-to-date expert knowledge from specialist publications, research reports and journal articles covering all conceivable topics related to building damage. The portal [www.baufachinformationen.de](http://www.baufachinformationen.de) provides access to key specialist information from the full range of databases to a broad range of industry experts.

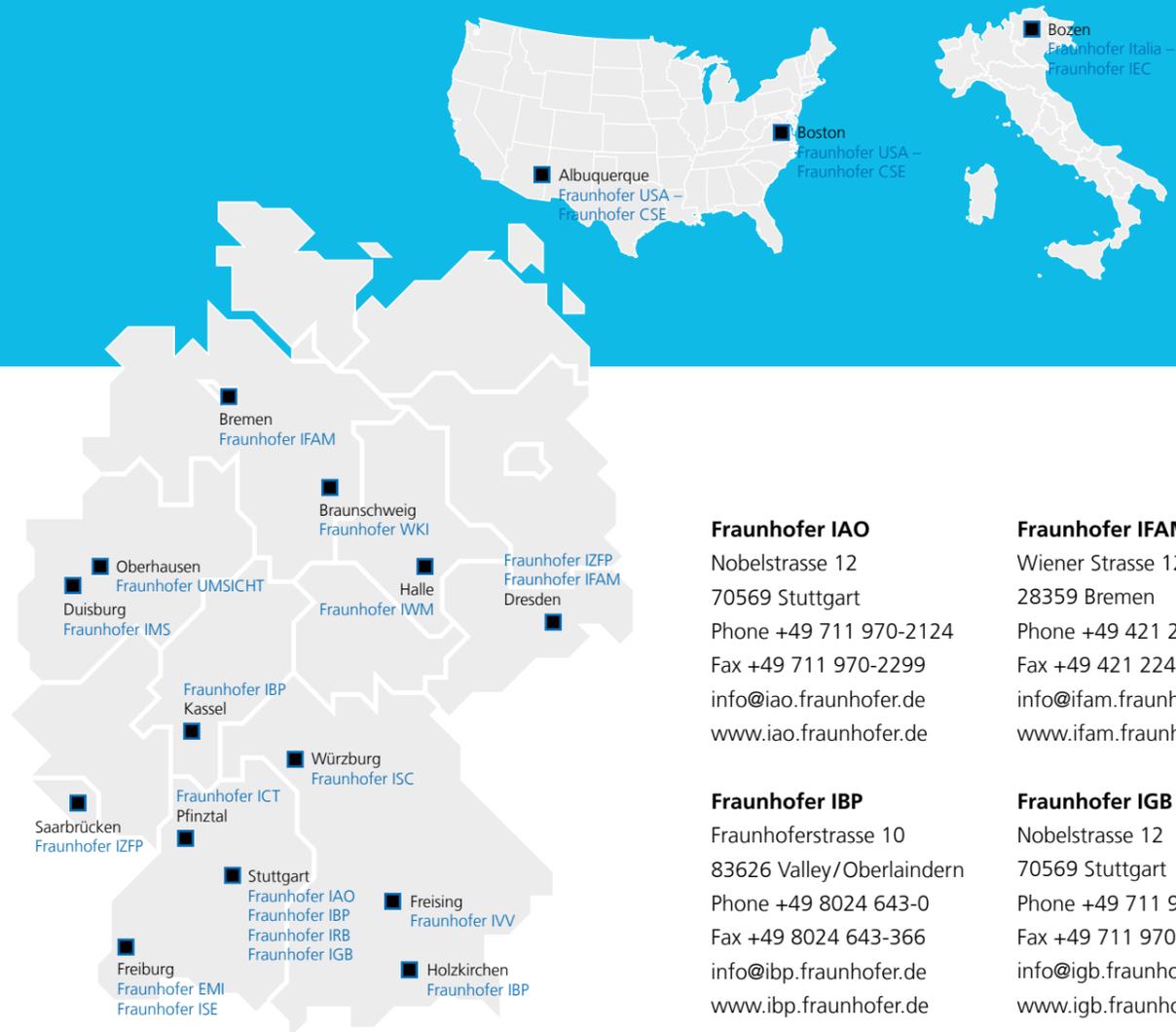
### In-house publications

The Fraunhofer IRB's in-house publishing operation (Fraunhofer IRB Verlag) is one of the most respected building trade publishing houses in the German-speaking world, offering a wide variety of publications from the fields of construction work in existing buildings, structural engineering, renovation and refurbishment, building physics, and building research. Its list of publications, which is available on request, currently comprises more than 4000 research reports, approximately 400 specialist books and four specialist journals. This is in addition to the 15,000 international building research documents and approximately 900 publications from interdisciplinary research areas within the Fraunhofer-Gesellschaft which have been published by the Fraunhofer Verlag since 2009.

### A world of information on building

Thanks to its close links to database research tools and specialist publishing houses, the Fraunhofer IRB has become the central point of reference for anyone seeking information on topics related to building and construction. Recent figures confirm this, with an average of 25,000 users visiting the web portal each day in the year 2009 alone. A total of 320,000 documents were downloaded from the Fraunhofer IRB's databases over the course of 2010. The Fraunhofer IRB makes an active contribution towards promoting the transfer of knowledge within the building industry, thereby helping to strengthen the expertise and innovative capabilities of the Fraunhofer Building Innovation Alliance.

# ADDRESSES



**Fraunhofer EMI**  
Eckerstrasse 4  
79104 Freiburg  
Phone +49 761 2714-0  
Fax +49 761 2714-316  
info@emi.fraunhofer.de  
www.emi.fraunhofer.de

**Fraunhofer ICT**  
Joseph-von-Fraunhofer-Strasse 7  
76327 Pfinztal  
Phone +49 721 4640-392  
Fax +49 721 4640-111  
info@ict.fraunhofer.de  
www.ict.fraunhofer.de

**Fraunhofer IMS**  
Finkenstrasse 61  
47057 Duisburg  
Phone +49 203 3783-0  
Fax +49 203 3783-266  
info@ims.fraunhofer.de  
www.ims.fraunhofer.de

**Fraunhofer IAO**  
Nobelstrasse 12  
70569 Stuttgart  
Phone +49 711 970-2124  
Fax +49 711 970-2299  
info@iao.fraunhofer.de  
www.iao.fraunhofer.de

**Fraunhofer IBP**  
Fraunhoferstrasse 10  
83626 Valley/Oberlaindern  
Phone +49 8024 643-0  
Fax +49 8024 643-366  
info@ibp.fraunhofer.de  
www.ibp.fraunhofer.de

**Fraunhofer IFAM**  
Wiener Strasse 12  
28359 Bremen  
Phone +49 421 2246-0  
Fax +49 421 2246-300  
info@ifam.fraunhofer.de  
www.ifam.fraunhofer.de

**Fraunhofer IGB**  
Nobelstrasse 12  
70569 Stuttgart  
Phone +49 711 970-4401  
Fax +49 711 970-4200  
info@igb.fraunhofer.de  
www.igb.fraunhofer.de

**Fraunhofer IRB**  
Nobelstrasse 12  
70569 Stuttgart  
Phone +49 711 970-2500  
Fax +49 711 970-2508  
info@irb.fraunhofer.de  
www.irb.fraunhofer.de

**Fraunhofer ISC**  
Neunerplatz 2  
97082 Würzburg  
Phone +49 931 4100-0  
Fax +49 931 4100-199  
info@isc.fraunhofer.de  
www.isc.fraunhofer.de

**Fraunhofer ISE**  
Heidenhofstrasse 2  
79110 Freiburg  
Phone +49 761 4588-0  
Fax +49 761 4588-9000  
info@ise.fraunhofer.de  
www.ise.fraunhofer.de

**Fraunhofer IVV**  
Giggenhauser Strasse 35  
85354 Freising  
Phone +49 8161 491-0  
Fax +49 8161 491-555  
info@ivv.fraunhofer.de  
www.ivv.fraunhofer.de

**Fraunhofer IWM**  
Walter-Hülse-Strasse 1  
06120 Halle (Saale)  
Phone +49 345 5589-0  
Fax +49 345 5589-101  
info@iwm.fraunhofer.de  
www.iwm.fraunhofer.de

**Fraunhofer IZFP**  
Campus E3 1  
66123 Saarbrücken  
Phone +49 681 9302-0  
Fax +49 681 9302-5935  
info@izfp.fraunhofer.de  
www.izfp.fraunhofer.de

**Fraunhofer LBF**  
Bartningstrasse 47  
64289 Darmstadt  
Phone +49 6151 705-0  
Fax +49 6151 705-214  
info@lbf.fraunhofer.de  
www.lbf.fraunhofer.de

**Fraunhofer UMSICHT**  
Osterfelder Strasse 3  
46047 Oberhausen  
Phone +49 208 8598-0  
Fax +49 208 8598-1290  
info@umsicht.fraunhofer.de  
www.umsicht.fraunhofer.de

**Fraunhofer WKI**  
Bienroder Weg 54 E  
38108 Braunschweig  
Phone +49 531 2155-0  
Fax +49 531 351587  
info@wki.fraunhofer.de  
www.wki.fraunhofer.de

**Fraunhofer-Gesellschaft**  
Hansastrasse 27 c  
80686 München  
Phone +49 89 1205-0  
Fax +49 89 1205-7531  
info@fraunhofer.de  
www.fraunhofer.de

**Fraunhofer Italia –  
Fraunhofer IEC**  
Schlachthofstrasse 57  
39100 Bozen, Italien  
Phone +39 0471 1966900  
Fax +39 0471 1966949  
info@fraunhofer.it  
www.fraunhofer.it

**Fraunhofer USA –  
Fraunhofer CSE**  
25 First Street  
Cambridge, MA 02141, USA  
Phone +1 617 575-7250  
Fax +1 617 588-0618  
info@cse.fraunhofer.de  
www.cse.fraunhofer.de

'The Fraunhofer Building Innovation Alliance was developed by the Fraunhofer-Gesellschaft as a means of pooling its skills and expertise in the building sector and offering a professional point of contact for the building industry. It is a key contact partner for integrated systems solutions in the building and construction arena and also acts as a barometer and incubator of innovative solutions and new topics in the world of construction research.'

*Andreas Kaufmann, managing director of the Fraunhofer Building Innovation Alliance*



**Fraunhofer Building Innovation Alliance**

**c/o Fraunhofer Institute for Building Physics IBP**

Fraunhoferstrasse 10 | 83626 Valley

Phone +49 8024 643-240

Fax + 49 8024 643-366

info@bau.fraunhofer.de

www.bau.fraunhofer.de

**Managing director of the Fraunhofer Building Innovation Alliance**

Andreas Kaufmann | andreas.kaufmann@ibp.fraunhofer.de

**Management assistant**

Astrid Achatz | astrid.achat@ibp.fraunhofer.de

**Press officer of the Fraunhofer Building Innovation Alliance**

Janis Eitner | presse@bau.fraunhofer.de

**Chairman of the Fraunhofer Building Innovation Alliance**

Prof. Dr.-Ing. Klaus Sedlbauer | klaus.sedlbauer@ibp.fraunhofer.de

**Deputy Chairman of the Fraunhofer Building Innovation Alliance**

Prof. Dr. Peter Elsner | peter.elsner@ict.fraunhofer.de