Institute of Networked Energy Systems

DLR

Facts & Figures:

An overview of the Institute of Networked Energy Systems

Founded	› 2007 (as EWE Research Centre NEXT ENERGY)
Integrated into the German Aerospace Center (DLR)	› 2017
Number of Employees	› 150
Institute Building	› Building A in Oldenburg, in the Wechloy district: › 4,290 m² net surface area, › of which 1,660 m² laboratory space › Building B is located directly in Oldenburg's city centre: › 1,600 m² office space
Budget 2018	› 14.7 million euros in total, of which › 47 % third-party funds › 53 % institutional funding (federal government/state)
Scientific Departments	› Urban and Residential Technologies › Energy Systems Technology › Energy Systems Analysis

The energy transition is coming. In the wake of the – partially dramatic – cost reductions we have seen in the last few years, there has been more newly installed electricity generation capacity based on renewable energies than added capacity based on conventional technologies. The question of how to link the large number of decentralised installations into a functional and efficient energy system has not yet been answered. Today more than ever, we need smart answers to system-related issues if the national and global energy transition is to succeed.

The Institute of Networked Energy Systems of the German Aerospace Center (DLR) is dedicated to investigating system aspects. We develop technologies and concepts for a future energy system based on renewable energy sources. The future energy system should meet the high requirements of climate protection, maintain the security of energy supply, and be implemented, with societal consensus, with financially attractive terms.

The technical challenge: the energy system of the future differs structurally from our existing supply. For example,

- production is based on fluctuating energy sources and therefore depends on the time of day and meteorological effects
- power is no longer generated centrally in large plants, but predominantly produced in a very large number of comparatively small decentralised plants
- the coordination of energy provision and requirements need an entirely new type of networking mechanisms that are partly digitalised.

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Our scientists take new framework conditions into account in their research, consistently incorporating the aspects of "defossilation", "decentralisation" and "digitalisation". Our Urban and Residential Technologies, Energy Systems Technology, and Energy Systems Analysis Departments focus on the challenge of building a cross-sectoral networked energy system mainly based on weather-dependent decentralised generation hubs. To this end, we

- develop concepts for the intelligent and efficient linking of the electricity, gas, thermal and mobility sectors;
- investigate systems at all levels, ranging from individual installations and "smart" buildings to networked residential districts and cities;
- evaluate energy systems at the national and international levels, using power grid and energy system models that we developed in-house, along with energy meteorology and technology assessment methods.

Here is an overview of our scientific Departments and Research Groups:

Urban and Residential Technologies	Energy Systems Technology	Energy Systems Analysis
Sector Integration – Buildings	Flexibilities and Ancillary Services	Energy Meteorology
Sector Integration – Gas Technology	Smart Energy Management	Grid and Systems Modelling
Sector Integration – Mobility	Power Grid Technologies	Technology Assessment

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Infrastructure Highlight

In different labs we have the opportunity to test and evaluate different CHP systems under real and simulated energy profiles. Our technical centre has a coating line with a structuring and lamination unit. Elements of the active building envelope are coated here, e.g. for multifunctional windows and façade elements. They are used within the building as energy converters that enable electricity and thermal energy to be used across different sectors.

Institute of Networked Energy Systems

Research Department

Urban and Residential Technologies

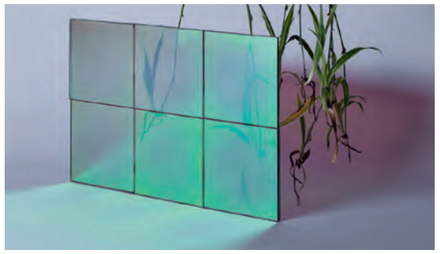
The energy supply of the future will be based on CO_2-free, weather-dependent and decentralised generation. However, our urban economic regions and living spaces must continue to be reliably and consistently supplied with energy in the future. In the age of renewable energies, people's mobility must be guaranteed, as must the supply of electricity and heat. With this in mind, our research focuses on two main aspects:

- What technological solutions can cities and buildings harness in the future in order to help cover their own energy demands?
- How can these technologies integrate energy sectors to create the flexibility on the basis of which the fluctuations of renewable energies can be controlled?

The Urban and Residential Technologies Department works on designing and integrating innovative individual technologies and components that are beneficial to the system. One research priority is on sector integration for buildings: for example, solar radiation can be turned into thermal, electrical or chemical energy by means of energy conversion. The goal is to develop efficient, integrated and reliable technologies that will later serve as the foundation of new energy systems for industry.

Another focus of our research is on "Sector Integration – Gas Technology", where we are developing solutions for how this sector, which has so far been dominated by natural gas, can also play a major role in a defossilised energy future. An important goal here is the utilisation of synthetic gaseous energy carriers (e.g. hydrogen) using an adapted gas distribution infrastructure. We examine the entire chain, from system-beneficial energy generation and cavern storage facilities to transport networks and users.

In terms of sector integration for mobility, we are also investigating technologies at the interface between electrical vehicles and the power network, with the focus on engines driven by electricity, hydrogen and synthetic hydrogen compounds. Due to their ability to be fed back into the power grid, these approaches have great potential for flexibility and are regarded as key elements for future energy systems.



An overview of our Research Groups:

- **Sector Integration – Buildings**
  Research on active building envelopes that enable the integration of different energy sectors at all system levels, from energy conversion to storage.
- **Sector Integration – Gas Technology**
  Improvement of the infrastructure for the generation, storage and transport of synthetic gaseous energy sources for the defossilised energy future.
- **Sector Integration – Mobility**
  Development of mobility technologies at the interface between vehicles and the power network, integrating sources of chemical energy (e.g. hydrogen, methane) with the electricity system.

Institute of Networked Energy Systems

Research Department

Energy Systems Technology

Through the expansion of renewable energy, our electricity supply is increasingly becoming decentralised and weather dependant. At the same time, digitalisation of the energy sector is opening up whole new design options. In order to allow an overall system to be structured cost-effectively and robustly and to enable surplus electricity supplies to be used locally whenever possible, concepts need to be designed that go beyond the limits of individual energy sectors.

The synchronisation of electricity generation and consumption plays a crucial role in this. To achieve this, the energy system of the future needs to be structured flexibly. This can be implemented for instance through greater incorporation of energy storage systems and through sector coupling, i.e. using energy from the electricity sector to provide thermal energy and mobility. New measures aimed at system stabilisation are also required in order to ensure that future energy systems with a very high proportion of renewable energies are sufficiently robust.

Against this background the Energy Systems Technology Department concentrates on the interaction between system-relevant technologies within decentralised networked structures. At the low-voltage and medium-voltage level in particular, we strive to achieve new architectures for the energy systems of the future. We recognise the need for new technological approaches in terms of network technologies, e.g. the integration of DC networks and new network operation equipment, in order to ensure more efficient operations and save network expansion costs.

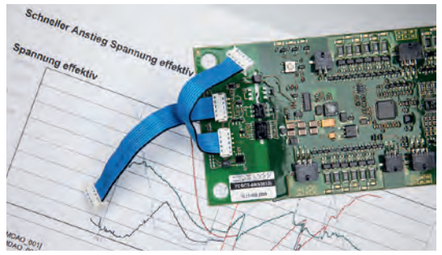
We also optimise the design and operational management of areas of the grid that feature a high proportion of renewable energies. This includes the integration of flexibilities for stabilising the grid as well as upcoming loads like the electromobility. One focus area for our research here is on coupling of the electricity sector with the thermal energy and mobility sectors as well as with industrial processes.

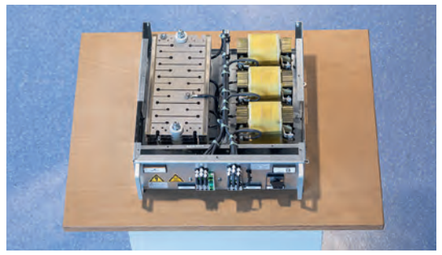
An overview of our Research Groups:

› **Flexibilities and Ancillary Services**
Design and operational management of networks through integration and management of flexibilities, investigation of system services for robust network operations of future energy systems.

› **Smart Energy Management**
Design of energy solutions for buildings and residential districts, energy management concepts and operational management strategies for sector coupling in smart homes and smart cities, development of fundamental bases for new business models.

› **Power Grid Technologies**
Research into new network technologies and architectures for robust operation of smart grids with a high proportion of renewable energies.





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Infrastructure Highlight

Our network laboratory has an electrotechnical infrastructure which allows network structures (e.g. a residential district) to be realistically mapped. It is controlled via a real-time simulation system and network control room. The laboratory enables research on new network structures (AC and DC), the integration of electric mobility, the interdependencies between the power network and digitalisation, and system security.

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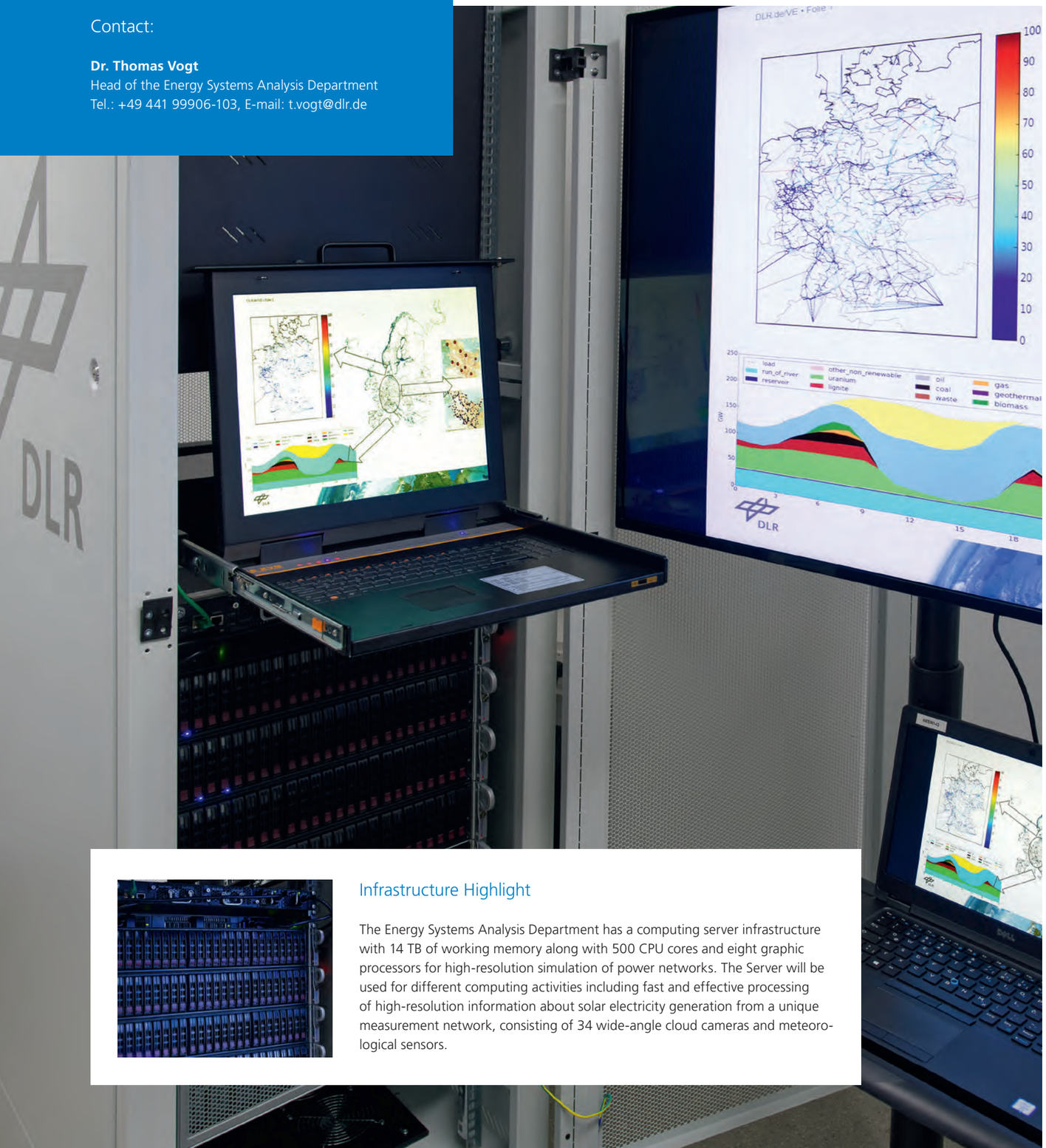


Infrastructure Highlight

The Energy Systems Analysis Department has a computing server infrastructure with 14 TB of working memory along with 500 CPU cores and eight graphic processors for high-resolution simulation of power networks. The Server will be used for different computing activities including fast and effective processing of high-resolution information about solar electricity generation from a unique measurement network, consisting of 34 wide-angle cloud cameras and meteorological sensors.

Research Department

Energy Systems Analysis

In our energy systems, large central power plants and fossil fuels are increasingly being replaced by weather-dependent renewable energy sources and decentralised energy systems. The goal is to have resilient and sustainable energy provision at all levels. In order for these energy systems to be not only stable in the future, but also economically and ecologically advantageous as well as socially acceptable, their design first requires a comprehensive analysis of existing and future structures. Moreover, suitable analysis methods must also be developed to guide political and social decision-making.

By providing detailed background knowledge, the Energy Systems Analysis Department pursues the goal of enabling optimal energy structures and regulation for networked energy systems featuring a high proportion of renewable energies. To achieve this goal, we examine the spatial and temporal variability as well as the systemic behaviour of renewable energies. Energy meteorology provides methods and valuable data records for this task by using different ground and satellite-based measuring methods along with numerical modelling procedures. Depending on the results, we develop feed-in management tools that enable prospective improvements to regulation of power networks.

We are shedding light on various aspects of energy system stability and flexibility at different voltage levels using power grid models which we develop based on open data and open source principles to answer research questions of system analysis. Grid models enable potential analyses of the optimal structure and of the stability of the overall energy system at city, national and international levels. Drawing on the Institute's technical expertise, we also carry out multidimensional assessments with a techno-economic, ecological and socio-technical character of both existing grid-connected energy technologies as well as systems currently under development.

An overview of our Research Groups:

- **Energy Meteorology**
  Methods and premium data records for analysing and predicting the system behaviour of renewable energies.
- **Grid and System Modelling**
  Development of models, methods and algorithms for the simulation and optimisation of power networks and energy systems based on fluctuating and decentralised power production.
- **Technology Assessment**
  Identification of potentials and recommended actions through multidimensional and prospective assessment of energy technologies and systems.

Working at the Institute

Scientific Exchange
The Oldenburg site is a cradle of renewable energies research in Germany. Located right near the natural sciences campus of the Carl von Ossietzky University of Oldenburg, the Institute of Networked Energy Systems is closely connected with scientists from various faculties at the University, other energy research institutes in the city and regional companies. Together, the Oldenburg-based energy researchers form the ENERiO association („Energy Research in Oldenburg").

The Institute of Networked Energy Systems also actively cooperates with university partners from across Lower Saxony that joined forces to form the Energy Research Centre of Lower Saxony (EFZN), as well as with a number of further national and international institutes. Within the German Aerospace Center (DLR), the Institute also benefits from numerous synergy effects at the interfaces with the DLR focal research areas of energy, transportation, digitalisation, aerospace and security.

Working Conditions at the Institute
The research building was constructed in 2008 with the specific aim of ensuring an optimum research environment and a modern workplace design. At this site, laboratories and offices for research, technology and administration are located under one roof, promoting active exchange and discussion between the employees across all disciplines.

The productive capacity of the Institute of Networked Energy Systems is based on expertly-trained and highly-motivated employees who have access to an attractive further educational programme. With flexible working hours and part-time employment options, we ensure the best possible balance between career and family. We also promote the balance required as part of everyday working life through exercise, healthy eating and relaxation with our Healthy Institute programme.

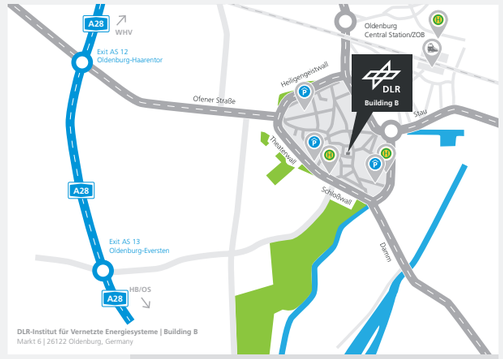
Promoting young scientific talent is very important to us: we enable young scientists to gain a practical introduction to research through early involvement in research projects. Students can collaborate with the Institute as part of their studies through apprenticeships, bachelor's and master's dissertations.

Living in Oldenburg
The university city of Oldenburg with a population of just under 170,000 is known for its excellent quality of life. As a commercial and cultural centre in the north-west of Lower Saxony, the city offers a lively pedestrian zone, several theatres and museums, attractive leisure facilities and various markets and events. Convenient bicycle lanes and bus networks make it easy to get around the city with a high degree of flexibility. Oldenburg is easy to reach via the motorways A 28 and A 29 and through the Intercity railway connection, while Bremen Airport is only 40 km away. Moreover, extensive natural areas and recreational spaces are available right on our doorstep, thanks to our proximity to the North Sea and the Netherlands.

Getting to the Institute of Networked Energy Systems

The Institute of Networked Energy Systems has two addresses in the Oldenburg urban area: Building A is right near the natural sciences campus of the University of Oldenburg in the Wechloy district. Building B is centrally located in the city centre. Both locations are easily accessible by train, bus and car.

Building A of the Institute of Networked Energy Systems is located in the west of Oldenburg in the Wechloy district.



With Building B, as of 2018 the Institute also has a location in the middle of Oldenburg's pedestrian zone.

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DLR at a glance

The German Aerospace Center (DLR) is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport, security and digitalisation is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for one of the nation's largest project management agencies.

DLR has approximately 8000 employees at 20 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Bremerhaven, Dresden, Goettingen, Hamburg, Jena, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Oldenburg, Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

DLR's mission comprises the exploration of Earth and the Solar System and research for protecting the environment. This includes the development of environment-friendly technologies for energy supply and future mobility, as well as for communications and security. DLR's research portfolio ranges from fundamental research to the development of products for tomorrow. In this way, DLR contributes the scientific and technical expertise that it has acquired to the enhancement of Germany as a location for industry and technology. DLR operates major research facilities for its own projects and as a service for clients and partners. It also fosters the development of the next generation of researchers, provides expert advisory services to government and is a driving force in the regions where its facilities are located.

DLR **Deutsches Zentrum für Luft- und Raumfahrt**
German Aerospace Center

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