Direct Current Boosts Energy Efficiency in Buildings

An EU project envisions to take an important step to reach Europe's ambitious climate and energy policy goals by developing power distribution systems with highest efficiency and best integration of renewable energy sources. Using direct current will save energy and support smart grids.

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The series of numbers "20-20-20" may seem cryptic, but it stands for a crucial shift in European climate and energy policy. It represents the three targets the EU has set itself by 2020: a cut in greenhouse gas emissions of at least 20 percent below 1990 levels, a 20 percent share of energy consumption from renewable resources and a 20 percent decrease in energy use by improving energy efficiency. This ambitious agenda requires a broad range of innovative technologies and the smooth interplay of industry and science in research.

An important step in the run-up to 2020 is the project Direct Current Components + Grid (DCC+G). It boosts energy efficiency and the use of renewables in many ways. "Today, voltage in local networks fluctuates due to the decentralized injection of power by solar energy plants. Central converters can stabilize these networks," explains Roland Weiss, Project Coordinator and Senior Research Engineer at Siemens, which leads the consortium of 13 companies and institutes. Too high a fluctuation could even lead to a temporary shutdown of photovoltaic power systems. If a central converter is smart-grid-capable and, thus, can communicate with other big converters, they are able to stabilize the local network. An active, intelligent rectifier can influence electricity in local networks due to changing demands and can optimize the quality of electric energy. But intelligent, IT-based converters support the smart grid in yet another way: By aligning with other intelligent converters, they are able to build a "virtual synchronous machine," as Weiss puts it, that extracts electricity in optimum shape, creating a "harmonic, ideal consumer load."

These are the key goals of DCC+G. Another advantage of centralization is higher efficiency, since the transition from alternating current (AC) to direct current (DC) power grids using a central rectifier reduces the number of AC-to-DC power converters with a poor degree of efficiency.

Only Net-Zero Energy Buildings after 2020

For the EU's 20-20-20 targets, buildings also play a major role. They consume 40 percent of Europe's current energy. To address this fact, the European Commission has set the goal that after 2020 only net-zero-energy buildings shall be constructed. More than 50 percent of the energy used in today's commercial buildings is for heating, ventilation, air-conditioning (HVAC) units and lighting. These appliances use DC, but like all of the DC-generating and -consuming appliances in buildings they are connected via AC power grids. Therefore, the DCC+G partners aim to demonstrate at least 5 percent energy savings by distributing electricity with a 380-volt DC building power grid. It makes building appliances like HVAC and lighting very efficient by avoiding local rectifiers and power factor correction circuits. Moreover, the project partners want to increase the efficiency of solar power systems by at least 7 percent. And there is yet another cost advantage. In the long run, devices will become cheaper by 5 to 7 percent according to Weiss' forecast, because they can do without rectifying.

"Our experts forecast that buildings will contain as much electronics as cars in the future," says Andreas Wild, Executive Director of ENIAC Joint Undertaking (JU). It is a European public-private partnership on nanoelectronics and finances €3.1 million of the total budget of €18.7 million for DCC+G, which is cofunded by the European commission and five EU countries. He emphasizes: "Energy efficiency is the most important topic among our programs. It makes sense both economically and ecologically. We sponsor projects aiming at the markets of the future and bringing together participants that can build an ecosystem."

ENIAC JU is responsible for monitoring the technical progress of DCC+G, which started in April 2012 and will last until spring 2015.

The DCC+G consortium will realize a first test bed in the office building of a participating research institute. In 2014 a second test bed shall be created in a retail environment. Future applications will be in industry, office buildings, supermarkets, warehouses, public halls and event centers.

Among the specific contributions by Siemens to the project are intelligent energy management systems. Sensors and control software ensure continuous data acquisition and evaluation for maximum transparency of the energy flow from sources to loads. "They can detect heightened consumption and failures. In addition, the broadband sensors support the protection of electricity distribution at short-circuit faults," explains Weiss.

DC gains traction not only in Europe, but also in America. The EMerge Alliance, an association of companies and governmental agencies, wants to develop standards leading to the rapid adoption of DC power distribution in commercial buildings. ■

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AC Grids vs. DC Grids

Electricity in power grids and buildings is distributed as alternating current (AC) today. This is due to a historical decision based on AC's better capability for transmitting power over long distances. The decision taken in the late 19th century has resulted in the 21st century in the disadvantageous requirement for a high number of AC/DC (direct current) rectifiers and DC/AC inverters in buildings. This combination of AC and DC reduces energy efficiency, increases investment cost and total cost of ownership due to power losses in the inverters and rectifiers.

As more renewable electricity generators like photovoltaics and wind turbines producing DC come online, DC power systems can ease their integration into the grid. Currently, DC power has to be inverted to AC before it is fed into a home, an office or the grid. Almost exactly 120 years after it lost the grid battle against AC, DC could finally make a comeback.