Electromobility: Fast-tracking innovation

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A lot's going to change with the transition to electric cars: The automotive industry will no longer manufacture certain parts for vehicles, yet new ones will take their place instead. Utility companies will need modified business models and fee structures for supplying electricity to vehicles.

In Germany, electromobility must be expedited on a systematic and holistic basis, and must be seen from the perspective of a complex system. "We are working on all angles of electromobility: Designs, system integration, energy generation and distribution, storage technologies and a whole lot more. The expertise is uniquely available at the Fraunhofer-Gesellschaft and bundled into our consortium 'Fraunhofer System Research on Electromobility,'" as Professor Ulrich Buller, Senior Vice President for Research Planning, points out. The goal of the Fraunhofer researchers is to develop prototypes for hybrid and electric vehicles, in order to support the German automotive industry as it makes the crossover to electromobility. The federal ministry for education and research BMBF is funding these plans with a total of 44 million euro from Economic Stimulus Programs I and II.

Demonstration vehicle as scientific test platform

The researchers in the group project are therefore not only working on new parts, but also on an electrically operated demonstration model, the "Frecc0," which is the abbreviation for "Fraunhofer e-concept car Type 0." Currently under construction, this vehicle serves as a scientific integration platform and will indeed demonstrate the system competency

of Fraunhofer institutes. Automobile manufacturers and suppliers can also use the "Frecc0" to test new components jointly with the Fraunhofer institutes starting in 2011. The basis is an existing car: The new Artega GT from Artega Automobil GmbH provides an ideal platform for the integration of Fraunhofer components. For example, researchers can test how a crash-proof battery system, a wheel hub motor and a battery charger behave in the car as a total system.

Networked research on the battery system

The experts from eleven Fraunhofer institutes are working at full speed on the battery system: It's no easy task, because the batteries and electrical systems in the vehicle are subject to the toughest standards. They must be safe, durable and efficient. And the driver must be able to tell at any time how much farther he can get before the battery needs a recharge. He also wants to know about traffic hold-ups so that, if necessary, he has enough time to find a service station. Whereas it is easy to determine the filling level of a gas-powered vehicle, this is not so easy with the battery of an electric car. A lithium-ion battery system mostly consists of several hundred cells, and they do not always run down at an equal pace. And if isolated cells break down or no longer deliver the intended capacity, then the entire battery may be affected.

To counter these problems, elaborate, cross-networked battery management systems are used, as well as a higher-level energy management system. Researchers are developing such a system, which until now, has only existed in prototypes - for stationary battery systems, at that. Project manager Dr. Matthias Vetter of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, who is coordinating the plan, explains the basic principle this way: "Within fractions of seconds, the electronics measure the line-to-line current, the single cell voltage and the temperature of each cell, and from this determine their state of charge and state of health. This way, a determination can be made for

each cell on the threat of overload, excessive discharge, overheating or premature aging."

One challenge that scientists face is being able to determine reliable values during continuous operation. For the most part, the data cannot be captured here in the quality required. One has to draw conclusions regarding the actual measured values and internal conditions - like state of charge and state of health - based on defective measurements. Vetter explains this complex car battery system: "It contains two strings, each with eight modules of twelve cells. For controlling, a total of 16 interlinked battery management systems are used. They communicate with an energy management system integrated into the battery pack via a databus widely used throughout the automotive industry - a CAN (Controller Area Network). For example, the system can equalize differing charge statuses of the cells, and thus always provide maximum capacity and energy. At the same time, it can also issue forecasts." The electronics also measure the onward and reverse flow temperatures of the attached cooling circuit. On the one hand, the pump should ensure that no overheating occurs; on the other hand, it should consume as little energy as possible itself. To do so, the system also controls the cooling circuit by means of a model-based regulator, thus optimizing energy consumption, lowering peak temperatures, and increasing reliability.

At the same time, the system takes over communication with the vehicle. For instance, it submits forecast reports on distances and threshold values, both for drive control as well as for charging operations. In addition, it monitors itself to determine if the desired power violates critical current and voltage limits. Then, at any time, the driver can read from the instrument panel how far he needs to drive until the battery has to be recharged.

Even in an accident, the system takes precautions: Through its circuit breaker, the higher level energy management is capable of shutting down

the battery either in its entirety, or just line-by-line. This could be necessary if individual cells overheat, suffer an internal short circuit or have gone completely dead. Even in the event of an accident, safeguards must be taken to make sure the car's body is not exposed to any live voltage, so that emergency rescue squads can open the car without risk. This is guaranteed by the appropriate sensors.

The scientists bring in their expertise - from designing the battery system to safety tests; from the connection technology through to recycling. Through shared efforts, it is possible to rapidly accelerate research projects, and swiftly usher the results to market-ready condition. Because if German industry intends to hold its ground against the international competition, it has to move its pace of innovation to the fast track.

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