DC Power Distribution Cuts Data Center Energy Use

The Problem

In a typical data center, power is delivered using alternating current (AC) that goes through multiple conversions between AC and direct current (DC). Each conversion creates inefficiencies, which wastes energy and produces heat, increasing the load on the center's cooling system. For every watt of power used to process data, an average of about 0.9 watts is required to support power conversion and between about 0.6 watts and 1 watt is needed to cool the power conversion equipment.

The Solution

The Lawrence Berkeley National Laboratory (LBNL) led a demonstration project that showed that alternative, DC-based power distribution systems can reduce the total system energy use in a data center by 5 to 7 percent compared to the most efficient AC systems and by up to 28 percent compared to typical AC distribution systems. DC distribution systems also reduce cooling loads and have the potential to improve reliability by reducing the number of possible failure points.

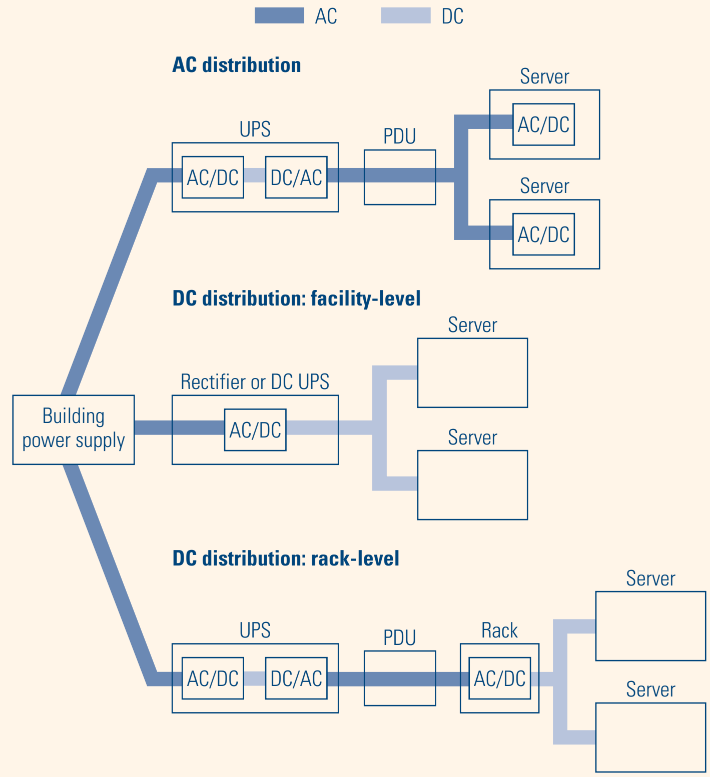
Features and Benefits

The demonstration project found efficiency gains for two different DC distribution configurations when tested alongside a traditional AC system (Figure 1):

- Facility-level DC configuration. AC power was converted to 380 volts (V) DC once at the entrance to the test facility and then distributed throughout. This achieved the highest efficiency improvement—7 percent—compared to "best-in-class" AC distribution systems, and up to 28 percent compared to typical AC systems. This configuration would be most applicable to new facilities because of the high cost of converting AC systems to facility-level DC distribution in existing centers.
- Rack-level DC configuration. This approach can be effective in existing facilities and is similar to an AC system since AC power is distributed through the facility and to the racks where servers are mounted. However, at the rack level the AC power is converted to 380V DC, which is then fed directly into the servers. Eliminating the need for each server to convert AC to DC power individually results in a 5 percent efficiency gain compared to traditional AC distribution.

Figure 1: Data center power distribution systems

Data centers can operate using an alternating-current (AC) or direct-current (DC) power distribution system. Distributing DC power minimizes the overall number of conversions between AC and DC power, saving energy and increasing reliability.



Notes: PDU = power distribution unit; UPS = uninterruptible power supply.

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Additionally, because DC configurations produce less heat, they can save 28 percent of the electricity used by a building cooling system. The servers and the power distribution and cooling systems account for the bulk of the energy used in data centers; so savings from DC configurations, when compared to typical AC systems, can amount to 28 percent of the electricity used by the entire facility.

Two other conclusions were reached through the demonstration project that help establish the viability of using DC configurations:

- DC-powered servers exist in the same form factor as AC servers or can be built and operated from existing components with minimal effort. Thus, there are no technical obstacles to obtaining DC equipment.

- DC-powered servers can provide the same level of functionality and computing performance when compared to similarly configured and operating servers containing AC power supplies.

Applications

DC distribution systems can be used in new and existing data centers.

What's Next

To go further with DC systems, researchers must establish grounding guidelines, set up protection and overload prevention strategies, and quantify the increases in reliability and decreases in cost that DC distribution systems can provide. Also, a lack of industry awareness of the advantages of DC distribution, as well as misconceptions about DC power, will require additional education and outreach efforts if the energy savings potentials of DC-powered data centers are to be realized. In addition, it will be necessary for the industry to standardize distribution voltage(s) and develop standard DC connectors to facilitate widespread adoption. Finally, although it is not technically difficult to produce servers that run on 380V DC distribution systems, manufacturers do not currently produce such equipment. Collaboration with the manufacturers and operators of data centers is needed to ensure both the supply and demand of DC products.

Collaborators

Lawrence Berkeley National Laboratory led the demonstration project, with the support of Ecos Consulting and EPRI Solutions. More than 25 firms contributed materials, equipment, and services for the demonstration.

For More Information

For more information, please contact the California Energy Commission researcher listed below.

More PIER Technical Briefs can be found at www.energy.ca.gov/research/techbriefs.html.

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About PIER

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