E.ON Energy Research Center

Research & News

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News on Research & Education at E.ON Energy Research Center of RWTH Aachen University

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Topics in this Edition

Editorial

Dear Readers,

This edition of Research & News primarily focuses on the successful application of a RWTH consortium for research funding from the German Ministry for Education and Research. Since the end of September, we have learned that our interdisciplinary project "Electric Grids of the Future", encompassing various university faculties, will be funded to a sum of up to two million Euro per year for a maximum period of 15 years. All seven professors of the E.ON ERC will be involved in the research activities. We consider this to be exciting news that deserves to be reported in detail. Moreover, this distinction affirms the general approach of our research center: The cooperation with colleagues from other faculties belongs in a certain sense to the genetic underpinnings of the E.ON ERC.

I wish you enjoyable reading!

Rik W. De Doncker

RWTH | Approved Funding

Up to 30 Million Euro for Consortium of University and Industry

RWTH-Research Campus "Electric Grids of the Future" asserts itself against strong competitors

A great success for the Aachen research campus "Electric Grids of the Future": By the end of September, the research project, under the direction of E.ON ERC together with 14 chairs of RWTH Aachen University and industrial partners, has been named as one of the ten winners of the funding initiative, "Research Campus—Public-Private Partnership for Innovations" (also see page 2: Interview with Prof. Kagermann) of the Federal Ministry for Education and Research (BMBF).

Universities, research institutes and companies need to join forces at one place, namely the campus of the involved universities, to undertake joint and long-term investigations of a complex research theme. The research initiative belongs to the new instruments of the high-tech strategy of the German federal government. Each selected research campus is funded with up to two million Euro per year for a maximum period of 15 years. According to the BMBF in its calls for tenders, the involved partners

Immediately after his return from Berlin Professor De Doncker (right) informed during an informal celebration, that was spontaneously organized, RWTH Rector Prof. Schmachtenberg (left), as well as his colleagues and co-workers at E.ON ERC about the Research CAMPUS award and its underlying intentions.

have to bring in their own funds for the subprojects. This means that the federal funds will only be disbursed when the involved industrial partners match the federal funds. In addition, within the scope of the entire project, extensive third-party research funding has to be generated from other governmental ministries, the German Research Foundation, the EU or from industry.

"One of the most important principals at the E.ON Energy Research Center is to look beyond the horizon," said Professor Rik W. De Doncker, director of E.ON ERC, immediately after the winners had been announced in Berlin. "The multidisciplinary, task-sharing approach and the continuous exchange of experience and know-how of geophysicists, mechanical engineers, economists and electrical engineers in the meantime come natural to us. With the research campus "Electric Grids of the Future", we are even going farther in this regard (see p. 3 for more details). The cooperation with political scientists, urban and landscape planners, researchers from the social sciences and humanities or landscape architects is new and thrilling for us. I am completely convinced that all those involved will profit from this project and that, together, we can significantly contribute towards successfully realizing the energy transition."

"With the research campus, we have created a totally new type of cooperation centers that sustainably links the competencies and activities of the sciences and industry. With this long-term funding initiative, we are offering industry an incentive to maintain a direct and binding engagement in scientific research."

Source: BMBF

Prof. Dr. Annette Schavan, Federal Minster for Education and Research at the award ceremony for the ten winners of the funding initiative.

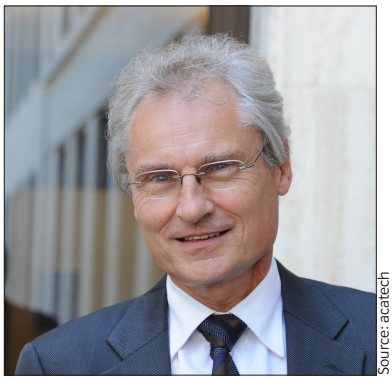
RWTH I Interview with Professor Kagermann

In an interview with Research & News, the jury chairman Professor Henning Kagermann explains the background of the funding initiative "Research Campus—Public-Private Partnership" and cites the essential reasons for deciding in favor of the RWTH project "Electric Grids of the Future".

Editor: *Professor Kagermann, what actually is the funding initiative "Research Campus—Public-Private Partnership" and what are its aims?*

Prof. Kagermann: Within the scope of its high-tech strategy, the federal government has named five fields that need to be addressed: health and nutrition, climate and energy, safety, mobility of the future, as well as communication. The federally funded initiative "Research Campus—Public-Private Partnership" ought to promote the long-term collaboration among universities, research institutes and companies in research involving these fields.

The aim is to bring together the competencies and activities of the sciences and industry to address particular challenges in these fields. The partners hereby establish a joint research campus to investigate a particular complex research topic. The federal government is to support these long-term projects with research funds of up to 2 million



Source: acatech

Henning Kagermann, habilitated physicist and former CEO of SAP, is the president of acatech—the German Academy of Technological Sciences. This academy, oriented for the good of society and supported by the German federal government and states, advises politicians and heads of society regarding issues of socioeconomic and technological relevance.

As chairman of the National Platform on Electromobility, spokesperson of the promoter group Communication of the Research Union as well as of the Control Circuit of the Innovation Dialogue among the German Federal Government, Industry and Science—Henning Kagermann is spurring the advance of important future-oriented projects such as "Electromobility and Industry 4.0".

He was chairman of the jury for selecting proposals within the scope of the funding initiative "Research Campus—Public-Private Partnership for Innovations of the BMBF".

Euro annually for a maximum period of 15 years. In addition to this are the extensive third-party funds coming from the cooperating partners of the research campus.

Editor: *Out of the around 90 qualified proposals, the jury, under your direction, selected the RWTH Aachen project "Electric Grids of the Future" as being worth funding, among other project proposals. What were the decisive reasons for this choice?*

Prof. Kagermann: With so many good proposals, our selection wasn't easy. However, we could quickly agree upon ten projects. There were three principal reasons for choosing the project "Electric Grids of the Future": these could be summarized under the terms 'relevance', 'compatibility' and 'consortium'.

The relevance of the topic was clear. Energy efficiency, power grids and energy storage all play a central role to ensure the success of the energy transition. The RWTH Aachen project addresses all three factors and hereby shows the great potential of DC power with respect to efficiency and cost-effectiveness. We considered this to be an interesting approach that should be continued further.

Nevertheless, it is hereby important that the new technological path be compatible with existing infrastructure. It is not feasible to completely replace the existing grid. For the jury, it was an important plus-point that the compatibility, i.e. the interface between alternating current and direct current is considered in the project. Finally, we were convinced by the broad spectrum and the competency of the consortium.

RWTH I Research Campus

Flexible and Secure DC Power Grids for Ensuring the Future Energy Supply

Demonstration plant on the new RWTH campus

The existing power grids in Germany—high-voltage, medium-voltage and low-voltage grids—are not capable of to sustaining the energy transition. Rather more frequently, they have proven themselves to be strategic bottlenecks, potentially resulting in power shortages. Electric grids of the future need to be more flexible in order to reliably feed more volatile and decentralized-generated electricity into the system. At the same time, these grids have to transport energy more efficiently, also during partial load.

There is good evidence that direct current technology will help to realize the energy transition in a definitely more cost-effective way—to counter recent arguments that it is simply too expensive. Not only are DC grids more flexible and secure, but they also work more efficiently than the existing power system.

Consequently, the research campus "Electric Grids of the Future" focuses on DC grids for all three voltage levels. To ensure compatibility with the existing grid infrastructure, the possible interfaces among the various systems are being investigated thoroughly. Moreover, a growing linkage among the various energy networks—electricity, gas, heat—plays a significant role in the research consortium. For example, this concerns the conversion of (an excess of) wind energy to hydrogen or, in the next step, to synthetic natural gas by means of the Power-to-Gas technology and the resulting enormous possibilities to store and transport energy in existing infrastructure.

The primary aim of the research campus is to enable a more efficient and flexible transmission and distribution of electrical energy, without impairing the already high quality of a secure power supply in Germany. Ultimately, the aim is to guarantee a sustainable, climate-friendly energy supply of the future at affordable prices.

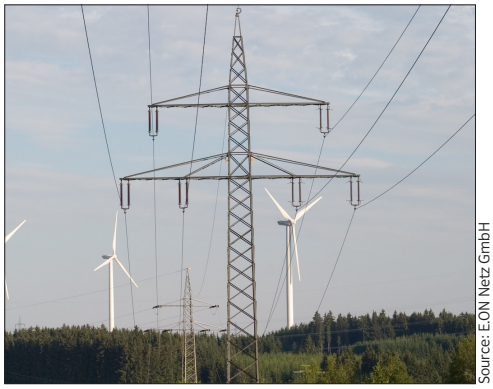
Advantages on all voltage levels

Today, modern voltage source converter (VSC) - direct current (DC) connections with voltages of over +/-300 kV are used to connect offshore wind farms into the main grid. Recent developments deal with raising the transmission efficiency and reducing costs. "DC connections are already now the most cost-effective solution when dealing with point-to-point transmission of electrical energy by undersea cables over large distances (transmission lines). Moreover, it is being researched how the capacities of existing AC transmission lines can be raised by simultaneously guaranteeing power system security when the systems are partially converted to DC systems," explains Professor Armin Schnettler of the Institute for High-Voltage Technology (IFHT) and who is responsible for the high-voltage field in the research campus "Electric Grids of the Future".

Currently, the advantages of the DC grids in the medium-voltage range are being intensively

investigated for busbar systems of wind farms, small combined heat and power plants or large photovoltaic plants. Such DC collector fields do not only improve the efficiency but also increase the reliability, because clearly less error-prone power electronics are needed at the source site, in particular in offshore turbines.

"Our studies in the medium-voltage range have meanwhile progressed so that concrete projects can be realized within the next five years," said Professor Rik W. De Doncker who, as head of the institutes "Power Generation and Storage Systems" (PGS) of the E.ON ERC as well as of the Institute for Power Electronics and Electrical Drives (ISEA), is director of the research campus as well as of the research consortium "Medium Voltage". "Thus, demonstration plants will be built on the new campus area of RWTH Aachen University so that we can gain practical experience with DC voltage systems in the medium-voltage range. Moreover, in cooperation with partner companies, we are developing key components such as the DC-DC converter, also called electronic DC transformers, as well as DC circuit breakers."



Source: E.ON Netz GmbH

Professor Antonello Monti, head of the E.ON ERC institute "Automation of Complex Power Systems" (ACS) and responsible for the field "Low Voltage" in the research campus "Electric Grids of the Future", is likewise convinced of the advantages of direct current systems: "In the low-voltage field, two important application areas can be identified: the use in households as well as the exploitation of DC technology for the efficient supply of energy in data processing centers. Both applications prove to be considerably advantageous in terms of efficiency."

For example, in the household area the realization of a parallel DC system with newer components such as photovoltaic units, heat pumps, storage batteries or accumulators for electric cars appears feasible. With DC technology, these components can be easier and, most importantly, more efficiently integrated into systems in particular, into Smart Homes. Even the electricity generated from larger producers can be directly integrated via a DC system into existing systems—avoiding the double conversion of AC to DC and again back to AC at the necessary frequency. "We are totally convinced that the home of the future will be particularly efficient when AC- and DC-systems are used together and in parallel," explains Monti.

Electricity, gas and heat networks move closely together

In the future, the connections of heat and gas networks with the electric grid will be tighter and more transparent. Thus, there are increasing possibilities to store electrical energy—inexpensively supplied during sunny and windy periods—in the form of heat. Consequently, by means of heat-pump technology and electrolysis, the electric grid can be more intensively linked with heat-storage systems, as well as with networks of the gas- and heat supply. Hot water storage tanks with electrical heat sources can likewise intermediately store any excess supplies of wind- and sun energy as heat. In addition, an overproduction of electricity generated by the renewable sources, such as wind and solar PV can be "buffered" by using this cheap electrical energy to produce hydrogen or synthetic natural gas. Through this Power-to-Gas technology, enormous capacities will be exploited for the indirect transport and indirect storage of electricity generated from renewable resources.

E.ON ERC Ticker

Already for the tenth time, RWTH Aachen University opened its doors for "5 to 12—The RWTH Science Night" on November 9th. This unusual Friday evening entertainment has meanwhile evolved to become one of the largest annual events in the city and region of Aachen. Also this year E.ON ERC represented itself with its own information booth in the Super-C building (see picture). Moreover, Professor **Dirk Müller**, head of the institute Energy Efficient Buildings and Indoor Climate, held a talk about the opportunities for success regarding the energy-efficient renovation of buildings.

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Within the scope of the CDU-information event at the Chamber of Trade of Aachen, the Federal Minister for Environmental Protection, **Peter Altmaier** (picture), explained his fundamental positions about implementing the energy transition. The subsequent discussion, organized by EnergyHills e.V., at which several scientists of RWTH Aachen University were invited and which was moderated by Professor **De Doncker**, clearly showed that the minister concurs in many points with the theses of the research campus "Electric Grids of the Future".

CDU/CSU/Christian Doppelgatz

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The research training group "Integrated Energy Supply Module for Electromobility – Range Extender" of RWTH Aachen University has been awarded with a stipend of around 4.5 million Euro. These funds will help finance a total of 24 doctoral projects. In this research training group, E.ON ERC is represented by the chairs of Professor **Rik W. De Doncker** and Professor **Dirk Uwe Sauer**.

Research Campus "Electric Grids of the Future"—Involved Chairs of RWTH Aachen University

Three research associations will be formed. At the head of the area "High Voltage" stands Professor **Armin Schnettler**. Moreover, Professor **Rik W. De Doncker** is responsible for the area "Medium Voltage", whereas Professor **Antonello Monti** is responsible for the area "Low Voltage".

In the research campus "Electric Grids of the Future", altogether 14 chairs of RWTH Aachen University, from the faculties of electrical engineering and information technology, architecture, economics, mechanical engineering, georesources and materials science, as well as the humanities and social sciences will be cooperating along with partners from industry. This includes the following people and their respective competencies:

• Prof. **Daniel Barben**, VDI –professorship, Chair for Future Studies, Institute for Political Science (IPW)	→ Analysis of the governance of science and technology: innovation, safety and risk control, intellectual property rights, ethics, acceptance policy; global challenges, sustainable development, preemption and evaluation of technology futures, energy and climate policy
• Prof. **Christoph Clauser**, Institute for Applied Geophysics and Geothermal Energy (GGE, E.ON ERC)	→ Geophysical and hydrodynamic reservoir technology (e.g. for geothermal energy and gas reservoirs)
• Prof. **Rik W. De Doncker**, Institute for Power Electronics and Electrical Drives (ISEA) and Institute for Power Generation and Storage Systems (PGS, E.ON ERC)	→ Power electronic DC converters, inverters, components, electronic stations for DC grids and control units of electric generators
• Prof. **Kay Hameyer**, Chair for Electromagnetic Energy Conversion / Institute for Electric Machines (IEM)	→ Drafting, design and optimization of electric machines and transformers; development and use of numeric 3D FEM calculation methods
• **N. N.**	→ Ethics of energy technologies
• Prof. **Frank Lohrberg**, Lehrstuhl für Landschaftsarchitektur (LA)	→ Design of energy infrastructure and spacial development
• Prof. **Reinhard Madlener**, Institute for Future Energy Consumer Needs and Behavior (FCN, E.ON ERC)	→ Energy economics, energy management, energy policy, energy risk management
• Prof. **Antonello Monti**, Institute for Automation of Complex Power Systems (ACS , E.ON ERC)	→ Dynamic simulation of grids, real-time simulation, components for automation
• Prof. **Albert Moser**, Chair and Institute for Power Systems and Power Economics (IAEW)	→ Grid planning and grid simulation, power economics, power supply reliability
• Prof. **Dirk Müller**, Institute for Energy Efficient Buildings and Indoor Climate (EBC, E.ON ERC)	→ Demand-side management in buildings and urban neighborhoods, connection of electric energy usage with heat usage
• Prof. **Ferdinanda Ponci**, Institute for Automation of Complex Power Systems (ACS, E.ON ERC)	→ Distributed intelligence and measurement technology
• Prof. **Dirk Uwe Sauer**, Chair for Electrochemical Energy Conversion and Storage Systems at ISEA and Institute for Power Generation and Storage Systems (PGS, E.ON ERC)	→ Storage systems with the focus on battery systems, modeling of electrochemical systems, in particular batteries and electrolyzers (in cooperation with the Research Center Jülich)
• Prof. **Armin Schnettler**, Chair and Institute for High Voltage Technology (IFHT)	→ Transmission line and cable technology, protection and switch components, insulation coordination, diagnostics, eco-balancing
• Prof. **Kunibert Wachten**, Chair and Institute for Urban Development and Regional Planning (ISL)	→ Evaluation of visual tolerance to urban and regional landscapes

E.ON ERC | Colloquium

Within the scope of a colloquium at the E.ON ERC, **Jürgen Apfelbeck** of the Institute for Energy Economics and Rational Use of Energy (IER) of the University of Stuttgart presented **Model Approaches for Taking into Account Operative and Strategic Congestion Management in the Analysis of Electricity Markets**. After introducing the research fields of IER and the model tools, Apfelbeck addressed the current challenges placed on the electricity system and grid infrastructure. He introduced measures to relieve congestion, and he comprehensively reviewed and evaluated the various possibilities of operative and strategic congestion management and combinations thereof, including the connected costs. On the basis of an integrated model approach, Apfelbach also introduced exemplary results for grid expansion up to 2030.

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Professor **Seung-Ki Sul** of Seoul National University, Korea gave a talk at E.ON ERC entitled "**Series Connection of Current Source Converters in the Viewpoint of Control and Implementation Issues.**" For application in high-voltage ranges, voltage source converters (VSC) are generally used in parallel connection. By contrast, current source converters (CSC) are connected in series for multi-megawatt power conversion. Current source converters show pros and cons. On the one hand, the current source converter has to be equipped with bulky inductors in the DC link. On the other hand, the current is limited, and it is very robust during short-circuits. The DC link voltage can be easiliy increased by a series connection. This, in turn, can be advantageous with regard to power transmission over long distances, for example, in the connection of offshore wind farms to the transmission grid. In his talk, the Korean scientist presented, among other aspects, the necessary technical framework conditions for the practical incorporation and control of current source converters.

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In their tandem presentation entitled "**Envisaging Cradle-to-Cradle Biorefineries**" and in light of increasing pressure to develop more environmentally friendly and sustainable processes and products, Dr. **Fabrizio Sibilla** (left) of the Nova-Institut GmbH and Dr. **Pablo Domínguez de María** of RWTH Aachen University pointed out the increasing significance of the complete recovery of materials in the production cycle that is typically observed in natural cycles. The general framework conditions of an 'ecodesign' were also presented as well as the effects on and the implications for our future lives expected through the realization of such holistic principles.

Events/Dates

January 8, 2013	**Visit of a BMBF-delegation at the research campuses "Electric Grids of the Future" and "Digital Photonic Production"**
January 24, 2013, 4 p.m.	**Colloquium: The Role of Grids in Energy Economics.** Arjuna Nebel, Wuppertal Institute for Climate, Environment and Energy
Information/E-Mail:	***colloquium@eonerc.rwth-aachen.de***

E.ON ERC | E.ON Energy Research Center,
RWTH Aachen University,
Prof. Dr. ir. Dr. h. c. Rik W. De Doncker

ACS | Automation of Complex Power Systems, Prof. Antonello Monti, Ph. D.

EBC | Energy Efficient Buildings and Indoor Climate, Prof. Dr.-Ing. Dirk Müller

FCN | Future Energy Consumer Needs and Behavior,
Prof. Dr. rer. soc. oec. Reinhard Madlener

GGE | Applied Geophysics and Geothermal Energy, Prof. Dr. rer. nat. Christoph Clauser

PGS | Power Generation and Storage Systems, Prof. Dr. ir. Dr. h. c. Rik W. De Doncker

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