Topics of this issue

Forschungscampus Future Electrical Networks: first main phase approaching launch

The launch of the first main phase of the Forschungscampus (Research Campus) Future Electrical Networks (FEN) is coming up. Its flagship project is a medium-voltage DC grid that is being developed on the RWTH Aachen campus for research purposes. The 5-megawatt DC-to-DC converter developed at the PGS institute (see illustration) is an important prerequisite for this.

Alternative mobility: conventional engines continue to dominate the market

Better fuel economy, lower emissions, and larger ranges are the main things consumers require from vehicles with alternative drives, according to an FCN survey. Among these vehicles, the research shows that those with natural gas (image) and hybrid drives have the brightest prospects.

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E.ON ERC | Energy storage

Aachen to host world’s unique large-scale battery storage system

Institutes at E.ON ERC responsible for concept, operation, system integration and academic and scientific support

Germany’s energy transition needs storage. Alongside storage facilities to help compensate for long-term fluctuations in generation and demand over the course of the year, buffer storage is also needed to help compensate for short- and medium-term dips in production or peaks in demand. The world’s first large-scale modular battery storage system in the five-megawatt power class is currently being built in Aachen for just these short- and medium-term uses. The project, entitled M5BAT (Modular Multi-Megawatt Multi-Technology Medium-Voltage Battery Storage), encompasses 12.5 million euros in investment volume. The German Federal Ministry of Economics and Energy is providing about half of the total, with 6.5 million euros in funding as part of its Energy Storage Funding Initiative.

The partners in academia, the research sector, and the business sector that are involved in this project are

E.ON ERC at RWTH Aachen University, including the PGS and EBC institutes, the RWTH Institute

The large-scale battery storage system is being built in an existing building on Aachen’s Hüttenstrasse.
of Power Systems and Power Economics (IAEW), the energy provider E.ON SE, battery manufacturers Exide Technologies and Beta-Motion, and inverter manufacturer SMA. The partners will be working together over four years to optimize the structure, construction, and operation of these kinds of large-scale battery storage systems.

What makes M5BAT distinctive, aside from its size, is the modular structure of the storage system. Different battery technologies are being combined across five banks. Two lithium-ion banks will serve above all to provide short-term compensation for up to 0.6 hours. These batteries feature high output and accordingly fast charge/discharge cycles, but are – still – more expensive than lead-acid batteries, which will account for two other banks. Assuming a full charge, these batteries will discharge the rated output over a period of about one hour. The fifth bank of batteries will consist of sodium nickel chloride high-temperature batteries that serve to provide energy for about two hours. Overall, the large-scale battery storage system, located on Aachen’s Hüttenstrasse, is designed to ensure that even if one bank fails, a reliable output of five megawatts can still be fed into the medium-voltage grid via the neighboring substation.

Compared with conventional storage methods, battery storage systems have a number of advantages. Unlike pumped-storage hydroelectric plants or compressed-air energy storage, location decisions for batteries are completely independent of geographic circumstances, with economic and technical considerations being the deciding factors instead. Long periods of preliminary planning are not necessary, in part because it is relatively easy to accommodate environmental protection requirements in choosing a site.

Thanks to the modular structure with its multiple battery banks, the planned academic research to be performed as part of this project goes far beyond the field of technical layout and functionality of various storage techniques. The project will primarily be exploring ways to integrate electricity generated through renewables more easily into the complex supply system, but it will also look at whether, and if so how, the different banks and overall system are suitable for providing or delivering primary and secondary reserve power, reactive power compensation, and for use of electrical price differences in electricity trading.

Within this project, energy provider E.ON SE is handling the renovation of the existing building and, with support from the RWTH institute IAEW, the marketing of the electrical energy for various applications in the energy market. Operation of the system, system integration, and scientific support and supervision will be provided by the institutes at E.ON ERC. The above-mentioned manufacturers will supply the various components. In principle, additional innovative battery technologies can also be put to the test in the future. Construction work is scheduled to start this fall, with the large-scale battery storage system going into operation in 2015.

### M5BAT – goals

- Development of a design manual for battery storage plants in a medium-voltage grid (cost-optimized structure, security technology, control technology, operating costs)
- Preparation of guidelines for pre-qualification for various market segments
- Conceptual development for cost-effective operation in a medium-voltage grid
- Optimization of system controls (operation and battery management)
- Development of controls for inverters in battery storage plants
- Determination of standard load profiles for various market segments
- Establishment of a requirements catalog for the further development of battery technologies
- Development of optimized battery cells for certain load profiles
- Studies of reliability, lifespan, and efficiency

### First main phase: four projects with ten million euros in funding volume applied for

The Forschungscampus Future Electrical Networks (FEN – see Research & News Nr. 3/2013 und Nr. 4/2013) is taking concrete form. Work is slated to get under way in the first main phase on the RWTH campus right away. A report on the progress that has been made and the applications submitted for specific individual projects – both of which are among the preconditions for further funding of the FEN by the German federal research ministry – were edited and published in late March. The four project applications were developed by RWTH with close cooperation of industry partners, under the leadership of Professor Rik W. De Doncker and the management of the PGS institute at the E.ON ERC. Before that, the planned research topics were presented at workshops with industry partners and discussed in detail. The specific projects are:

- Modeling, planning, conceptualization and evaluation of networks of the future
- System and network technology
- Control, operational management, automation
Conventional engines continue to dominate the market

Prospects for alternative drives trains improve with larger ranges, lower maintenance costs, and better environmental protection

Better fuel economy, lower purchase prices and emissions, and larger ranges are the main things consumers require from vehicles with alternative drives, according to the main results of a survey conducted by the FCN institute at E.ON ERC as part of a recent study. The survey focused on how consumers can be motivated to purchase a vehicle with an alternative drive. All 711 respondents from Germany had purchased a vehicle in the previous year or planned to buy a new one within a year.

There were seven drive types listed in the survey: biofuel, natural gas, hydrogen/fuel cell, hybrid, plug-in hybrid, full electric, and conventional gasoline or diesel combustion engine.

According to the study, the factors with the strongest influence on the choice of vehicle type are the purchase price, costs of fuel, and CO₂ emissions. Younger respondents and users who drive primarily in urban settings prefer hybrid or electric vehicles, with the decision in favor of pure electric drives being affected mainly by driving range and battery charging times.

Low maintenance costs increase acceptance of higher purchase prices. For example, the car buyers surveyed are willing to pay a price that is between 530 and 1,070 euros higher, depending on vehicle class, if that means in return that the fuel costs are one euro lower for every 100 kilometers. For each percent of vehicle-specific CO₂ emission reduced, purchase prices of between 20 and 90 euros
more are accepted. Survey respondents would also accept rising prices in exchange for extended ranges, approving between 16 and 33 euros more for each additional kilometer driven in vehicles with all-electric drives and anywhere from eight to 17 euros in the case of the other kinds of alternative drives.

Targeted government support can also have a significant impact on purchasing decisions. If a tax exemption is granted over the vehicle’s entire lifespan, sales prices can be from 2,330 to 4,700 euros higher than those for vehicles with conventional drive systems. Even “soft” factors such as free parking or permission to use bus-only lanes boost the prices respondents find acceptable by 1,620 to 3,280 euros.

Regardless of the nature and extent of the improvements in the characteristics of vehicles with alternative drives, conventional engines will continue to rule the vehicle market for a long time to come. Among vehicles with alternative drives, respondents believe natural gas and hybrid drives have the brightest prospects. In the case of purely electric vehicles, the survey results show that rising success on the market cannot be expected until a single battery charge is enough to drive about 750 kilometers.

The survey results were published under the title “Consumer preferences for alternative fuel vehicles: A discrete choice analysis.” To request the article and additional materials on this topic free of charge, please e-mail newsletter@econerc.rwth-aachen.de.

**New geophysics textbook**

A new textbook titled “Einführung in die Geophysik” (Introduction to Geophysics) has been published, the first of its kind to be published in German since 1990. The book’s author is Professor Christoph Clauser, head of the institute GGE at E.ON ERC. It summarizes the current status of knowledge on global physical fields and processes within and outside the earth in a modern form.

In the book, Clauser introduces beginners to geophysics at an intermediate level. Students of geophysics, earth sciences, environmental studies, physics, and geocology will gain a fundamental understanding of the physical forces, fields and processes within and outside the earth. Mathematical derivations are explained in detail where necessary. Exercises allow students to check what they have learned.

All of the book’s chapters are prefaced by a brief historical section that explains how the discipline dealt with in that chapter has developed up until the very recent past. Biographical information on selected scientists shows the outward and personal conditions under which groundbreaking results have been produced.

Einführung in die Geophysik has been published by Springer Spektrum and is available from the publisher for 59.99 euros in hardcover or 46.99 euros as an e-book. For more information, please visit [www.springer.com](http://www.springer.com) and see the Geowissenchaften/Angewandte Geowissenschaft (Earth Sciences/Applied Earth Science) section or [click here](#).
German-Canadian working group pursues bilateral research project

The international approach taken by E.ON ERC is clearly apparent in various ways, including the center’s many cooperative arrangements within the scope of the International Energy Cooperation Program (IECP). On the bilateral level, the center’s philosophy is evident in its membership in the Canadian-German U15/U20 initiative, in which 15 leading Canadian universities and 20 German ones have joined forces to generate synergetic effects through international cooperation. The goal is to map out joint research topics and then, as the next step, identify and implement specific research projects that merit support in two fields: “smart grids for the future” and “innovative geothermal field systems.” To this end, two working groups for the respective research topics have been founded under the leadership of the University of Alberta, Canada, and E.ON ERC at RWTH Aachen University in Germany.

A first joint workshop in the geothermal energy working group was held in Edmonton, Canada, on December 6, 2013, during which four areas of focus for research activities were identified. After that, the researchers met in early March 2014 at E.ON ERC at the invitation of the GGE institute in order to set out concrete details for their work and identify possible projects and financing options. Over the course of the discussion, it became clear that renewable geothermal energy is still considered more of a niche in both countries. The researchers concluded that the only way to change this will be through projects with global relevance. Against this background, long-term use of geothermal reservoirs was identified as a particularly important topic. Based on research projects that are currently under way, but whose importance lies more at the local level, the researchers plan, finally, to develop an overarching project on the topic of creating and maintaining geothermal reservoirs that is of interest to the national research funding sectors in both countries.

Dr. ir. Erik Delarue of Katholieke Universiteit Leuven gave a presentation titled “Modeling electricity generation systems: on integration of renewables and CO₂ abatement” in mid-March as part of the FCN Colloquium series. His talk focused on how CO₂ prices affect power generation structures and the development of the relevant emissions as well as the effects of increasingly renewable generation on CO₂ prices. Ultimately, Delarue said, use of power plants will be affected to a large extent by the price of carbon allowances. Low prices for allowances, which are practically an automatic product of increases in power generation from renewable sources, tend to favor the use of coal and lead to increases in CO₂ emissions in other economic sectors as well. Eco-friendlier power generation with efficient natural gas power plants does not become economically attractive until the costs of allowances rise. The scope of reduced emissions also depends significantly on the prices of raw materials and on grid loads. CO₂ emissions decrease to a remarkable degree when both demand for electricity and raw material prices are moderate. This advantage shrinks, however, as the prices of natural gas and coal rise and power consumption grows.

Professor Reinhard Madlener of FCN and Dr. Delarue plan to pursue further cooperation and are currently preparing their first joint research project.