SCIENCE OBSERVER

Edison's Final Revenge

David Schneider

The story of how our nation did away with gas lamps and adopted electrification has been told many times. And why not? It's a dramatic tale, with the larger-than-life Thomas Edison fighting for the direct-current (DC) system he had built to power his light bulbs and electric motors, while George Westinghouse championed the more sophisticated alternating-current (AC) approach that Nikola Tesla had devised. That Westinghouse's forces won this "War of the Currents" very early in the 20th century is no surprise. The voltage of AC could be easily transformed, allowing long-distance power transmission by virtue of the fact that electricity sent at high voltage (and correspondingly low current) suffers very little loss in the wires. Edison's DC system, by contrast, required that the generating station be located within a mile or so of where the electricity was to be used.

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Though far less practical than the AC distribution system that soon supplanted it, Edison's DC system did not die immediately. The power utility that serves Manhattan, Consolidated Edison, continued for decades to offer DC power to those who needed it—say, to operate ancient DC motors in old elevator machine rooms. But Con Ed had been urging such customers to switch to AC and, as of last November, it ceased supplying DC power altogether. So Edison's brainchild, a system of distributing electrical power as DC to equipment located just a short distance away from the generator, is now completely dead—or is it?

In fact, Edison's concept is alive and well, particularly among people who manage data centers. These facilities, which might belong for example to an Internet service provider, typically contain racks of furiously cooled file servers, which are set up to operate through short power outages. These computers can continue to run because they are not directly connected to the grid. Rather, they are fed by uninterruptible power supplies (UPS), which contain batteries that are continuously being charged off the grid. When the lights go out elsewhere, the file servers draw their power from the center's many UPS batteries.

But batteries are DC devices. And file servers, like the computer that sits on your desk, normally run on AC. So a number of conversions have to take place: from the AC that the grid provides to DC to charge the UPS batteries and then back to AC for the various servers. Actually, the situation is even worse than that, because the output of the kinds of UPS systems found in data centers is typically transformed to a lower voltage before it is sent to the many computers. And within those computers, that AC is converted to DC, and that DC is converted yet again to low-voltage DC, at least once if not twice. So there can easily be five or six power conversions between the grid and the circuitry that's actually doing the computing work.

The inefficiencies of each of these conversions are small, but they add up. A recent study of this issue sponsored by the California Energy Commission found that for each watt used to process data, another 0.9 watt was required to support the upstream power conversions. And those losses generate heat, so they exacerbate the problem of trying to keep equipment cool.

William Tschudi, who heads Lawrence Berkeley National Laboratory's High Tech

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Eventually, after much testing and experimentation, Tschudi and his colleagues found the answer: By converting to DC just once, distributing the DC power around a data center and stepping the voltage down as necessary, the overall efficiency could be improved by 5 percent compared with the very best AC equipment available. And compared with more typical equipment found in data centers, the gain was 28 percent.

As this study was going on, a very similar exercise was taking place in Sweden. The municipality of Gnesta, located near Stockholm, wanted to provide high-speed Internet access to residents and local businesses as a public service. The information-technology managers there thus needed to upgrade their equipment. The five existing UPS units never worked very well anyway, so they took the bold action of replacing them with a UPS system that provides 350 volts DC, which is then fed to standard server equipment. John Åkerlund's company, Netpower Labs, provided the necessary electronics. He characterizes the manager who committed the town to this then-untested scheme "a brave man."

What's remarkable is that Gnesta's off-the-shelf computer equipment ran just fine on 350 volts DC—or almost fine. The European standard is 230 volts AC, a number that refers to the root-mean-square value of the sinusoidally varying voltage. The peak level is considerably higher, so feeding a piece of European electronic equipment 350 volts DC will not damage it. This strategy requires only that the connectors and fuses be changed over to ones rated for DC; the built-in switching mode power supplies typically work just fine. The worst hitch that Åkerlund and his coworkers discovered was that special protection circuits in some equipment may detect that something is amiss with the power and either prevent the unit from starting or perhaps allow it to run but report a fault. Before coming up with more sophisticated solutions, Åkerlund and his colleagues got around such difficulties by just ignoring the bad-power alarms or, in the case of stalled gear, by merely pulling the plug and plugging it in again. All of Gnesta's servers have been running on DC now for nearly a year.

Similar change-overs are being tested in France and Japan. And the telcom industry has a long history of running switching centers on 48 volts DC. Tschudi points out that one advantage of this approach, above and beyond the energy savings, is that it allows a facility to run more easily off of various DC sources, such as photovoltaic panels. And for power-hungry installations, the notion of generating the power locally is growing in popularity. Part of the reason is that waste heat from the generator (be it a fuel cell, diesel engine or conventional steam turbine) can be used to warm nearby buildings.

By combining the production of heat and power, facility managers can squeeze much more useful energy out of the fossil fuels they use, so this approach will certainly become more widespread as time goes on. At the moment, this kind of locally generated power is AC, but perhaps soon the advantages of DC will pave the way for its reintroduction in more places than just data centers. If so, George Westinghouse and Nikola Tesla will no doubt turn over in their graves.—*David Schneider*

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