E.ON Energy Research Center

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

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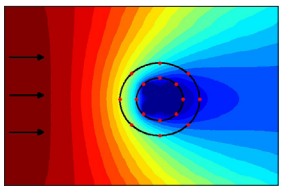
Topics of this issue

Optimized operational management of a geothermal probe field



With a combination of innovative measurement techniques and simulation methods, GGE collects and processes data on the direction, speed, and temperature changes of groundwater flows. Based on these data, supply concepts for energy-efficient buildings are being developed and refined with the inclusion of near-surface geothermal energy.

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In this interview with Research & News, Dr. Christian Haag, head of the central FEN coordination office, explains current developments regarding the Forschungscampus (research campus) Future Electrical Networks (FEN), a joint project involving 14 chairs at RWTH and numerous industry partners.

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Editorial

Dear Readers,

We are pleased to present FINESCE, a European research project being conducted within the scope of the EU's extensive Future Internet Public-Private Partnership (*FI-PPP*) project, in which the institute ACS is involved in a leading role. E.ON ERC has won international acclaim, a fact that is also apparent in that ACS is strongly represented on both the Steering Board and the Architecture Board of FI-PPP. Innovative systems to supply heat and cooling to our main building play a major role in this issue. The same is true of the latest positive developments at the Forschungscampus Future Electrical Networks. We are also pleased to announce that the international exchange program IECP, which we initiated, is successfully being used by students.

Happy reading!

Rik W. De Doncker

ACS I Smart grid

Real-time communication makes networks smarter

ACS simulates regional and local solutions for FINESCE research project

Power grids need to become not only stronger, but also smarter. Otherwise, it is hardly possible to integrate the increasingly volatile energy generated through solar and wind power into the complex electricity supply system. But the grid can only become more intelligent if power generators, consumers, and storage facilities exchange all of the important information with each other on an ongoing basis and in real time. Generators need to know when and where power usage changes, and consumers need to be informed of when generation increases or decreases as a result of weather conditions. At the same time, it must be known where which storage facilities are available to act as consumers or suppliers, and what their capacity is. Only then will the overall system be able to respond appropriately in order to ensure a reliable, safe and efficient energy supply at all times.

FUTURE INTERNET SMART UTILITY SERVICES

FINESCE

In other words, the often-mentioned smart grid will not work without intelligent – and above all, fast – communication between everyone involved. In the FINESCE (Future Internet Smart Utility Services; see *http://www.fi-ppp.eu/projects/finesce*) project, about 20 well-known European partners from industry and the research sector are working together to simulate and realize a smart power grid in selected sample cities or regions as examples. The EU is providing 13 million euros in funding for the two-year project as part of its Future Internet Public-Private Partnership program (*http://www.fi-ppp.eu*), with another six million euros being provided by industry partners.

In terms of simulation of communication infrastructure, the research lab of Swedish tele-

communications group Ericsson, in the city of Herzogenrath, near Aachen, is a leader, with simulation of energy supply handled by the Automation of Complex PowerSystems (ACS) institute of the E.ON ERC at RWTH Aachen. Alongside large-scale exchange of energy, including across national boundaries, FINESCE also – and especially – aims to study whether, and if so how, consumption and generation can be aligned within a regional framework. "If fluctuations in generation are already compensated for by local adjustments in consumption, the load on the national transmission grid automatically decreases," says ACS professor Antonello Monti, explaining this approach. "Having only short distances to travel also helps cut unnecessary waste," he adds.

The researchers in Aachen are studying, as an example, how the power generated at an international virtual power plant – with generation facilities in Belgium and Germany controlled centrally – and demand from the new production facilities for the electric StreetScooter in Aachen, can be aligned with each other. At present, the ACS team is using simulation to test the power plant software to achieve this. "To do this," Monti says, "we can use the Real Time Digital Simulator, or RTDS, which is, after all, Europe's most powerful test platform."

In the Italian city of Terni, northeast of Rome, one of the FINESCE teams is working to develop an energy marketplace where generators and major consumers can trade energy in a coordinated way in order to prevent unnecessary transmission. At the same time, the team is studying whether, and if so, how end consumers can be prompted to shift energy use to "favorable" times. In Malmö, Sweden – with substantial involvement by E.ON Sweden – in Horsens, Denmark, and in the Spanish capital, Madrid, the main goal is to ensure that buildings or neighborhoods, some of which have their own power generation facilities, are integrated efficiently into the overall system. Another subproject, this one in Ireland, is highly important to the future of the energy supply and electric mobility. In it, researchers are investigating whether, and if so to what extent, centralized control of electric vehicles' charging and discharging processes can be used to compensate for the fluctuations in power generated by the many wind turbines in the west of the island.

Beyond his work on the FINESCE project, Professor Antonello Monti is a member of the Steering Board of the Future Internet Public-Private Partnership (*FI-PPP*). Together with Padraic McKeever, he is also part of the Architecture Board of this EU program.

All of the test regions except Terni regularly supply current data to Aachen. On this basis, ACS performs new simulations on an ongoing basis to calculate variations and further refine systems. "Simulation and reality work closely together here," says Padraic McKeever, who supervises the project together with Professor Monti, Marija Stevic, Mohsen Ferdowsi, and Michael Diekerhof, summing up the task of ACS.

Alongside the processes that take place in electric supply systems, the FINESCE project is also using simulations to study the thermal behavior of buildings. This task has been taken on by the Energy Efficient Buildings and Indoor Climate (EBC) institute of the E.ON ERC, which is headed by Professor Dirk Müller.

GGE I Near-surface geothermal energy

Optimized operational management of a geothermal probe field

Innovative geothermal probe with temperature sensors measures groundwater flow speed and direction

There are a lot of innovative ideas behind the efficient supply of heat, cooling, and power within the main building of the E.ON ERC (see *Research & News 2/2013*). But that's not all; the complex system is also part of multiple research projects aimed at further refining and improving the system during live operation and arriving at important insights to help design similar facilities. In one of these research projects, the Applied Geophysics and Geothermal Energy (GGE) institute of the Aachen-based energy research center is optimizing the use of the geothermal probe field, with its 40 boreholes approximately 100 meters deep. In the winter, these boreholes supply heat as needed. During the warmer half of the year, the system is simply "turned around," and the excess heat generated when cooling the building is discharged into the subsoil via the probe field.

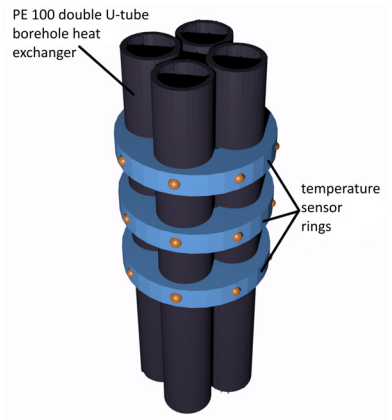
GGE is working closely with the Energy Efficient Buildings and Indoor Climate (EBC) institute to study topics such as how dynamic control of the probe field can be used to optimize the efficiency of the building's energy supply. To that end, numerical simulations are being performed based on the boreholes' physical parameters and on data on the heat conductivity of the subsoil.

These data are gleaned through long-term monitoring of the entire probe field using fiber optic temperature measurements in the boreholes. To that end, all 40 double U-tube boreholes are equipped over their entire length

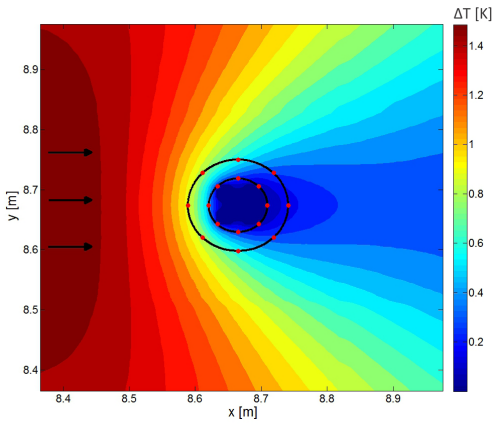
with optical fibers. An optical technique is used to capture temperatures at ten-centimeter intervals in each borehole. The data gathered in the process are used for new simulation calculations on an ongoing basis, allowing the researchers to bring the system up to its optimum operating mode step by step. Two of the boreholes are also equipped with hybrid cables – optical fibers with a copper core. The copper wire can be heated for short periods to gain information on heat conductivity in the subsoil via the optical fiber. The measurements taken so far have shown that the heat conductivity around the main building of the E.ON ERC is especially high between 70 and 90 meters under the surface.

As part of a separate research project, an additional borehole, also 100 meters deep, is planned for a special double U-tube borehole heat exchanger (BHE) (see figure at right). This probe will be equipped with a ring of temperature sensors to determine groundwater flow speed and direction. There are also plans to use the new system to depict the effects of temperature fluctuations on the heat conductivity of the filler material, a special cement mixture with high heat conductivity. The measurement technology and method are currently under development, and should be ready to use in the next few months. To check the functionality and reliability of the new measuring method, the relevant data are also being collected using "conventional" methods in a different borehole equipped with the technologies that have been common to date.

Ultimately, the combination of known and new measurement techniques and simulation methods used here will help collect and process reliable data on the direction, speed, and temperature changes of groundwater flows at different depths below the surface. This will lay the foundation for the development and further refinement of innovative supply concepts for energy-efficient buildings, including near-surface geothermal energy.



Schematic diagram of a double U-tube borehole heat exchanger (BHE) with temperature sensors to determine groundwater flow speed and direction.



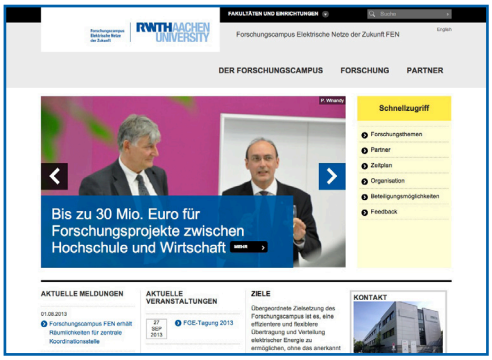
Simulation results for the temperature difference in the area surrounding the BHE with groundwater flow from left. Flow speed: 85 m/a; subsoil temperature: 10°C; temperature difference between inlet and outlet: 0.5 kelvins.

RWTH I Interview with Dr. Christian Haag

Forschungscampus Future Electrical Networks successfully launched

Industry making use of attractive partnership models

The Forschungscampus (research campus) "Future Electrical Networks" (FEN), a consortium of 14 chairs at RWTH Aachen and industrial partners, is among the ten winners of the "Forschungscampus – Public-Private Partnership to Foster Innovation" funding initiative launched by the German Federal Ministry of Education and Research (BMBF) (s. *Research & News 3/2013*). Activities in Aachen focus on direct-current networks for all three voltage levels, interfaces between the existing AC system and the new DC grids, and increasing coupling among the networks for electricity, gas, and heat. The three main areas of high, medium, and low voltage are the responsi-



Current information on partners, schedules, ways to get involved, and the organization of the FEN is available at www.fen.rwth-aachen.de.

bility of RWTH professors Albert Moser, Rik W. De Doncker, and Antonello Monti. On the university side, the consortium encompasses all five institutes at E.ON ERC as well as nine other chairs at RWTH.

The FEN Forschungscampus will receive as much as two million euros per year in funding over a period of 15 years. The funds will be approved in several phases, but only if industry research partners involved in the initiative provide matching funds in each case. To ensure the continuity of funding, the selected projects are required to submit regular reports on the progress of their work (see the interview with Dr. Christian Haag below).

In this interview with *Research & News*, Dr. Christian Haag, head of the central FEN coordination office, explains current developments in this joint project involving 14 RWTH chairs and numerous industry partners.

Editor: *Dr. Haag, winning one of the ten funding awards in the "Forschungscampus – Public-Private Partnership to Foster Innovation" initiative is definitely the most important step, but it is also only the first step. Where do things stand right now?*

Dr. Christian Haag has been in charge of the FEN coordination office since August 2013. Before that, he worked for RWTH Aachen Campus GmbH, a role in which he was responsible for campus development and corporate acquisitions.

Dr. Haag: We are already making good progress even after just a few months. With the central coordination office, we have launched the operational avtivities of FEN in the RWTH Campus Cluster Sustainable Energy. In the meantime we have set up and moved into our own office space and a firm agreement is in place about moving temporarily to the RWTH Campus Logistics Cluster – the building is under construction now.

Redaktion: *Why do you want to move to a site on campus?*

Dr. Haag: There are several reasons. The Center for Wind Power Drives is located near the Logistics Cluster. There will be a high-performance DC cable connection from there to the new DC grid on the campus. For that reason alone, many partner companies are highly interested. In addition, many companies want to be represented in FEN with their own employees right on site. Plans already call for a total of 30 people. We simply need the space for it.

Beyond that, it is no accident that the word "Forschungscampus" also includes the term "campus." In both cases, the setting focuses on close cooperation among equal partners in interdisciplinary research areas, between academia and the business sector. That is definitely also one of the reasons why we receive so much support from RWTH leadership.

Redaktion: *Can you tell us anything about industry partners at this stage?*

Dr. Haag: I'd rather not name any names yet. But there is definitely a lot of interest. After all, research at the FEN focuses on all three voltage levels. In addition, expanding and renovating the electrical grids is a very important topic right now, as Germany works on its energy reconversion, the so-called "Energiewende" – in terms of transmission grids as well as distribution grids.

Our partnership models are obviously very appealing. We offer a highly innovative setting, all partners gain access to patents and publications, existing test infrastructure is available for use. Furthermore, our partners' employees can gain further skills and qualifications, and contact with the next generation of researchers arises practically automatically. There is also a lot of interest in the industry in developing standards for DC components.

E.ON ERC Ticker

In mid-September, **Professor Rik W. De Doncker** (here, at left) was awarded the **IEEE William E. Newell Power Electronics Award** for his outstanding contributions to the further development of power electronics (for more info, click *here*).

IEEE President **Dr. Peter Staecker** (here, at right) presented the award in person during the Energy Conversion Congress and Expo, in Denver. During his speech, Professor De Doncker thanked the IEEE, the world's largest association of engineers in the fields of electrical engineering and information technology, and announced that this award gave him and his colleagues and research associates at the RWTH institutes ISEA and PGS as well as throughout E.ON ERC further impetus to intensify their research on an environmentally friendly energy supply. Power electronics, he said, is a key technology as we move toward becoming a sustainable, CO_2-neutral society.

* * *

In September, the **European Power Electronics** (EPE) and **IEEE Energy Conversion Congress and Expo** (ECCE) were held jointly in Lille, France. As part of a talk by the E.ON ERC (PGS and ACS), the design for a new transfer station to supply energy to the European Spallation Source (ESS), in Lund, Sweden, was presented. Other important topics included direct current high and medium voltage networks and the concept for a high-voltage DC grid in the Mediterranean area, in which the DC-DC converter developed at E.ON ERC plays an important role. Professor De Doncker, who was heavily involved in ensuring that this joint EPE and IEEE event could take place, was elected the chairman of the coordination committee for organizing the next IEEE-EPE ECCE conferences.

E.ON ERC I International Energy Cooperation Programm

RWTH student writes master's thesis at Loughborough University

The international approach of the E.ON ERC takes many forms, including the *International Energy Cooperation Program (IECP)*. This program offers opportunities for researchers, students, and postgraduates (master's and PhD candidates, interns), including exchange opportunities, through cooperation on various subjects with research institutions all over the world.

The first student to successfully participate in the program was Manuel Siegl. For his master's thesis, Siegl, a business administration and engineering student, selected a topic from the area of hydrogen production. With the support of the E.ON ERC administration, Loughborough University was soon identified as a possible exchange university. After what Siegl calls a "remarkably uncomplicated" process to clear up the organizational details, he arrived at the English university in April 2013.

Right from the start of his stay in England, Siegl was integrated into the Renewable Energy Research Group within the university's chemistry department, where he was able to focus on his thesis topic, from the field of photoelectrochemical production of hydrogen. One primary area of focus was the influence of different heat treatments on the photoelectrochemical properties of photoanodes made of tungsten(III) oxide.

The graduate student was very pleased at how helpful and friendly his supervisor and the PhD students were. His summary: "If you want to write your master's thesis in a very international environment while also greatly broadening both your personal and professional horizons, I can only recommend a stay in England."

E.ON ERC I Colloquium

Under the title **Research and Scholarship for Enabling a Sustainable Society**, **Professor Jayant Baliga**, Distinguished University Professor an der North Carolina State University, held a talk as part of the E.ON ERC's colloquium series.

At the start, Baliga, a world-renowned and highly regarded power electronics specialist

who worked at RWTH Aachen in the summer of 2013 as a visiting scientist as part of the ERS fellowship program, outlined how his research brought him to develop the insulated-gate bipolar transistor (IGBT). Baliga highlighted the extensive use of this power electronics switching element in various fields of application, from electrical consumer goods to industrial applications, in lighting, in the transportation sector, in the automotive industry, in healthcare, and, of course, also in the use of renewable energies. Baliga said that according to his calculations, the reduced use of energy and fuel that the transistor has made possible has, by itself, saved consumers have more than 15 billion U.S. dollars since the early 1980s. During the same period, he said, that added up to about 35 million tons of CO_2 that was not emitted into the environment.

Finally, Baliga explained, the development of high-efficiency power electronics components paves the way for a society that uses power sustainably. The improved quality of life benefits billions of people, while at the same time, negative influences on the environment have been reduced. Professor Baliga called the trend toward a sustainable society and energy supply essential in terms of maintaining prosperity. With this in mind, many of Baliga's publications call for greater investment in outstanding scholarship.

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

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

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

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

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

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

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