

# Empa in a Nutshell



**Empa**

Materials Science and Technology

# VISION

# Materials and Technologies for a Sustainable Future

# MISSION

## Empa – The Place where Innovation Starts

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Empa conducts cutting-edge materials and technology research, generating interdisciplinary solutions to help overcome major challenges faced by industry, and creates the necessary scientific basis to ensure that our society develops in a sustainable manner.

Together with partners from industry, Empa turns research results into marketable innovations. In doing so, Empa makes a significant contribution to enhancing the innovative power and international competitiveness of the Swiss economy.

As an institution of the ETH Domain, Empa is committed to excellence in all its activities.





# WHO WE ARE

## Empa – Kick-Starting Innovation in Switzerland

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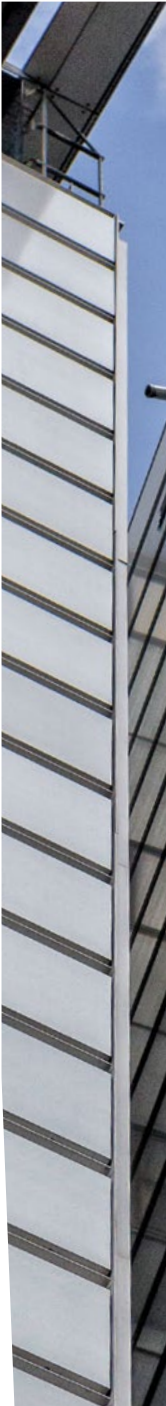
As an interdisciplinary research institute of the ETH Domain, Empa, the Swiss Federal Laboratories for Materials Science and Technology, conducts cutting-edge materials and technology research. Empa's R&D activities focus on meeting the requirements of industry and the needs of society, and thus link applications-oriented research to the practical implementation of new ideas in the areas of nano-structured, "smart" materials and surfaces, environmental, energy and sustainable building technologies as well as biotechnology and medical technology. As a result, Empa is capable of providing its partners with customized solutions that not only enhance their innovative edge and competitiveness, but also help to improve the quality of life for the public at large, true to its mission statement: Empa – The Place where Innovation Starts.

### Research Focus Areas

- Nanostructured Materials
- Sustainable Built Environment
- Health and Performance
- Natural Resources and Pollutants
- Energy

### Research and Technology Transfer Platforms (RTTPs)

- NEST
- move
- ehub
- dhub
- Coating Competence Center (Center for Advanced Manufacturing Technologies)





# NANOSTRUCTURED MATERIALS

## Engineering at an Atomic Level

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Advanced materials with improved and /or novel properties are a prerequisite for most technological innovations and mandatory to meet the increasing demands of a growing global population in areas such as energy, the environment and personal health. The most promising approach for the development of novel materials and manufacturing processes is nanotechnology.

Nanostructured materials and devices exploit physical phenomena and properties that cannot be derived by simply scaling down the associated macroscopic structures – so “nano” is more than just another step of miniaturization. Tackling nanoscale phenomena in the context of materials science and development means pushing the physical and technological limits. Rationalizing and explaining these effects will yield results and insights, which are essential for the successful development of nanomaterials and -technologies.

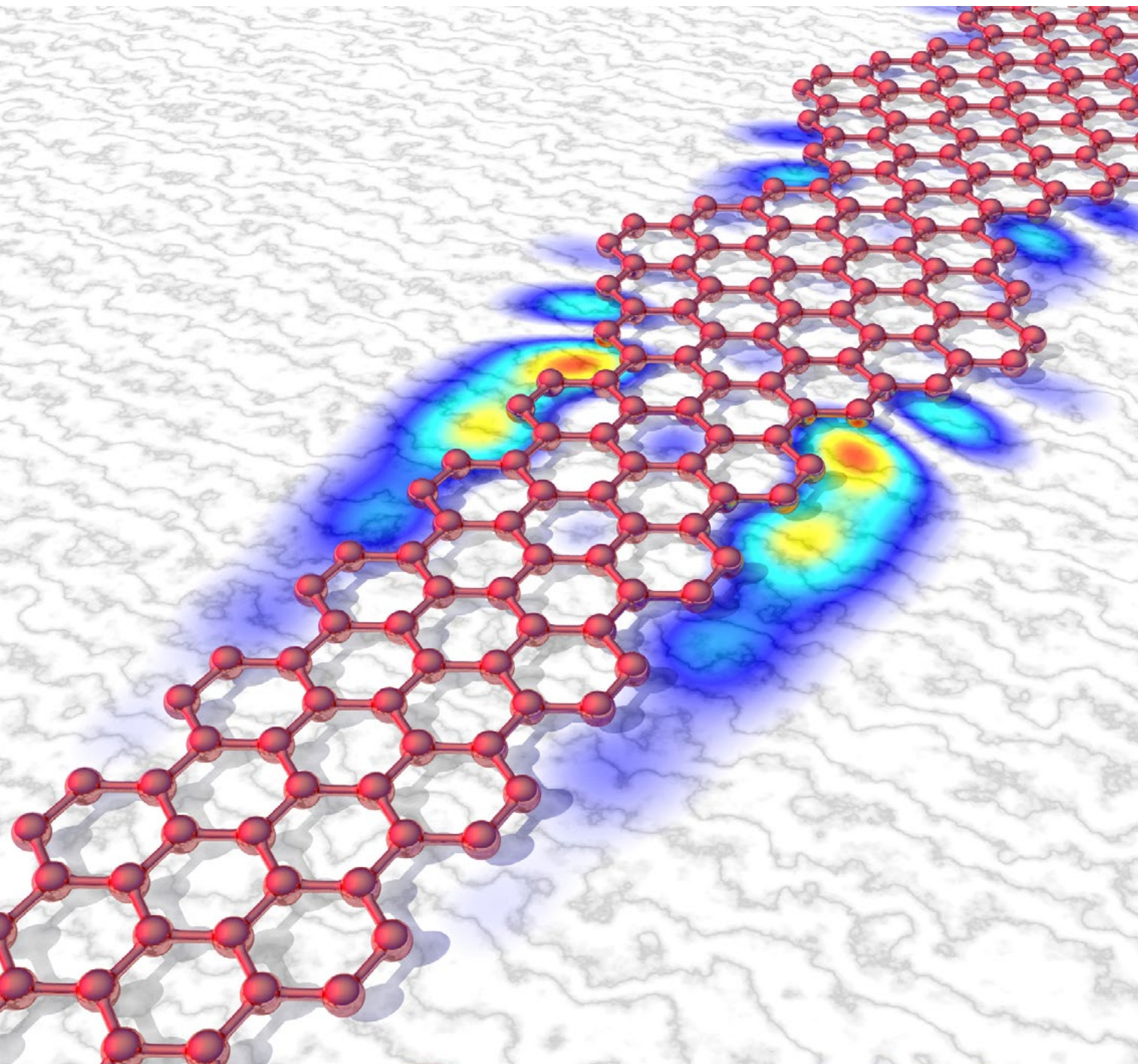
The physical properties of nanostructured materials and coatings are based on complex and subtle interactions of their nanoscale components, in particular at their interfaces. There are limits to the extent, to which experimental methods can be used for investigating and developing such materials. Therefore, computational material science, including modelling, simulation and materials design algorithms, is becoming a mandatory tool for the development and testing of nanostructured materials and devices.

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# SUSTAINABLE BUILT ENVIRONMENT

## Practical Solutions with an Added Value for Society

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The quality of our built environment is a key factor for a truly sustainable society. This includes high-quality and affordable living and working space, networks for transportation of people and goods and a reliable distribution of energy, water and information.

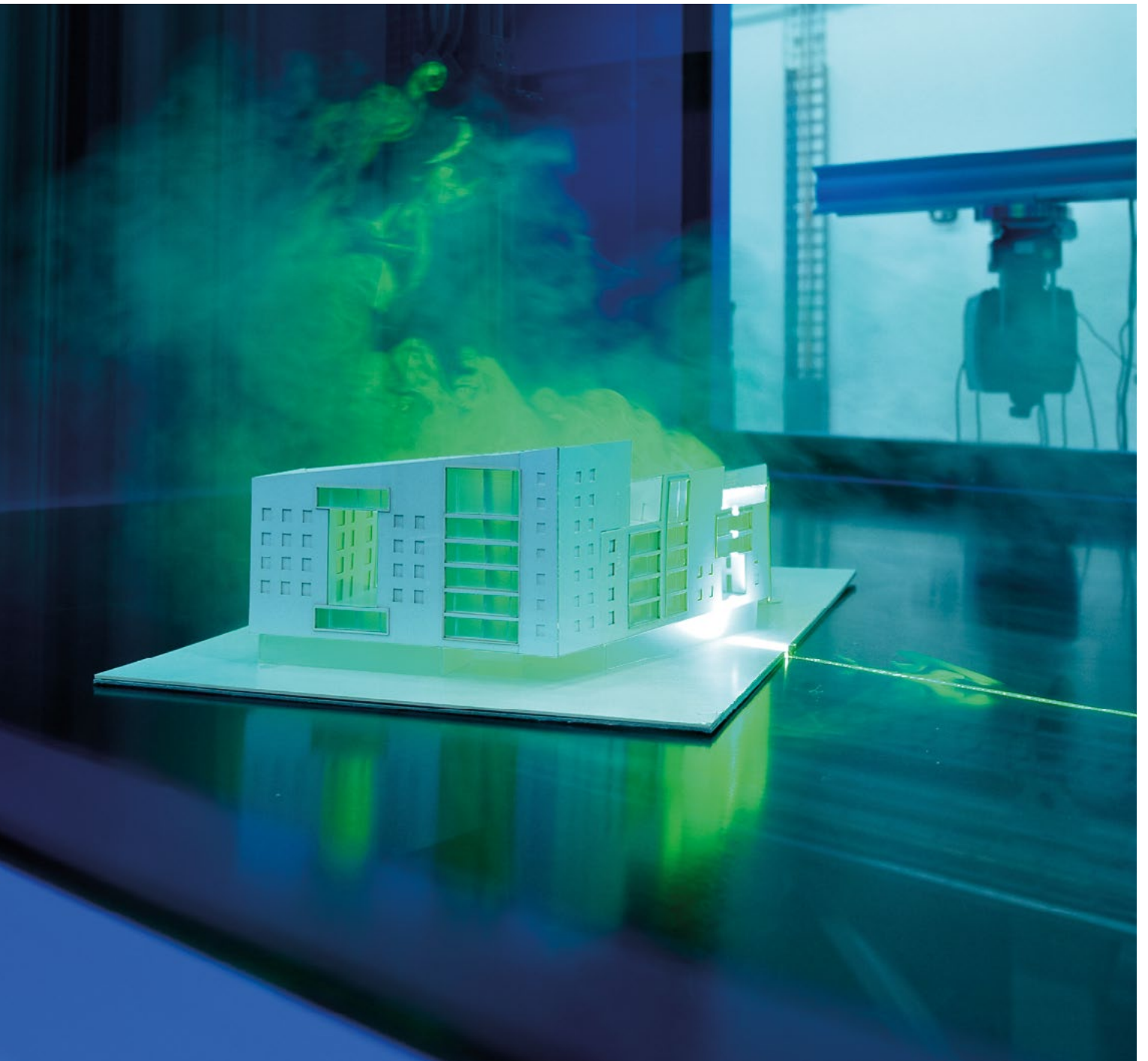
At Empa research is carried out at different levels, starting from the development of new materials to the design of advanced systems and their integration into buildings and structures. Furthermore, we also look at entire cities and their interaction with the environment. Key issues at all levels are the minimization of the environmental footprint and the enhancement of comfort and safety offered by the built environment to its users.

Technology transfer to industry is fostered by large-scale demonstration projects. In both the construction and energy sector it is nowadays extremely challenging to quickly bring new ideas and products to the market. High investment costs inhibit the companies' risk propensity. Under the leadership of the two research institutes Empa and Eawag, the experimental building NEST is being built on their joint campus in Dübendorf. This novel guesthouse, which opened its doors in 2016, aims at accelerating the market entry of new construction materials and building technology innovations. NEST offers researchers and research-driven companies the opportunity to test new technologies in full-scale; innovative materials and systems can thus be implemented, monitored and optimized/developed further under real-world conditions.

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# HEALTH AND PERFORMANCE

## Innovative Materials for Medical Applications

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Protecting people, promoting good health in a sustainable manner, maintaining and improving our quality of life and physical constitution – these are and will remain major challenges, especially in light of our increasing life expectancy. In the Research Focus Area “Health and Performance”, Empa pools its interdisciplinary expertise in the fields of textiles, material science, biology and nanotechnology. Empa’s Scientists focus on the development of materials for medical applications in and on the human body, and investigate and develop materials and new systems that protect and support us in our daily lives. Moreover, they closely examine and analyze the safety of new materials and develop new methods to study this in biological systems.

Some of the questions Empa scientists address are: which materials are suitable to maintain human health or even restore it? Which products improve the quality of life or safety for elderly people? How can we improve performance in sport or under extreme conditions? How can we functionalize fibers and textiles to give them specific properties? Can we guarantee the safety of new materials in future? And how can we test this accurately – do we need novel assay systems?

Empa develops, for instance, novel flexible sensors that are comfortable to wear and can be incorporated into clothing and accessories such as T-shirts or smart watches. This will make it possible to reliably measure physiological data such as blood pressure, pulse rate, cardiac currents and body temperature, even if people are in motion. With partners from industry Empa developed an antimicrobial coating for hip implants, which also supports and accelerates integration into the bone.

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# NATURAL RESOURCES AND POLLUTANTS

## Technology Development in Tune with the Environment

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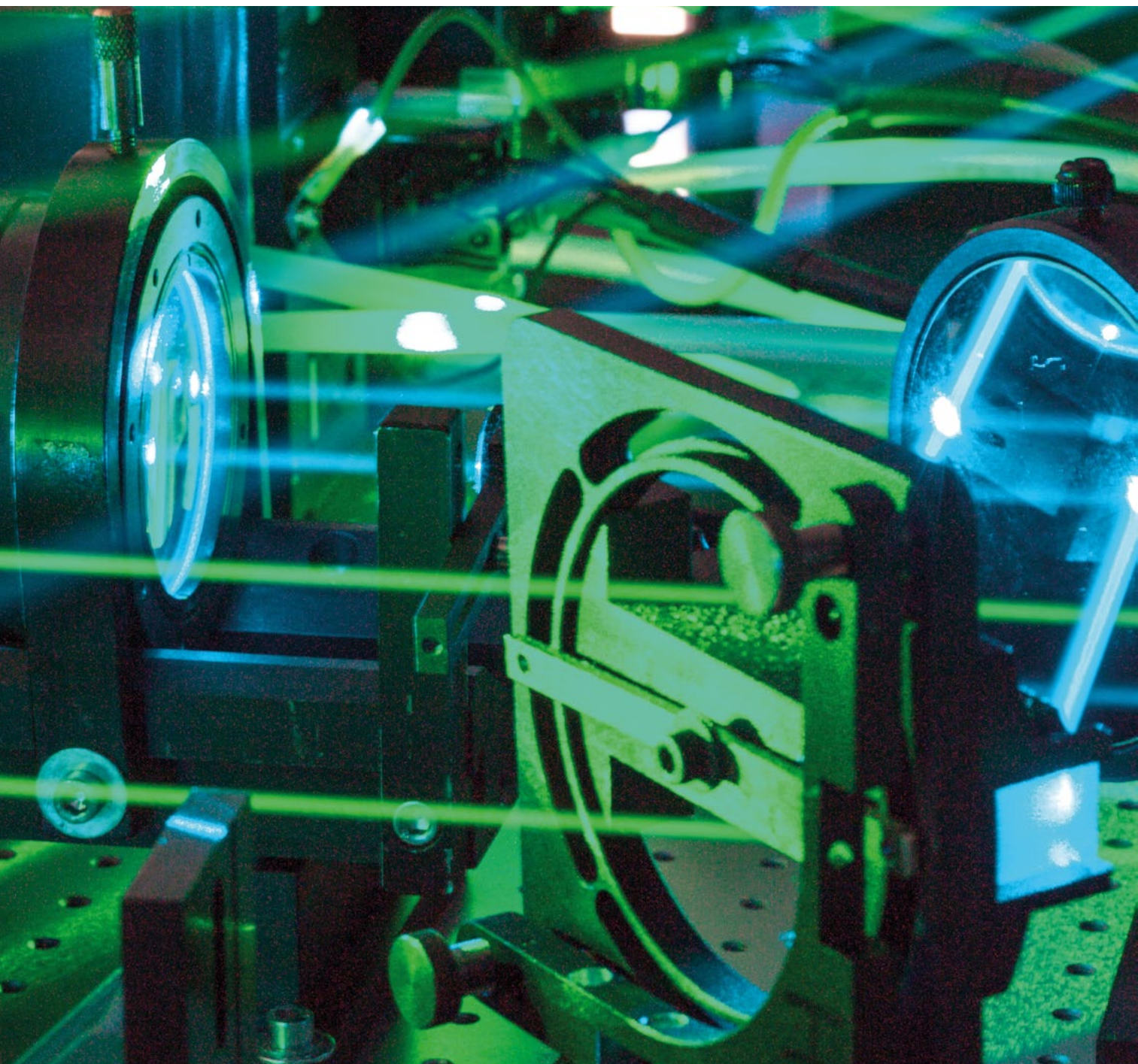
Every society requires raw materials and energy to fulfil its basic needs, for example heating or cooling buildings, individual mobility, food and goods for everyday life, or to make its dreams come true. Empa wants to make a contribution to a society that uses fewer natural resources and produces fewer pollutants than at present. Through its research activities, Empa lays the foundations for a better understanding of the fundamental physical and chemical processes. Empa scientists develop innovative technical solutions for the sustainable use of our natural resources and in order to minimize the impact on the environment caused by process emissions.

Empa scientists therefore study key processes like individual mobility, industrial production and material flows. Many of the substances released through these processes, e.g. greenhouse gases, volatile organic compounds or (nano)particles, make their way to the environment. We investigate the distribution of these pollutants on different scales, from local to global dissemination. The institute also carries out research into new ways and means of reducing the impact on our environment, whether through innovative exhaust gas cleaning, recycling or technical innovations in processing. The demonstrator for the mobility of the future – move – is an example of how renewable electricity can be used for mobility – in the form of hydrogen, synthetic methane and grid batteries.

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## Energy Research – Options for a Sustainable Future

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Satisfying our energy demand in an environmentally and climate-friendly way is an enormous challenge. Our energy consumption is constantly rising and all too often its production is harmful for the environment and the Earth's climate. The Research Focus Area "Energy" combines all research activities on new materials, technologies, models and concepts that create options for a sustainable energy future.

On the one hand, for instance, Empa investigates technologies for energy-efficient buildings and sustainable mobility to reduce the ever increasing energy demand in these sectors. On the other hand, our researchers also develop various forms of photovoltaics (PV) and new conversion and storage technologies to keep guaranteeing the energy supply in a reliable and environmentally friendly manner. However, the generation, distribution and consumption of energy doesn't just take place in isolated units such as individual buildings or vehicles but also in larger systems like neighborhoods or entire cities. As a consequence Empa scientists also model and calculate energy flows in these complex systems.

Obtaining, storing, converting and transporting renewable energies and using them efficiently should be sustainable from their generation to their disposal. Therefore, we also conduct life-cycle assessments (LCA) and study the environmental impact of research projects in a holistic way.

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## Building the Future Together

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In the construction and energy sector, launching new products and technology on the market quickly is easier said than done. Low energy prices, long investment periods and no end of red tape make companies and investors think twice about taking the plunge. Nowadays, there is often a huge gap between technologies that work in the lab and the market, which demands reliable, well-engineered products. NEST closes this gap and expedites the innovation process in the field of building technologies.

Empa and Eawag's modular research and innovation building consists of a central "backbone" and three open platforms as well as modules – referred to as "research and innovation units" – that can be installed on the platforms based on the "plug-and-play" principle. People live and work in these units, which double up as bustling experimental laboratories where new technologies, materials and systems are tested, researched and developed further under real-life conditions.

The close cooperation between partners from research, industry and the public sector means that innovative building and energy technologies are brought to market faster.

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## Mobility of the Future

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Sustainable mobility means significantly lowering the use of fossil and nuclear energy sources as well as CO<sub>2</sub> emissions. One opportunity to do just that is offered by converting renewable electricity that cannot be used on the electricity market into storable energy carriers such as hydrogen or methane. These can then be used as fuels for transporting passengers as well as goods. The share of this kind of electricity is already considerable.

In move, the “Future Mobility Demonstrator”, Empa shows in collaboration with partners from research, industry and the public sector how the mobility of the future could look like. Efficiency increases on the one hand and the flexibilization of the electricity system by means of storing and /or converting electricity into hydrogen and methane on the other are central factors for the future energy system. move combines various vehicles with different powertrain concepts.

E-mobility is highly efficient but is not very flexible in terms of electricity use. In summer it helps to reduce the share of unusable renewable electricity, but in the winter months it is dependent on fossil fuels for generating electricity. Combustion engines are less efficient than electrical motors, but they can be operated all year round on methane produced from renewable electricity that cannot be used on the electricity market. Hydrogen-powered fuel-cell cars are somewhere in between in terms of efficiency and flexibility. On the whole, these concepts complement each other and, taken together, offer the greatest benefit for a sustainable energy system.

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move

move | Empa



←  
Lobby / Besucher Service  
Einkaufs Nord  
Warenannahme  
Schulhaus 1 und 2  
Teilnehmer-Zimmer  
Rütelgebäude

## Implementing our Energy Future

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ehub – Short for EnergyHub – is an energy research and technology transfer platform aimed at optimizing energy management at district level and evaluating its influence on the overall energy system. In conjunction with the other Empa demonstrators NEST and move, ehub can be used to combine energy flows in the mobility, housing and work sector, test new energy concepts under real-world conditions and explore the potential for increasing efficiency.

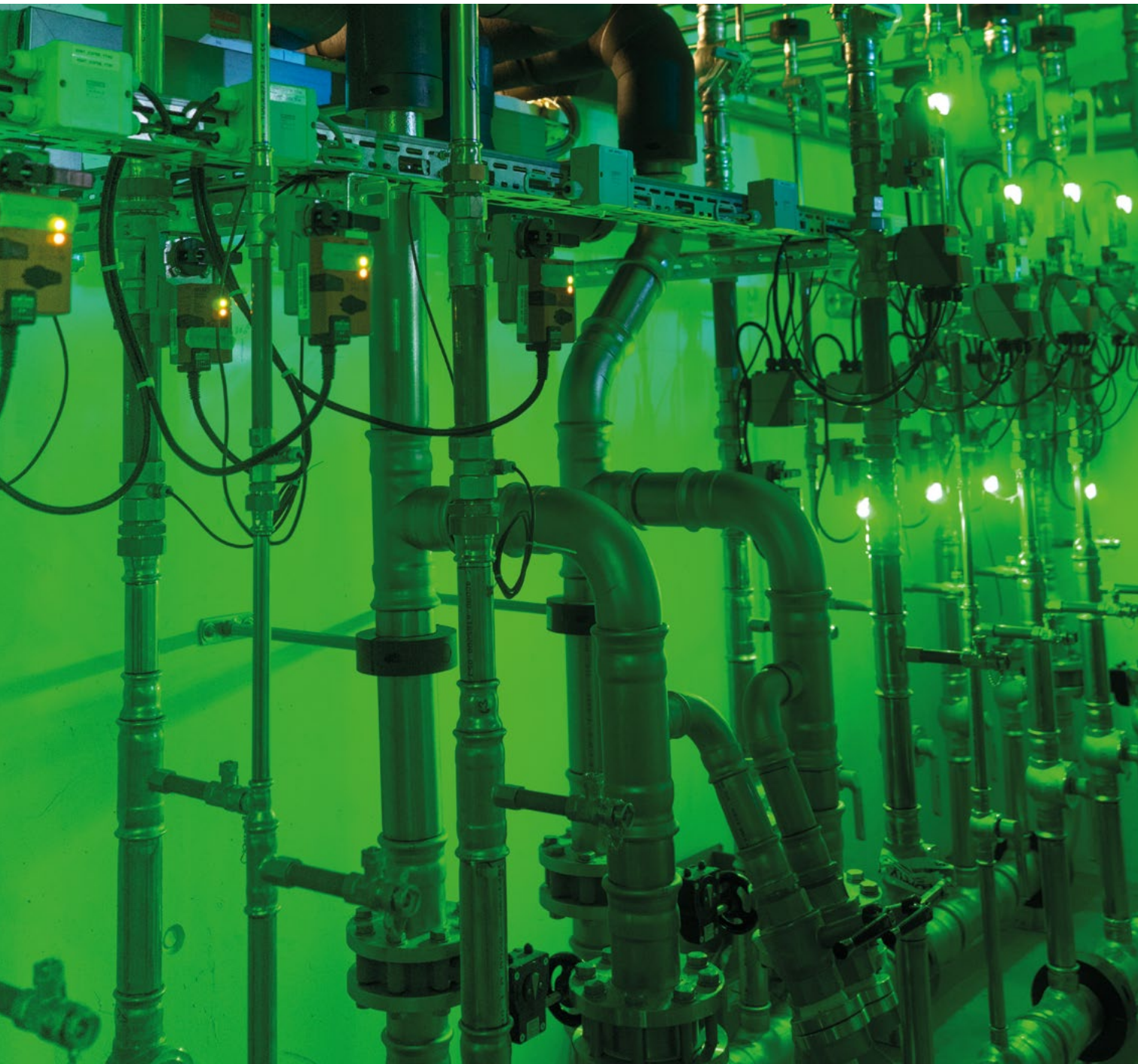
The seamless integration of renewable energy sources, efficient storage possibilities and a dynamic interplay between a wide range of technologies is pivotal for a sustainable energy future. ehub displays a large number of technologies for the production, conversion, transportation and storage of energy. NEST provides a kind of vertical neighborhood for research on new energy concepts for networks of buildings. And combining eHub with move, Empa's demonstrator for future mobility, enables renewable electricity to be extended to the mobility sector, where it can be used directly for charging e-cars or stored longer-term in the form of hydrogen.

ehub comprises a wide variety of components, three thermal networks, three electrical networks and two gas networks. All components can be controlled individually and – depending on the research question at hand – operated separately or in concert. This enables individual technologies to be used, analyzed and improved in ehub. The results on the practical capability and systematic combination of individual technologies will help our partners from the energy sector and from industry to make decisions on future investments and can provide useful recommendations for planners, architects, energy suppliers and authorities. The practical implementation of energy models paves the way for research on the impact of these models on Switzerland's future energy system.

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## Digital Hub – The Hub for Digital Innovation

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In future, digital technologies will massively change the competitive landscape in many areas, including the building, energy and mobility sectors. For companies that want to maintain or even strengthen their competitiveness, this requires constant experimentation with new and promising digital technologies, from artificial intelligence (AI) and augmented reality to the processing of “big data”. Empa’s Digital Hub – dhub for short – is embedded in the demonstrator park on the Empa campus in Dubendorf, which includes NEST for building technologies, move for future mobility and ehub, the energy demonstrator. dhub provides the basis for digital research, development and experiments. dhub, therefore, accelerates the market entry of new digital solutions in the building, energy and mobility sectors.

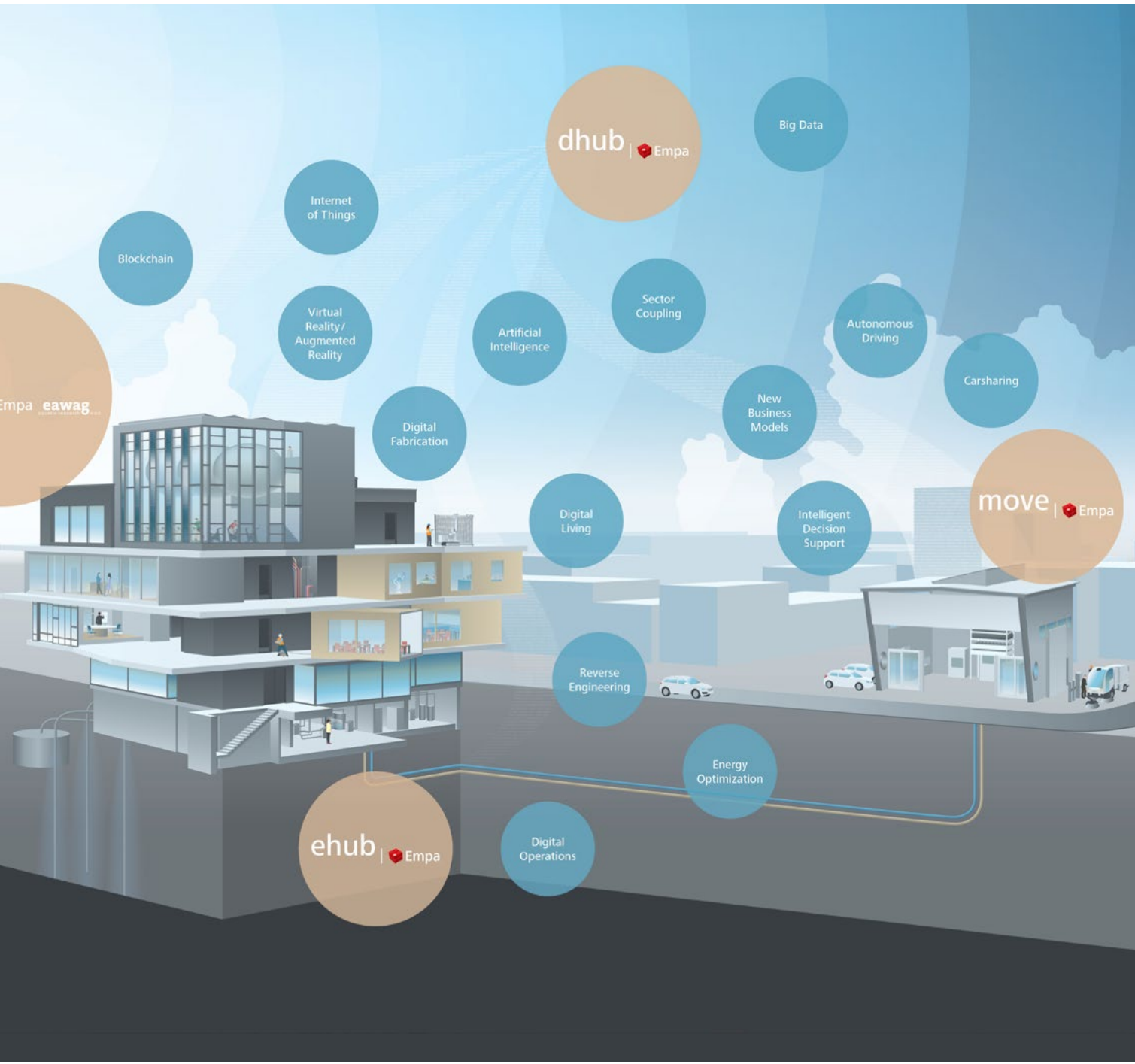
### Themes are

- Digital technologies for construction and operation
- Reverse engineering into digital models
- Artificial Intelligence in the construction and energy sector
- Blockchain technologies for P2P energy trading
- Virtual reality and augmented reality in construction
- Intelligent decision support
- Automated data preparation
- Validation of new business models

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## Breaking Ground for Industry 4.0

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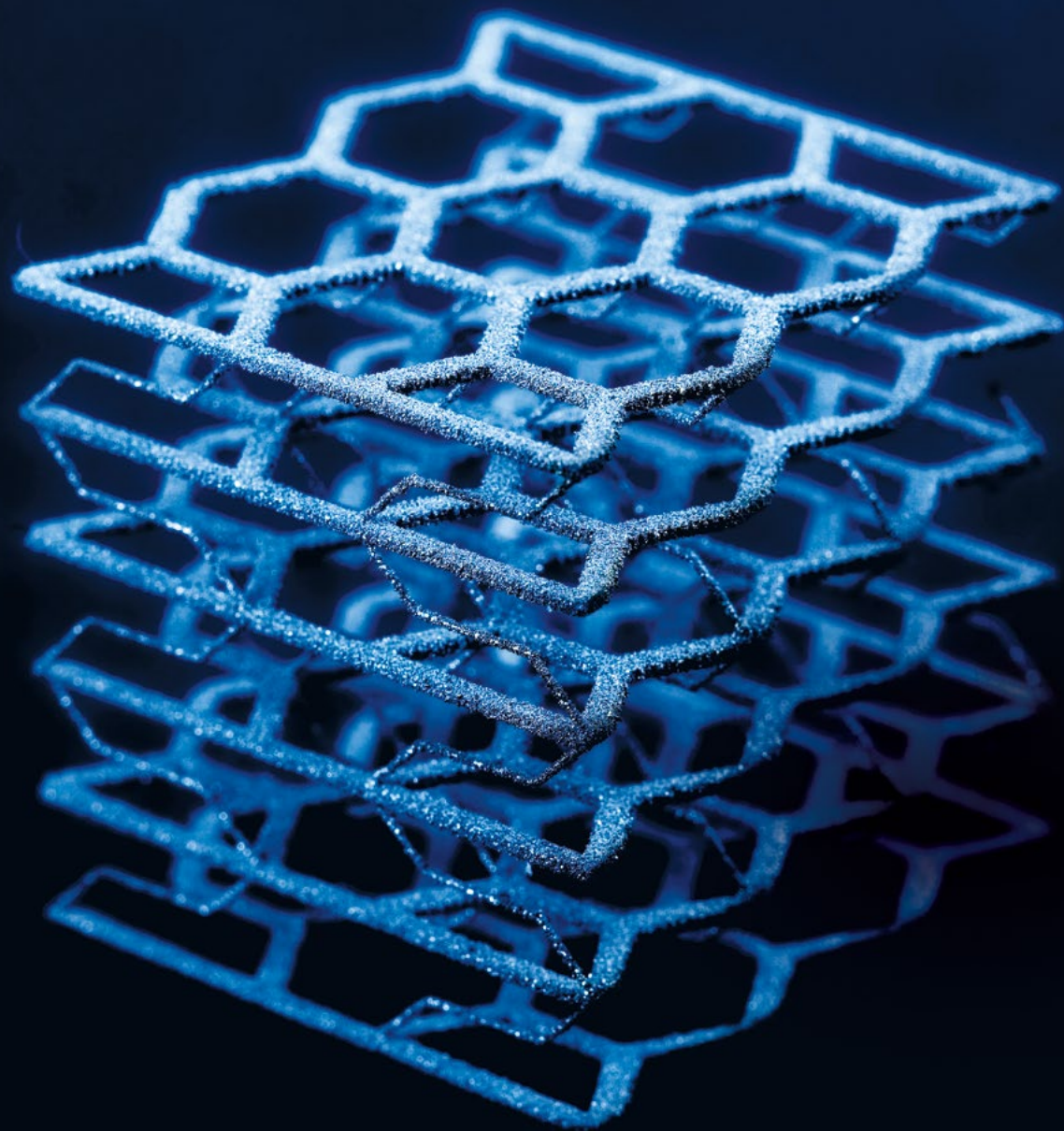
Empa's new coating center transfers tailored surface technologies from the research lab to marketable industrial applications. The center houses various coating machines for hard coatings, flexible photovoltaic units and organic electronics as well as 3D printers for metallic materials and biocomposites. The equipment is pilot scale in terms of the process engineering, but has modifications that allow our researchers to carry out detailed process analyses. This should make it easier for Swiss companies to upscale and thus create a competitive lead in the face of international competition.

The CCC aims to provide answers to new challenges confronting the Swiss mechanical engineering, electrical and coating industries in the near future. To succeed on the market, more and more tailored solutions are needed. This applies in particular to coatings, whether these are new, even tougher hard coatings or intelligent multi-layer systems with specific properties. Flexible solar cells, another promising futureproof technology, comprise a sequence of thin layers that are deposited in an ultra-high vacuum. Even complex layered structures like these can be realized in the CCC on pilot-scale machinery, not just on a lab scale.

However, the CCC is just a first step in closing the gap between experimental research and industrial production and bringing together various partners from research and industry along the value chain. At Empa we are already planning a "Center for Advanced Manufacturing Technologies". The idea behind it is to broaden sponsorship considerably, establish the Center as a Public Private Partnership (PPP) and extend the technology portfolio far beyond coating technologies.

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# KNOWLEDGE AND TECHNOLOGY TRANSFER

## From Invention to Innovation

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With an efficient knowledge and technology transfer Empa ensures that new technologies, materials and methods are available for interested partners to be developed further into innovative products and applications. A key to this mission is the Empa Portal. It offers a single point of contact for those looking for cooperation with Empa and its broad offering in use-inspired research and sophisticated services.

Empa embraces and supports the cooperation between its researchers and industrial partners in Switzerland and abroad. Collaborations can take various forms e.g. contract research, joint research, publicly funded research or consulting, and can be aligned with the requirements of SMEs and start-ups as well as large enterprises.

To create the best possible conditions for future development and marketing, Empa aims at filing intellectual property rights (IP) early on and to offer them to its partners for commercial use.

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## Exchange between Industry, the Economy and Society

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Keeping abreast of the rapid pace of technological progress in industry, the economy and society demands a broad overview of a wide range of research and development fields. The Academy is Empa's platform for knowledge transfer, used by experts from industry and academia as a vehicle for the dialog with each other, but also with a wider, non-specialist audience.

The Academy has taken on the task of disseminating to a wider public the know-how gained in the course of our numerous research projects and investigations. It offers partners open access to Empa's greatest strengths – the breadth of interdisciplinary experience, the depth of scientific expertise, continuity and a widespread network of national and international partners. The Academy organizes seminars, conferences and lecture courses for scientists and experts from industry, regulatory authorities and technical associations. In addition to the specialist technical and scientific activities, it also arranges events specifically for the general public.

In particular, knowledge transfer from research to industry is dear to Empa's heart. For this purpose the "Technology Briefing" series has been developed. Through short presentations with accompanying exhibitions, opportunities are presented for the practical implementation of new developments derived from the research.

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# Empa – The Place where Innovation Starts

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