



Digital Power

By PETER M. CURTIS

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The Direct Current Data Center

Are we ready?

According to the U.S. Department of Energy (DOE), commercial real estate buildings use 72 percent of the energy used in the U.S. A University of Virginia study shows that 80 percent of this energy is used by semi-conductor technology, which means that alternating current (ac) must be converted to direct current (dc). International Data Corporation research indicates that 28 percent of all servers reside in enterprise-class data centers, indicating that 72 percent of processing takes place in facilities of less than 5,000 square feet.

power is first rectified to dc at the UPS for the purpose of connecting to dc energy storage. It is then inverted back to ac for distribution to the server racks as well as other computer equipment. At the point of use, the ac is then rectified back to dc again by the power supplies that feed the electronics. Making only one conversion from incoming ac to dc at the UPS for distribution throughout the facility without any further conversions would eliminate two power conversions and the attendant losses. Not only would this make for a more efficient system, it would also reduce the number of components, thereby eliminating points of failure and making for a more reliable system, once the system is tested and perfected. The dc distribution system also facilitates the integration of onsite dc-generating alternative power sources, such as solar PV arrays, inverter-based wind turbines, and fuel cells, which all can provide dc power. I particularly like the combination of a fuel cell and a dc system because of the CHP capabilities and the improved reliability, but again it's imperative that we integrate a fully tested system.

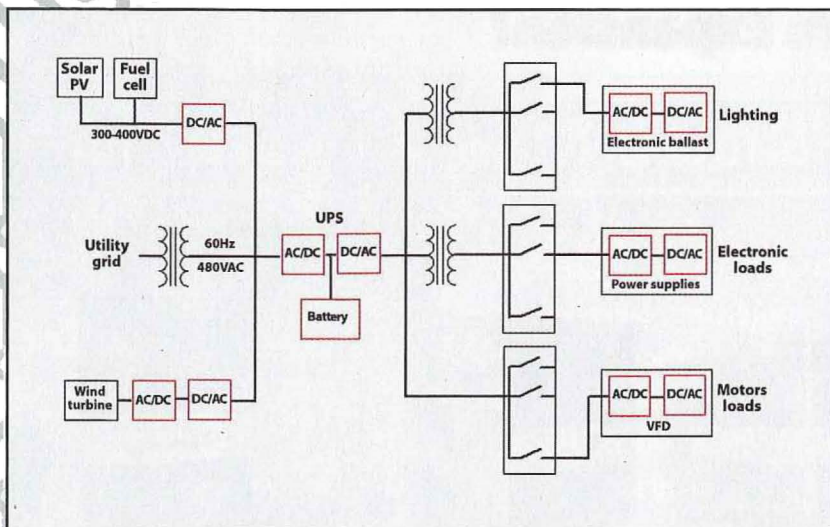


Figure 1. Extra power conversions must be done when using an ac distribution system

The U.S. Environmental Protection Agency's 2007 "Report to Congress on Server and Data Center Energy Efficiency" stated that data centers in the United States could use up to \$4 billion less electricity annually and reduce associated greenhouse gases by using more energy-efficient equipment and better operational practices. As a result, data center designers have been evaluating dc power distribution systems for the data center industry. The Electric Power Research Institute (EPRI) is also providing support.

When we step back and look at end-to-end power distribution in a conventional data center we see several power conversions taking place. Incoming ac utility

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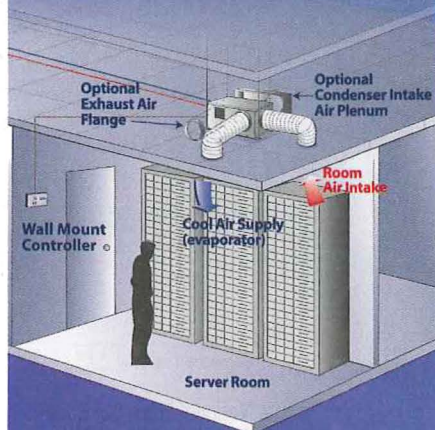
Figure 1 is a one-line diagram showing the number of power conversions that are typically done in a conventional data center with ac distribution, including those needed to connect alternate energy resources.

This kind of dc distribution system can decrease energy use up to a 25 percent when compared to a traditional ac power distribution system by eliminating the losses associated with the inefficiencies of power conversion. It also reduces the initial cost for electrical distribution equipment; some studies say by about half. Since there are fewer conversions from ac to dc and dc to ac, which translates into less equipment and the distribution system occupies significantly less space. Proponents of dc power in data centers claim fewer single points of failure in dc systems due to the reduction in components. There is also an accompanying decrease in heat production. This reduces cooling capacity requirements and provides further reductions in operating costs, especially when using the dc output of some fuel cells and taking advantage of the high-grade hot water output.

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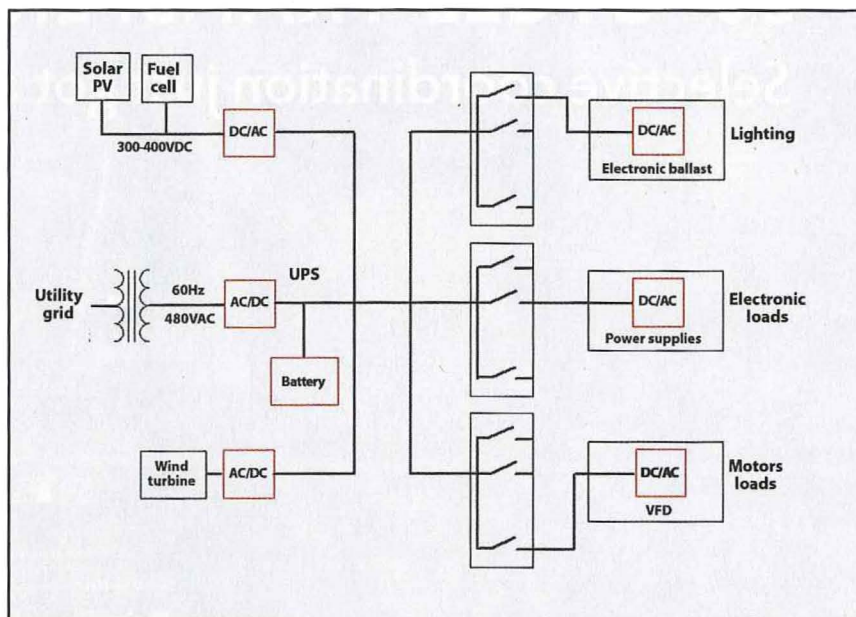


Figure 2. Fewer conversions required with dc distribution

Since dc distribution is a relatively new concept, early adopters will no doubt face higher installation costs, even though less equipment is needed. But new equipment is already being developed for this power system topology, and it is expected that as market penetration increases equipment prices will become substantially less than comparable ac distribution components. In the case of servers and storage hardware, some manufacturers may not offer dc solutions at this time, but it should be noted

As dc technology is integrated, the industry can anticipate difficulty in locating personnel with the appropriate experience to install and maintain these systems. However, aggressive training programs at colleges, universities, and trade schools could help existing personnel develop the necessary skills. This is the same education and training that currently supports the photovoltaic industry, where electrical distribution systems rated up to 600 Vdc are common.

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however, that OEMs are beginning to prepare offerings with dc input directly to servers and storage systems. Delta Products Corp., Fremont, CA, has announced commercial offering of 380 Vdc fans, server power supplies, and UPS units for total dc distribution topology. Validus DC Systems and UC San Diego are also demonstrating dc solutions.

An important step in shifting to dc distribution is developing consensus on appropriate dc voltages. Given the need to keep current levels and conductor ampacity within reason, the schools of thought range from 48 to 570 Vdc. The DC Power Partners, a group of industry power experts that meets monthly through EPRI-hosted conference calls took a big step toward

DC Distribution Benefits

Existing electronic fluorescent lighting ballasts can be retrofitted to use dc distribution	Streamlines integration of renewable energy sources (Solar PV, fuel cells, wind turbines)
Energy storage opportunities including direct utilization of dc power from batteries	Dc power has a proven track record in the telecom, transit, and defense industries
Reducing the number of components yields greater reliability and a lower total cost of ownership (TCO)	Dc systems are modular and flexible
Front-end system components can be located outside of critical environments	Allows for easy integration of flywheels, reducing the financial and environmental costs of batteries
Distributed redundancy and load management is easier with dc power	Dc power has a power factor of 1.0

voltage standardization. Participants selected 380 Vdc as the preferred standard during meetings held in combination with The Darnell Group's 2009 Green Building Power Forums in Japan and in California.

Additional benefits of dc include eliminating the need to balance phases, synchronization of multiple sources, static transfer switches, harmonics, simplifying wiring by reducing the number of breakers required, simplifying switching operations, and reduced voltage drop and wasted power due to I²R losses. The table shows other big picture benefits associated with dc distribution.

The industry must continue the dialogue and take steps to ensure the dc concept is thoroughly vetted. Small-scale demonstrations are a good first step. Direct Power Technologies, Inc. with Pentadyne, a leader in flywheel energy storage, assembled the first bench test at their Chatsworth, CA, headquarters a few years ago. An industry group sponsored by the California Energy Commission through Lawrence Berkeley National Labs and headed by EPRI Solutions and Ecos Consulting, is planning more demonstrations of data center applications. Commercial proof-of-concept demonstrations are also being conducted in Sweden and Japan. The Morrelly Homeland Security Center in Bethpage, NY, is another ideal venue for a demonstration.

In affiliation with the Long Island Forum for Technology (LIFT), the Center is a dual-purposed facility with the mission of

conducting applied research on new technologies, developing new products, and creating jobs. The Center is planning to apply for grants to fund a demonstration that will integrate solar, wind, and fuel cell power into a dc distribution test bed so that performance can be monitored and theoretical expectations can be verified. My company, Power Management Concepts, one of the research partners, has relocated its offices to the Center and will be recruiting prospective end-users of dc distribution that might be interested in participating in this demonstration. Any interested parties should contact me at pcurtis@powermanage.com.

The increase in efficiency and the associated reduction in operating costs will be the primary driving force behind moving to dc data centers.

The fact that dc promises higher efficiency and improved reliability makes it a big attraction. As with any change that upsets the status quo, the conversion to dc is only one weapon in our arsenals. We must continue to address all practical solutions and improve all pertinent technologies related to efficiency and reliability to make real measurable progress. That said, dc distribution is certainly a good start with benefits that seem too irresistible to pass up. ■

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