



ENERGY RESEARCH LIGHTHOUSE



THINK.
RESEARCH.
ACT.

Welcome

The path to a sustainable and climate-neutral industrial society requires new technologies and value-added chains. With its excellent research institutions and strong economy, Bavaria is one of the pioneers in the field of innovative technologies for the transformation of the energy system. The Nuremberg Metropolitan Region in particular, with more than 14,000 mainly medium-sized companies and a broadly diversified university and research landscape, is an important location for the energy industry in Germany and Europe.

In order to consolidate and expand this technological leadership, the State of Bavaria has been supporting the Research Association of the Energie Campus Nürnberg (EnCN) since 2011. The cooperation between the Friedrich-Alexander University Erlangen-Nuremberg, the Nuremberg Institute of Technology, three Fraunhofer Institutes, the Bavarian Center for Applied Energy Research (ZAE Bayern) and Ansbach University of Applied Sciences has developed the Metropolitan Region into a widely visible center of energy research. The EnCN's success factor is a comprehensive view of the energy system from a technological, social and economic perspective. The range of topics is impressive: it spans from hydrogen and printable photovoltaics to energy-efficient buildings, energy system analyses and market design. Through the consistent networking of science and industry in joint initiatives, projects and spin-offs, the technology transfer into application practice is realized quickly and sustainably. This is an important step on the way to a research cooperation that will be self-financing in the future.

The ambitious climate targets in Bavaria and worldwide present our economy with challenges, but also provide great opportunities. With their work, the scientists of EnCN provide important impulses - for the success of the energy system transformation in Bavaria as well as for securing local value creation. We wish them continued success in the future!



Hubert Aiwanger

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Bavarian State Minister of Economic Affairs,
Regional Development and Energy
Deputy Bavarian Prime Minister



Bernd Sibler

Bernd Sibler

Bavarian State Minister of Science
and the Arts

The Energie Campus Nürnberg

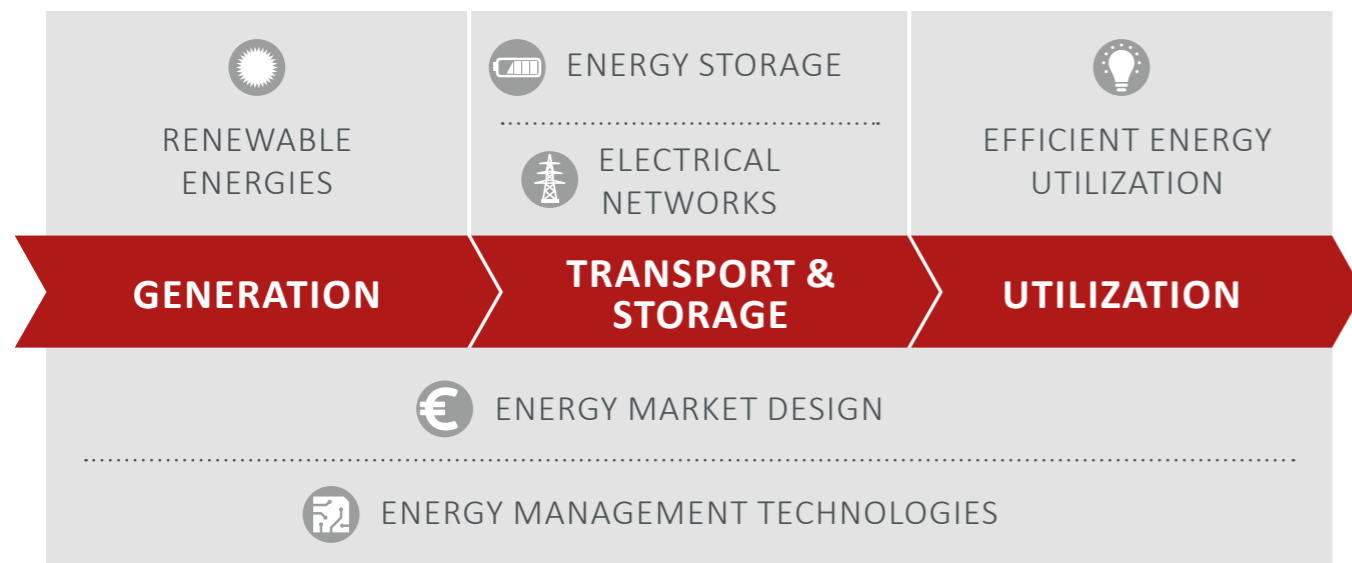
The Energie Campus Nürnberg (EnCN) is an interdisciplinary and internationally unique energy research center. Around 140 scientists from one university, two universities of applied sciences and non-university research institutes work together here on an interdisciplinary basis and cooperate closely with companies from the region and beyond.

The EnCN is divided into six research areas that cover all topics of the energy value-added chain. The actual added value of the cooperation is the systemic view of the energy chain across disciplinary and institutional boundaries. Currently, the State of Bavaria is funding five interdisciplinary collaborative projects at the EnCN. In addition, the researchers are collaborating in numerous other cross-disciplinary and cross-institutional third-party funded projects.

The Energie Campus Nürnberg is coordinated by the Scientific Board (seven members, chair: Prof. Veronika Grimm), the Extended Scientific Management (42 members) and the administrative office. It provides a research area of 5,200 square meters with 30 laboratories and technical rooms. The cooperation of various research institutions under one roof, which is unique in Germany, is regulated by a cooperation agreement.

The systemic view of the energy chain is the key to tomorrow's energy supply.

Research Areas



Scientific Board

Prof. Dr. Veronika Grimm
Head of Scientific Board
 · Friedrich-Alexander University of Erlangen-Nuremberg, Chair of Economic Theory

Prof. Dr. Matthias Luther
 · Friedrich-Alexander University of Erlangen-Nuremberg, Chair of Electrical Energy Systems

Prof. Dr. Christoph Brabec
 · Friedrich-Alexander University of Erlangen-Nuremberg, Institute Materials for Electronics and Energy Technology

Prof. Dr. Martin März
 · Friedrich-Alexander University of Erlangen-Nuremberg, Chair of Energy Electronics and act. Director Fraunhofer Institute for Integrated Systems and Device Technology IISB

Prof. Dr. Jürgen Karl
 · Friedrich-Alexander University of Erlangen-Nuremberg, Chair of Energy Process Engineering

Prof. Dr. Peter Wasserscheid
 · Friedrich-Alexander University of Erlangen-Nuremberg, Institute of Chemical Reaction Engineering

Prof. Dr. Wolfgang Krcmar
 · Nuremberg Institute of Technology, Faculty of Materials Engineering



Standing from the left: Prof. Dr. Martin März, Prof. Dr. Christoph Brabec, Prof. Dr. Wolfgang Krcmar, Prof. Dr. Jürgen Karl; Sitting from the left: Prof. Dr. Matthias Luther, Prof. Dr. Veronika Grimm, Prof. Dr. Peter Wasserscheid

The EnCN – Pioneer of the energy system transformation

The researchers at the EnCN are pursuing an ambitious goal: They want to develop viable scenarios of sustainable power supply, mobility and heat economy. The technical potential, the energy policy framework and the associated business models and social acceptance will also be evaluated.

The intelligent coupling of the sectors is the key to a sustainable energy supply and at the same time a question of fate for Bavaria as an industrial location. In

doing so, we must look far beyond regional structures and focus, for example, on completely new flows of international energy trade. Wise and foresighted industrial partnerships secure both energy supply and innovative strength and hold significant market potential for Bavarian companies far beyond the state borders.

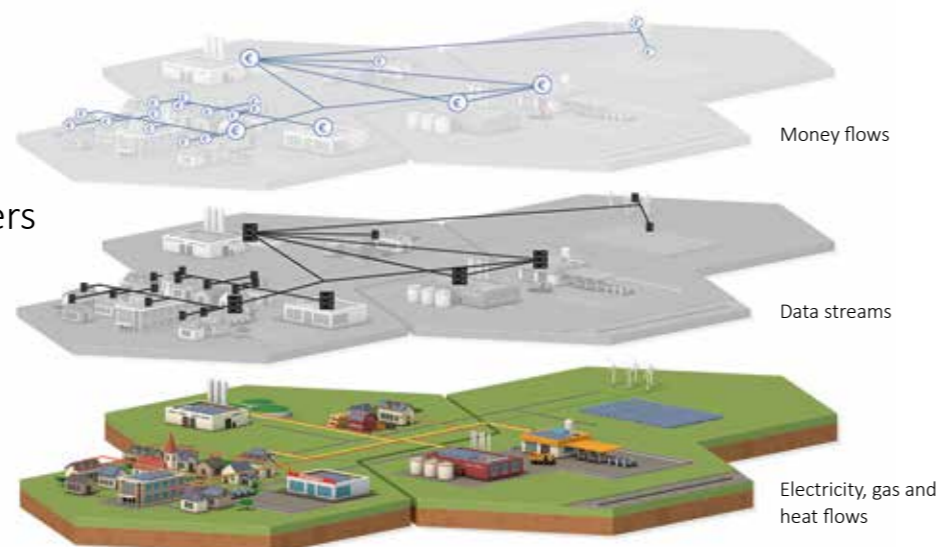
In addition to researching the technological possibilities, the researchers at EnCN are also developing proposals for the regulatory framework. The potentials of sector coupling depend heavily on the costs of climate-neutral mobility and heat supply - and these in turn are determined by the legal framework conditions on energy markets and, in particular, by taxes, fees and charges.

At the EnCN, energy system transformation is understood as the transformation of electricity, heat and transport.



The comprehensive expertise across a wide range of scientific disciplines and the ability to take a holistic view of the energy system make the EnCN unique - and thus a pioneer and hot spot for shaping the energy system transformation in Bavaria and Germany.

Example of sector coupling with various decentralized suppliers and consumers



Research facilities at the EnCN



Friedrich-Alexander University of Erlangen-Nuremberg

With 38,000 students and 260 courses of study, it is one of the largest, most research-oriented and innovative universities in Germany.



Nuremberg Institute of Technology

One of the largest and strongest research universities for applied sciences in Germany, with around 13,000 students.



Bavarian Center for Applied Energy

Research Materials research, component development and system optimization in the central areas of energy storage, energy efficiency and renewable energies.



Fraunhofer Institute for Integrated Systems and Device Technology IISB

Power electronics, intelligent energy systems, electro-mobility, semiconductor technology, materials for electronics and energy technology.



Fraunhofer Institute for Integrated Circuits IIS

Applied R&D for cognitive sensors, data acquisition, communication technologies, data evaluation and control with artificial intelligence.



Fraunhofer Institute for Structural Physics IBP

Applied R&D in the fields of energy efficiency, indoor climate, acoustics, hygiene and sensor technology, recycling of building materials, hygrothermics and comprehensive accounting.



Ansbach University of Applied Sciences

A young and modern university of applied sciences with more than 3,000 students in the fields of technology, business and media with a research focus on industrial energy efficiency.

Excellent place for strong partnerships

With the aim of conducting top-level research, the forces of strong cooperation partners are concentrated at the Energie Campus Nürnberg. A full university, two universities of applied sciences, three Fraunhofer Institutes and ZAE Bayern are integrated into the network.

This cooperation has been brought to life in an outstanding way: To date, more than 500 scientific publications have been produced, each of which has involved at least two EnCN partners. Practical applications and technology transfer have been successfully implemented in cooperation projects with well over 200 industrial partners.

In addition to the projects, numerous appointments and honors for the researchers testify to the successful work of the EnCN. The public participation of Prof. Peter Wasserscheid and Prof. Matthias Luther in the current Copernicus projects P2X and ENSURE is a good example of this. Together with Prof. Wolfgang Arlt, Prof. Peter Wasserscheid achieved the „Circle of Excellence“ in the nomination for the Future Prize of the Federal President.

The EnCN is at the forefront of support for the transformation of energy systems at the federal level: In April 2019, Prof. Veronika Grimm was appointed to the expert commission that will accompany the „Energy of the Future“ monitoring process initiated by the federal government in 2011. Prof. Veronika Grimm has already been a member of the BMWi's Scientific Advisory Board since 2018. In addition, the EnCN is an excellent place in the „Land of Ideas“ and „Shaper of the Energy Transition“.

The cooperation of strong partners enables top-level research at the EnCN.

The EnCN is at the forefront of the energy system transition.

A place of information and exchange

The EnCN is not only a place where scientists can conduct research at the highest level. It also offers the opportunity for information and professional exchange.

The primary goal is to link science, business, politics and the public. In numerous different event formats and in cooperation with other partners, EnCN offers information and exchange opportunities for different interest groups - here are some examples:

At the **annual conference**, EnCN scientists present highlights of their current research in specialist lectures. In addition, every year a top-class guest speaker is invited to discuss their visions for the energy supply of the future with the researchers.

Specialist seminars in cooperation with the ENERGIEregion Nürnberg, Bayern Innovativ, the Chamber of Industry and Commerce, the City of Nuremberg and other partners are a building block for the transfer of technology from research to industrial application, which succeeds through direct networking of science, industry and politics.

The EnCN brings together science, business, politics and the public.

Information events, e.g. the Long Night of Science, Fascination of Energy or the Children's University offer hands-on science for everyone.

Numerous (inter)national delegations from science, industry and politics use a visit to the EnCN for professional exchange and to inform themselves about current developments in energy research.

The EnCN office organizes the events. It is also available as a mediator to bring together interested parties with the appropriate contacts within the EnCN and to initiate joint research projects.





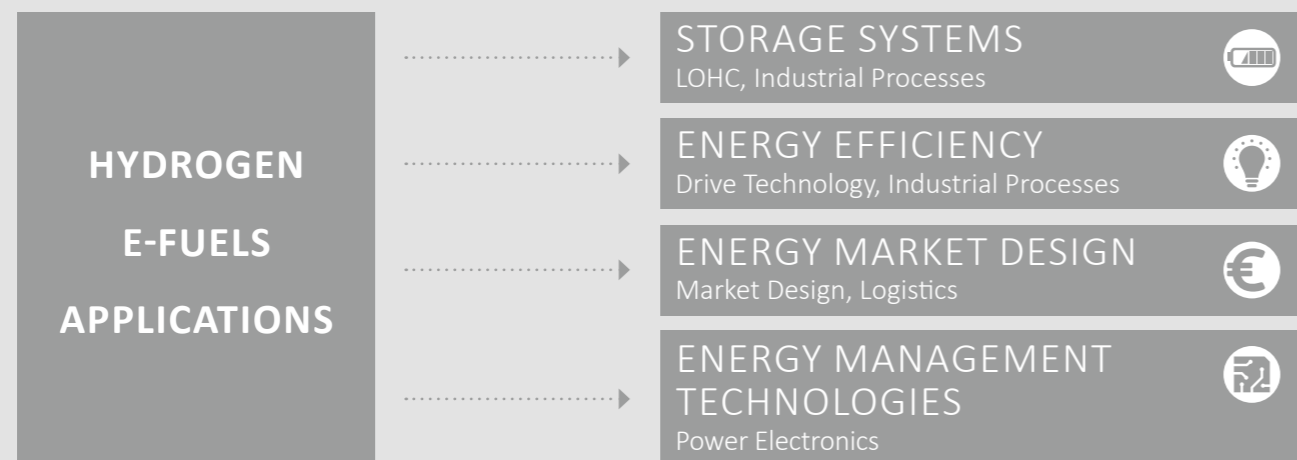
Research focus Hydrogen, E-Fuels, Applications

Chemical energy carriers, especially hydrogen and hydrogen-based synthetic fuels, will play a central role in the energy system of a sustainable and climate-neutral industrial society.

For some applications, hydrogen technologies are even the only reasonable solution - for example in the field of heavy-duty mobility, in industry or seasonal electricity storage. For Bavaria and Germany in particular, with their leading vehicle manufacturers and suppliers, a future hydrogen economy offers great opportunities, but also poses challenges. Hydrogen is particularly interesting where large amounts of energy have to be made available over several hours: for the operation of ships, trains, trucks, buses, construction machinery or long-distance passenger cars.

The storage of hydrogen in the form of hydrogen-rich liquids is of particular importance both in the mobility sector and for global energy trade: e-fuels enable infrastructure-compatible distribution in a similar form to conventional fuels and make hydrogen easy to use worldwide.

It is precisely these application scenarios that scientists at EnCN are working on: They research innovative technologies for hydrogen production, storage and logistics. They demonstrate in cooperative projects how hydrogen can be used profitably in industrial projects. And they investigate the market-based conditions for the successful integration of hydrogen technologies into the energy system and the possible role of the German economy in future global hydrogen logistics. They are also developing electric drive and control systems for more reliable and efficient mobility applications.



PROJECT LOHC HYDROGEN STORAGE

The EnCN has developed the material concept, catalysts, apparatus and processes of the LOHC technology (liquid organic hydrogen carrier) with the aim of safe and efficient hydrogen logistics. The basis is a non-explosive and non-toxic carrier liquid to which the hydrogen can be bound and released when required. The long-term storage of green hydrogen under ambient conditions makes LOHC interesting not only for decentralized and global energy logistics, but also for mobility.



HYDROGEN LOGISTICS PROJECT

In this project, the cost-effectiveness of LOHC technology and alternative e-fuels such as Fischer-Tropsch diesel or methanol is being investigated. Engineers and economists are not only looking at the production costs of e-fuels at home and abroad, but also at the systemic interplay of fuels, mobility concepts and electricity markets. Mathematical models depict the entire process chain - from hydrogen production and chemical bonding to the energetic use of fuels in the vehicle.



PROJECT I³UPGRADE

The decarbonization of energy-intensive sectors of industry is a key element of the energy system transformation. The i³upgrade project is investigating how carbon sources in the steel industry can be enriched with regenerative hydrogen. The researchers here are primarily concerned with the direct methanization and methanol synthesis of by-product gases produced during smelting. The refined carbonaceous streams will increasingly replace fossil fuels for energy supply.



PROJECT DC/DC CONVERTER FOR THE RAILWAY

The demand for reliable electronic assemblies for complex control, regulation, information or safety tasks is constantly increasing. The project deals with DC/DC converters for railway operation that process the widest possible range of input voltages and thus covers a broad spectrum of tasks. Within the framework of an industry-oriented research project, the researchers are concentrating on the use of microcontrollers with variable switching frequencies to regulate and control the converters.





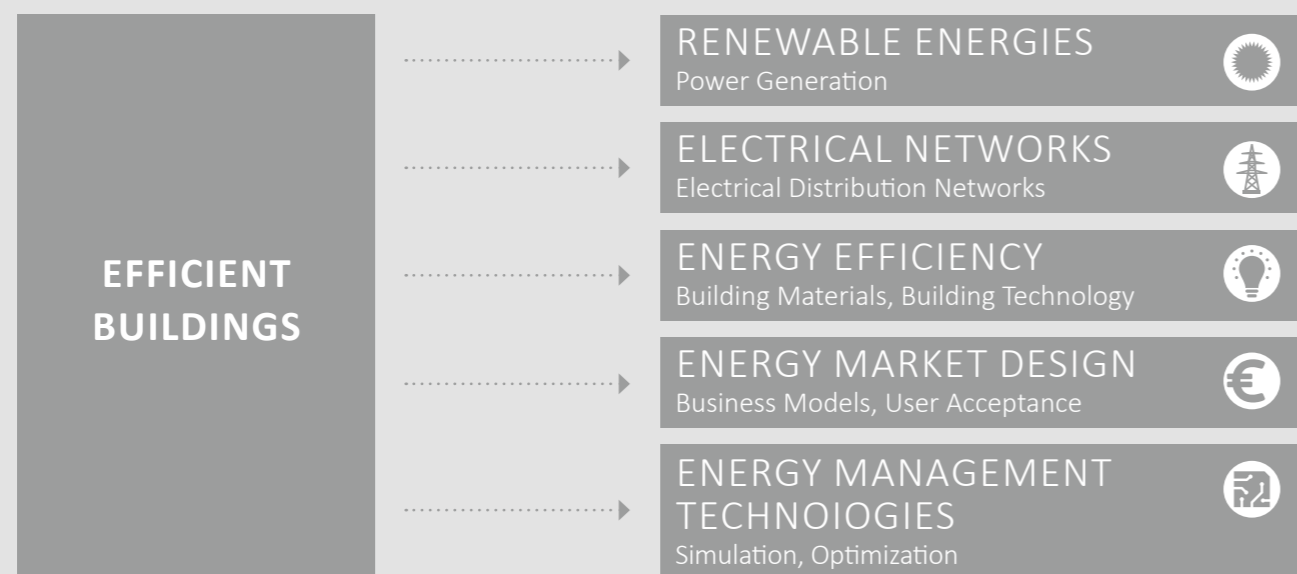
Research focus Efficient Buildings

Buildings account for almost forty percent of our total energy consumption. In order to achieve the climate protection goals we have set ourselves, both the energy requirements of buildings must be significantly reduced and the use of renewable energies must be increased. This requires new building materials for optimum thermal insulation and integrated building technology in which the local generation, storage and use of thermal and electrical energy are consistently coordinated.

Such comprehensive building concepts are being intensively investigated at the Energie Campus Nürnberg. With the HerzoBase demonstration project, EnCN has set standards for future-orientated building - and at the same time allows accelerated transfer of research results into practice. For example, the world's best-insulated brick was developed and an intelligent operational management concept was designed for storage facilities.

In addition to the passive components of sustainable energy management, EnCN has also the active components in view.

For example, the further development of storage technologies, the development of renewable energy sources or the use of ambient heat. In the future, energy management of the building shell will not be limited to its insulating properties: it should be able to react to the environment and convert and store energy, for example by means of integrated photovoltaics and solar thermal energy in the facade. PV technologies are being developed for this purpose in the solar factory of the future at the EnCN. Networked electrical storage systems can also be operated on the grid, as was successfully demonstrated in the SWARM project.



PROJECT HEROBASE ENERGY STORAGE HOUSES

As part of a demonstration project, eight plus-energy houses were built, which generate more energy than they consume themselves. A new type of insulating material made of fumed silica and glass fibers with extremely low thermal conductivity was used for the building shell. All components of energy generation (photovoltaic and geothermal) and storage (thermal, electrical) are integrated into a central and intelligent operating system. 250 sensors in the walls of the houses provide data on temperature, heat flows, relative air humidity and material moisture.



PROJECT LIGHTCOCE

Lightweight construction materials such as lightweight concrete and ceramics help to significantly reduce the ecological footprint and transport costs of building materials. They are resistant, versatile and can be equipped with multifunctional properties - for example through the use of nanomaterials. In the EU project LightCoce, EnCN is working together with other institutions to optimize these materials. The open source platform is intended to provide industry with easy access to research results.



SWARM PROJECT

The SWARM project dealt with intelligent networking across disciplines. The photovoltaic battery storage systems of 65 households distributed throughout Middle Franconia were networked to form a „virtual large-scale storage system“. Such micro-storage networks in the distribution grid area can be a key to a reliable supply of renewable energies. The EnCN developed a simulation model to determine the technical effects of the storage facilities on the networks and examined the economic benefits for the households and the willingness of the users to invest.



PROJECT FACADE³

In the joint project Facade³, EnCN and its partners are developing a modular, pre-fabricated facade element that combines several functions. Organic photovoltaics are used to generate electricity - flexible, printed thin-film modules are integrated as semi-transparent elements for this purpose. A controllable, selectively-coated solar shading system is to reduce the heating of the rooms and at the same increases the incidence of daylight. Integrated sensor technology and an intelligent overall control concept contribute to the energy efficiency of the entire building.





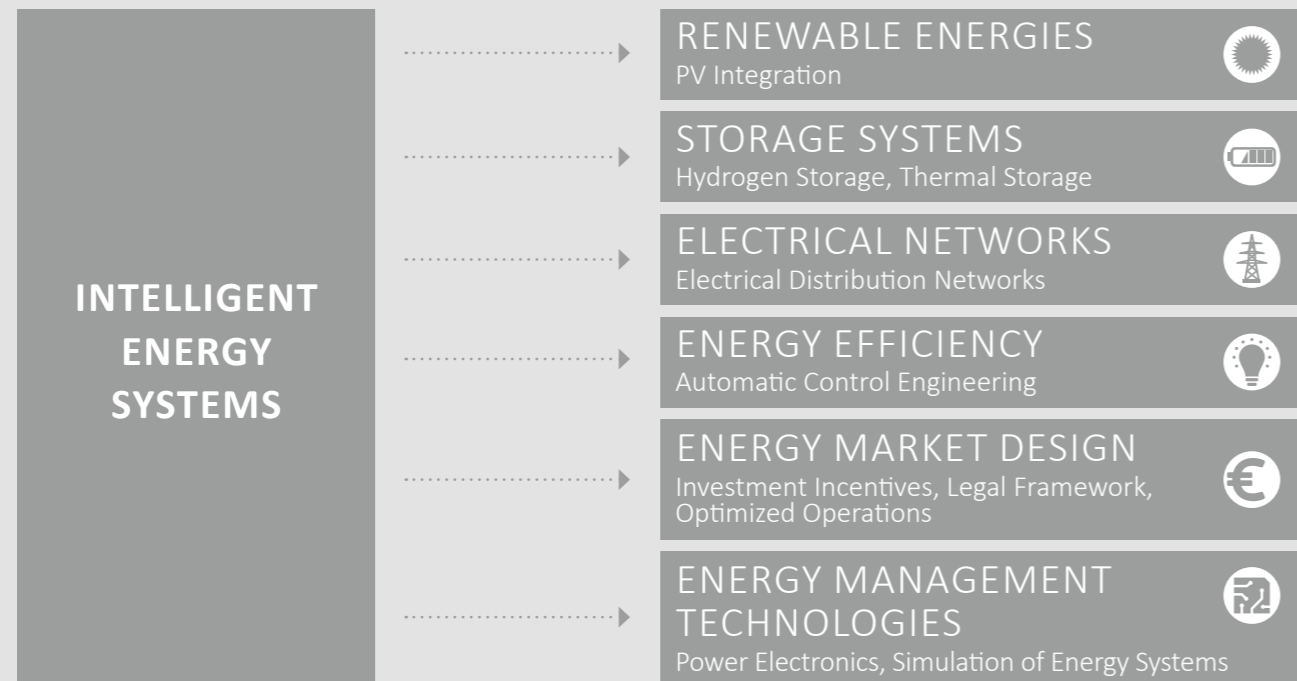
Research focus Intelligent Energy Systems

The reliable supply of renewable energy can only succeed in an integrated system. The intelligent coupling of the heat, mobility and electricity sectors, the development of efficient storage technologies and the networking of suppliers and users in new markets are of crucial importance in this context.

The basis of such a sustainable system is the decentralized supply of energy. In the solar factory of the future, EnCN is working on new photovoltaic technologies and is developing, for example, printed organic solar cells that are particularly light, thin and transparent. On the one hand, these solar films can be integrated more easily into buildings, and on the other hand, they can also be used to enhance mobile devices - from cars to smartphones - or textiles.

In the future, however, it will also be important to intelligently combine technological and non-technological innovations into a complete system.

In various demonstration projects, EnCN is working closely with energy suppliers, industrial partners and end users to test market-ready developments under real conditions and on an industrial scale. In addition to the marketability of the technologies, business models and social acceptance are also analyzed within the framework of accompanying research.



PROJECT SMART GRID SOLAR



Smart grids enable the dynamic control of power generation, consumption and storage. With this concept, private photovoltaic systems and storage facilities as well as a central storage facility and solar park were integrated into a renewable energy system in Arzberg. The EnCN has not only examined the effects of decentralized generation plants on low-voltage networks and developed corresponding operating strategies, but has also carried out network and market modeling for network planning. Potential investment incentives were also identified and evaluated.



PROJECT CONNECT



New concepts and technologies for energy conversion that are especially suitable for the bidirectional exchange of electricity with the grid were investigated. They support the extended integration of local storage and renewable energies such as photovoltaics. EnCN is developing a bidirectional DC/DC converter that can be used to couple low-voltage DC networks with protective low-voltage networks and devices. One application example from the office environment is the energy-autonomous desk.



COSIMA PROJECT



Photovoltaic systems make an important contribution to a sustainable energy supply. However, the modules do not always generate as much electricity as specified by the manufacturer. Defects, cracks and soiling contribute to a reduction in output. The measuring methods and control approaches developed by EnCN not only allow the system performance to be maintained and increased, but also enable a more meaningful and reliable yield forecast. This reduces maintenance costs and makes the technical risk more calculable.



OLE-3D PROJECT



The direct application of electronic components and conductor paths on surfaces goes beyond the limits of conventional planar electronics and can provide completely new functionalities to molded parts such as cell phone covers or car bodies. Organic photovoltaics play a decisive role here: It serves as a light sensor or for the energy supply of self-sufficient systems. In the OLE-3D research project, EnCN is developing new printing processes (ink and aerosol jet) for the production of organic functional layers on any 3D surfaces.



Promotion of young scientists at EnCN

The EnCN attaches great importance to young scientists. Numerous students write their theses here or, after successful completion of their studies, do their doctorate in one of the six research areas. The EnCN therefore specifically promotes young scientists in order to offer them the best possible research environment.

The Energie Campus Nürnberg e.V. in cooperation with the Energie Campus Nürnberg awards the **EnCN Energy Prize** for outstanding Bachelor and Master theses. The prize aims to reward and promote excellent contributions by young graduates in the field of research and development of renewable energies.

Also awarded by EnCN e.V. is the **EnCN travel grant**, which is intended to motivate young scientists to present their research work at scientific conferences.

For several years now, EnCN has been cooperating with the **Student Research Center** at the Willstätter Gymnasium of Nuremberg and the Highly Talented Model Central Franconia in order to inspire pupils with the research spectrum of energy research.

Numerous EnCN scientists and especially young scientists trained at EnCN, continue their scientific careers at other research institutions in Germany and abroad. In order to promote more intensive contact and joint research work with these scientists outside EnCN, the Energie Campus Nürnberg has established a **fellowship program**.



Advisory Board



The Advisory Board supports the Energie Campus Nürnberg in its strategic development. The energy experts from science and industry give recommendations on the content of the Campus' curriculum and provide impulses for further networking.

Current members of the EnCN advisory board are:

- **Prof. Dr. Reinhold Achatz**
Member of Supervisory Board, Unity AG
- **Dr. Michael Fraas**
Head Economic Department, City of Nuremberg
- **Josef Hasler**
Chairman, N-ERGIE AG
- **Prof. Dr. Rolf Hellinger**
Vice President, Siemens AG
- **Prof. Dr. Claudia Kemfert**
Department Head, DIW Berlin

- **Prof. Dr. Leo Lorenz**
President, European Center for Power Electronics
- **Markus Löttsch**
CEO, Chamber of Industry and Commerce Nuremberg
- **Prof. Dr. (em.) Joachim Luther**
former Director, Fraunhofer Institute for Solar Energy Systems ISE
- **Prof. Dr. Christoph Weber**
Chair Holder, University Duisburg-Essen
- **Prof. Dr. Eckhard Weidner**
Director, Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
- **Prof. Dr. Dirk Westermann**
Director of Institute, Technical University Ilmenau

Imprint

Editor/publisher:

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Data status: March 2020

Layout:

zur.gestaltung, Nuremberg

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