Michael Weinhold,
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Weinhold's Power Lines

From Invention to Innovation: New Impulse for DC Grids?

In November 2007, I was amazed to hear that the US utility Consolidated Edison was converting its last 60 direct-current (DC) customers to alternating current (AC). After all, the "War of the Currents" had been settled more than a century earlier at the 1893 Chicago World's Fair, when Westinghouse and Tesla demonstrated the superiority of AC. Today, however, Edison's DC seems set to make a comeback in distribution grids.

High-voltage DC transmission has been used since the first half of the 20th century – first with mercury arc valves, and since the 1970s, using power electronics.

The pioneering era in the second half of the 19th century was shaped by men like Edison, Tesla, and our own Werner von Siemens. Their achievement was to turn inventions into innovative applications that simplified life. This entrepreneurial spirit is essential. Heron of Alexandria's steam engine in the first century AD could have revolutionized engineering, but he failed to harness steam power for practical application. Thus, his invention never became an innovation, and the industrial revolution took place 2,000 years later.

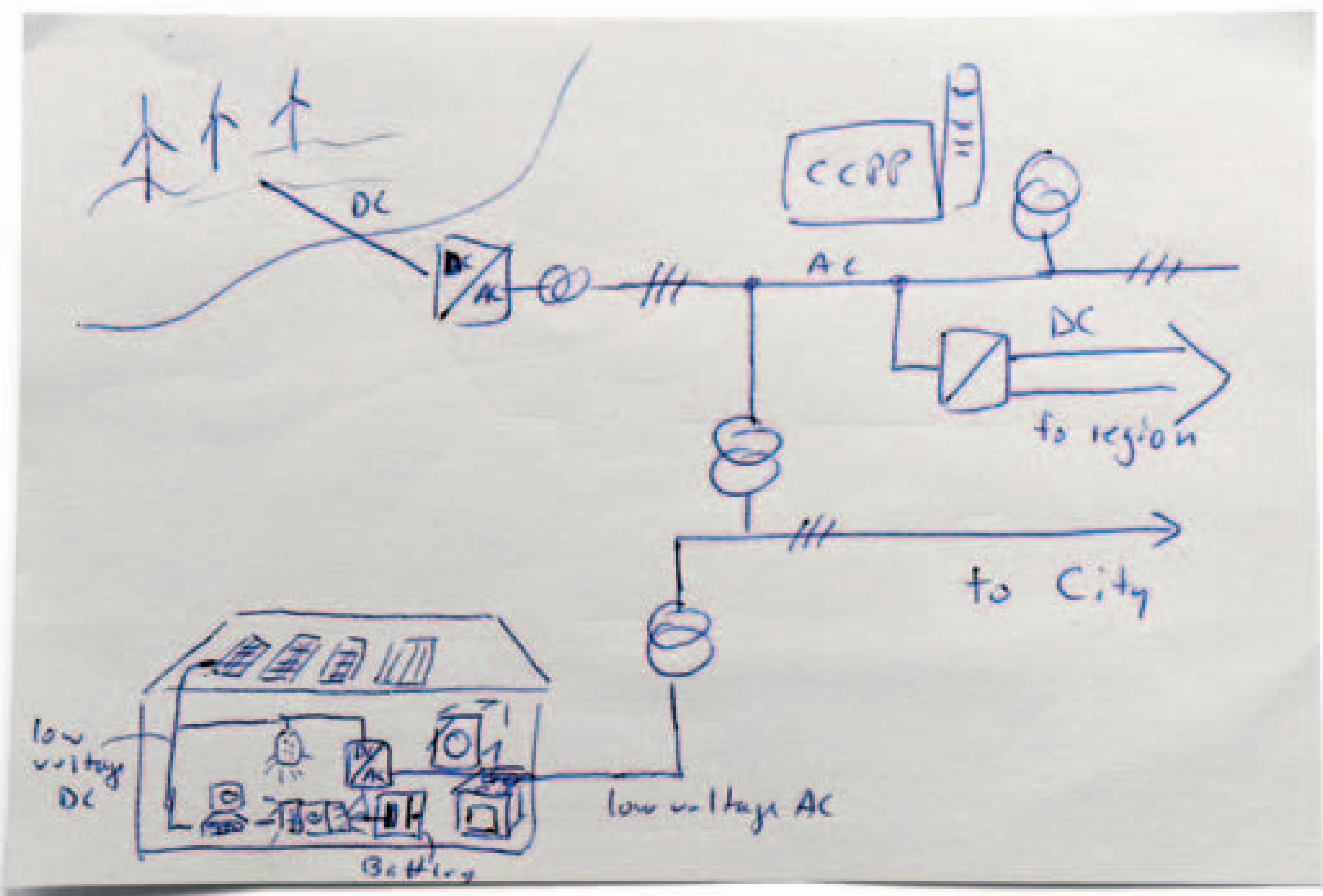
The second stage of electrification took place with the expansion of large-scale AC grids during the 20th century. But DC never vanished altogether. It is now being used in an increasing number of applications to link, for point-to-point operation, in hybrid AC and DC transmission systems, and in HVDC lines, where Siemens is a pioneer and market leader.

The third stage of electrification belongs to the "prosumers" who produce and consume power at the same time. In the second half of the 20th century, DC got a new boost following the invention of transistors and resulting innovations. We are now surrounded by (low-voltage) DC in consumer electronics such as communications equipment or computers and are using more and more LED lighting. This development is inspiring a range of applications for DC in low-voltage distribution. A first benefit is an efficiency gain: I can envision a scenario where a central AC/DC converter station in our homes converts the incoming AC power into low-voltage DC power, thereby saving losses and capital expenditure. PV panels could also feed into this home-based DC supply, maybe backed up with batteries in cases where grid power supply is unstable. In developing countries, where off-grid solutions are often the only option, DC combined with batteries is already in widespread use. In those rural areas, cell phones can be charged using solar power, facilitating access to information and business opportunities, and low-voltage DC power is used to refrigerate food and medicine.

It is being discussed whether DC power supply should be used in data centers and server farms to avoid AC/DC conversion losses. Less excess heat means that data centers and server farms could save up to 30 percent power costs if AC is only converted once to DC. Less excess heat also means less air-conditioning costs. In the future, newly constructed homes will feature hybrid systems. Prosumers will power the less energy-intensive part of their DC appliances directly with energy generated by DC sources such as rooftop PV. For reasons of security and economy, the DC voltage used in homes will be far below 50 volts. The AC grid will cover the energy gap due to the intermittent in-feed and may be supported by home-based batteries at night. Energy-intensive loads, such as electric stoves or heating and air-conditioning, will, of course, still be fed from the AC system.

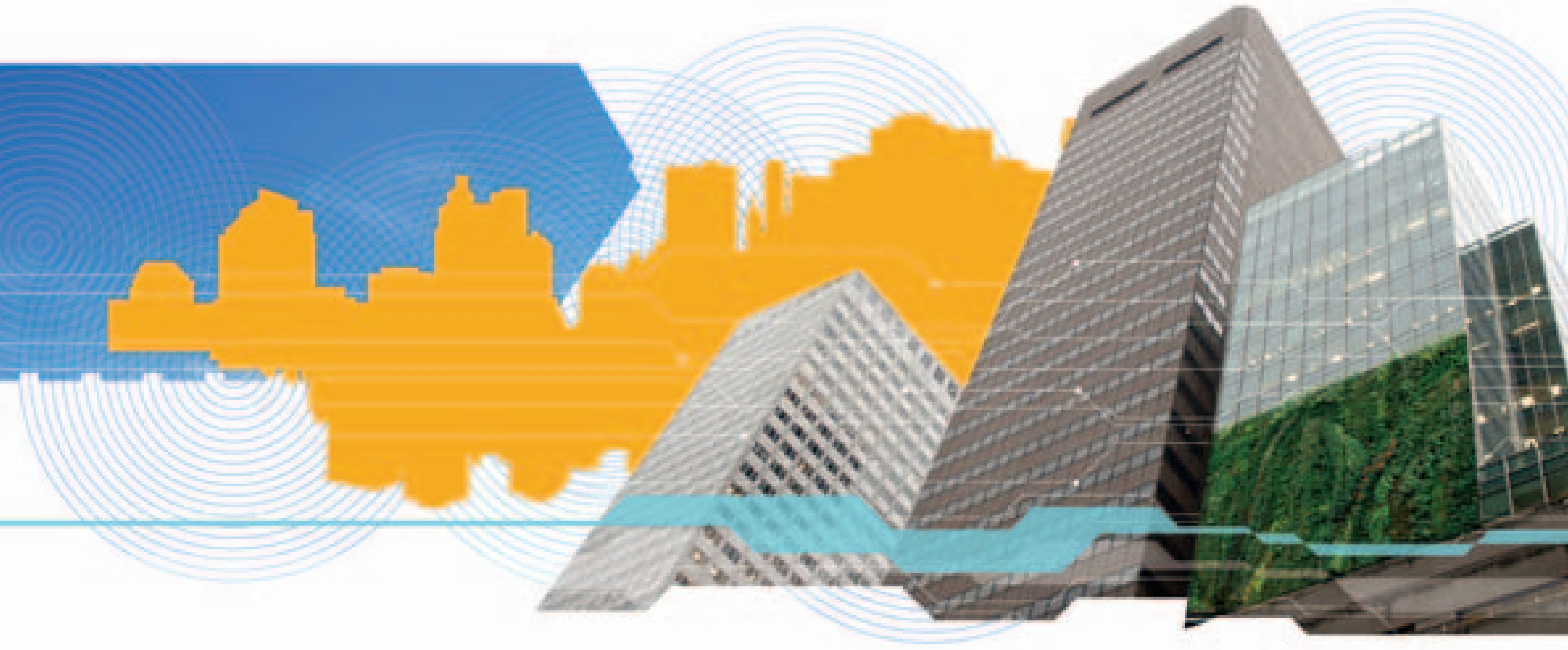
In high-voltage systems, as we move closer towards DC supergrid structures, we need DC switchgear and circuit breakers, for instance, to connect the North Sea wind

parks and terminals with the onshore grid. This means opportunities for business and innovation. I believe there will be applications for DC on both sides, high-voltage and low-load. On the high-voltage side, in power transmission the already existing lines will develop into full-fledged DC grids. On the low-load end of the electricity grid, DC will constitute integral parts of the prosumer lifestyle.
The trajectory of technology development that brought us power electronics, PV panels, LED lighting, and microprocessors is also driving the business case for DC on the consumption side. Edison would be delighted: Today, integration coincides with a proliferation of technology drivers. Instead of a "War of the Currents," we are debating how and when to use both approaches. And unlike in Heron of Alexandria's age, global communication and the concept of "open innovation" have created a wealth of new ideas ready for application. ■



From marine wind parks to household applications: exploring the full potential of DC. Michael Weinhold sketched his vision exclusively for Living Energy.

Illustrations: Elisabeth Moch, Michael Weinhold



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.

Text: Ulrich Hottelet   Illustration: Mariela Bontempi

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. ■

Ulrich Hottelet is a freelance business journalist in Berlin. He focuses on energy and IT and published articles on energy in *Focus Online*, *Cicero Online*, the *VDI-Nachrichten* and the *Atlantic Times*.

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.