By Peter M. Curtis

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Integrating Existing and Innovative Strategies in Data Centers

Staying abreast of best practices can lead to substantially reduced data center energy

While the U.S. Environmental Protection Agency's (EPA) Report to Congress, published in 2007, predicted a doubling of global power consumption between 2005 and 2010, the actual increase was only 56 percent. Energy consumption in the U.S. reportedly increased by only 30 to 36 percent. The energy increases predicted by the EPA did not materialize, in part, because the nation's data centers deployed fewer servers than the EPA report predicted. The U.S. also experienced a lower than expected demand for computing, because of the financial crisis of 2008.

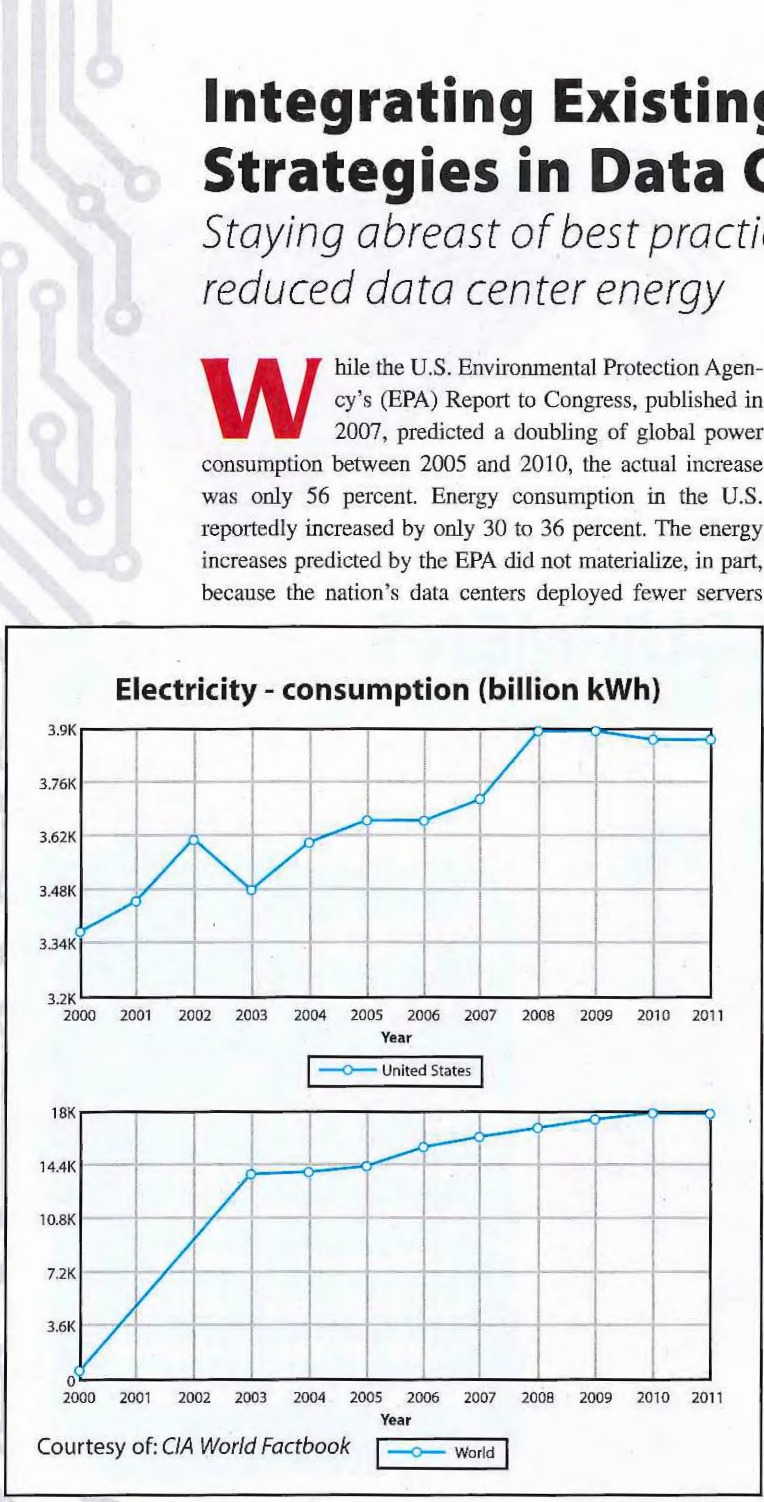

Figure 1. A look at rising electricity use.

Certainly more efficient computer chips and technologies like computer server virtualization, which allows fewer servers to run more applications, contributed to the energy savings. Even so, U.S. data centers now account for between 1.7 and 2.2 percent of the total electricity used in the country. New studies assess current trends in energy use and costs and also outline some existing and emerging opportunities for improved energy efficiency/reduction.

Data center energy consumption worldwide can be reduced by 20 to 30 percent, by combining existing tools and new technologies. To put these energy savings in perspective, a 30 percent savings equates to a reduction of 1,170 billion kilowatt-hour (kWh) or a national power consumption cost reduction of nearly $113 billion, assuming the U.S Energy Information Administration (EIA) cost per kWh of $0.0965 (see figure 1).

In order to reduce energy use, we must first evaluate how data centers use power (see figure 2). As shown in the pie chart, 40 percent of the energy input to a typical data center facility is applied toward cooling the IT equipment. Some best practices can reduce this cooling portion of the pie by 20 percent and the total load by 8 percent (see figure 3).

CFD/COOLING

Computational fluid dynamics (CFD) is one of the best tools for determining where better airflow and separation are required. Employing hot and cold aisles between server rows with return air plenums, along with active airflow management, is considered one of the best practices for low- to medium-density data centers. When used as a design tool, CFD ensures that the data center model is thorough. The modeling software enables engineers to consider several options for cooling by employing alternate approaches that wouldn't necessarily be utilized in an operational client facility. CFD

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can also save on control costs for new projects because less equipment may be needed.

In addition, the latest ASHRAE TC 9.9 Thermal Guidelines for Data Processing Environments relaxed the recommended high-end temperature from 77°F to 80.6° and the low-end temperature to 64.4°, effectively extending the allowable operating environments for Class 1 and 2 data centers. Coupled with increased humidity ranges from 20 to 80 percent, companies that are able to use Class A3 and A4 ranges will be able to make use of airside free cooling virtually all year long. Of course, high-density centers or data centers with extremely sensitive equipment operating in the class A1 range will not be able to make use of the updated thermal ranges.

Enclosure containment is a strategy that improves separation of hot and cold air. Active airflow management technologies—like server racks that employ door baffles and a variable-speed fan system—can provide sufficient cooling with much higher inlet air temperatures. Data center managers can save 4 percent of their cooling energy for every degree of upward change in cooling setpoint. For cooling systems that employ computer room air handlers, this means chilled water temperatures can be increased. Raising the chilled water temperature by 5° equates to a 20 percent cooling energy reduction. If we consider a 2-megawatt (MW) facility with 800 kW for cooling, the cooling-related energy can be reduced to 640 kW—which equates to an 8 percent reduction in overall energy input, bringing the total facility input down to 1.84 MW.

DC DATA CENTER

Direct current (dc) is another strategy for reducing data center energy. A UPS with battery backup is the industry standard for providing uninterrupted power to IT equipment. Since UPS batteries store dc electricity, a UPS rectifier is needed to convert ac to dc and a UPS inverter is needed to convert the dc back to ac. The losses in these conversions can be significant. The concept of eliminating the conversions and going to an all-dc distribution system is gaining acceptance. Data center lighting systems can also be designed to operate on dc.

A demonstration project conducted by Lawrence Berkeley National Laboratory (LBNL) showed that alternative, dc-based power distribution systems can reduce the system energy use by up to 28 percent compared to a typical ac distribution system. Assuming lighting and IT loads represent 60 percent of the power consumed by our 2-MW facility, we can shave off another 340 kW, or 17 percent of total facility load. When these dc-related efficiencies are combined with the reductions achieved with best practice cooling techniques, the original 2-MW facility load is reduced down to 1.5 MW, for a 25 percent overall reduction (see figure 4).

OEMs are beginning to prepare offerings with dc input directly to servers and storage

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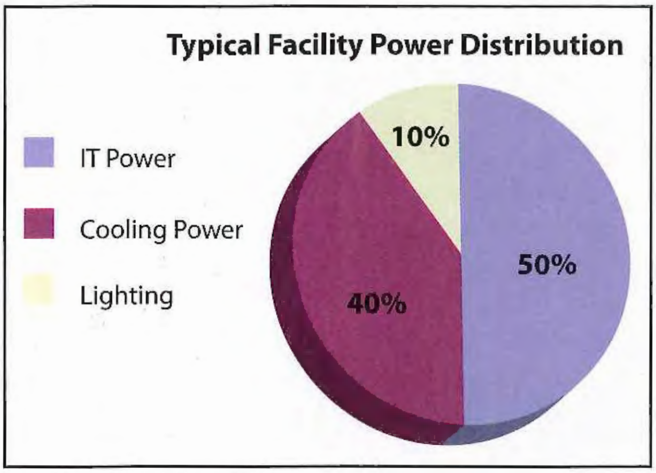

Figure 1. Power distribution in a typical facility

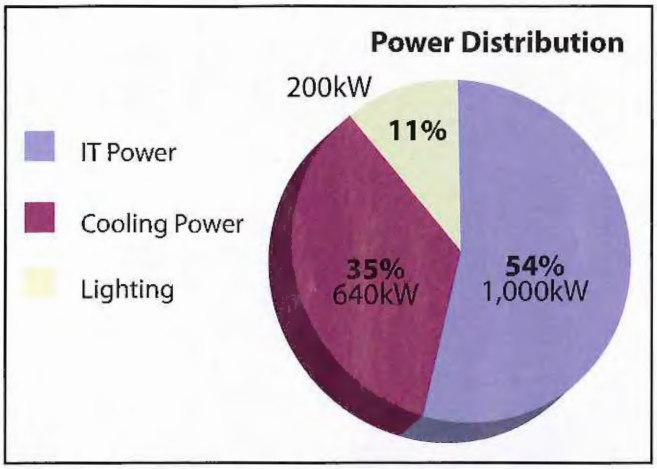

Figure 2. Improving the use of cooling energy changes the power distribution

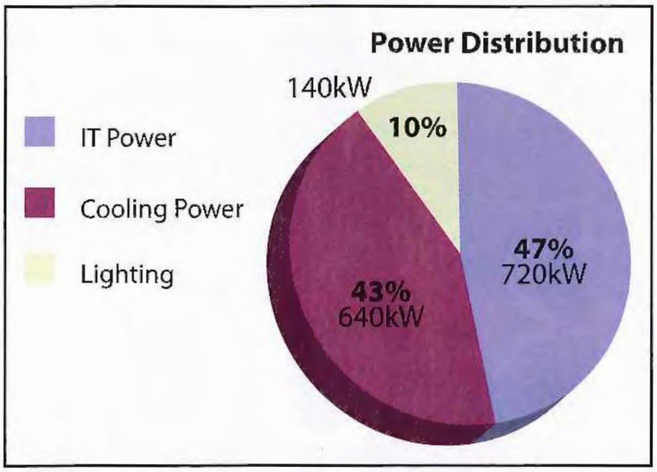

Figure 3. Dc distribution further changes overall power picture

systems. Delta Electronics has announced the first commercial offering of 380-Vdc fans, servers, UPS units, and racks with dc distribution power supplies.

ENERGY SECURITY

Another way we can reduce energy consumption is to employ onsite generation. The efficiency of central station generation averages slightly more than 30 percent, and distribution losses can approach 6 percent, so distributed generation that is more efficient can significantly reduce the amount of primary energy (e.g., oil, coal, natural gas) that is required to generate the electrical power required by data centers (and other facilities).

The fuel cell is a clean technology that appears to be a perfect fit for data centers due to high load factor of these facilities. And since the fuel cell produces dc electricity, it can be easily integrated within a dc distribution system. But just like anything different or new, transition/adoption will take time.

There are currently several commercial fuel cell products on the market that use different electrolytes, each with its characteristic operating temperature. Proton exchange membrane (PEM) fuel cells are a low-temperature technology. Phosphoric acid fuel cells are considered medium temperature. Molten carbonate and solid oxide fuel cells operate at the highest temperature and consequently have the highest efficiency. Bloom Energy's solid oxide fuel cells, which are close to 60 percent efficient, are already being used in a number of mission-critical applications.

Fuel cells can also provide thermal energy. Only a portion of a fuel cell's output takes the form of electricity. The remainder is converted to heat. A fuel cell that is equipped with heat recovery, like the U.S Department of Energy's phosphoric acid fuel cell, can reach 70 to 90 percent combined electrical and thermal efficiency.

However, this approach can be quite complex. A fuel cell that is equipped with heat recovery can convert its own thermal output to chilled water through the use of an absorption chiller. Using this source of available cooling can further reduce a data center's cooling energy requirement, and consequently its total electrical need.

Clean distributed generation further offsets central power plant emissions of criteria pollutants and greenhouse gases (GHG). Since a fuel cell generates electricity without combustion, NOx and SOx emissions are negligible. And since the fuel cell is much more efficient than a central plant and the on-site generation eliminates distribution losses, there is a significant overall reduction in GHG production that gives a fuel cell-powered data center a significantly smaller carbon footprint.

One of the initiatives at the Bethpage, NY-based Applied Science Center for Homeland Security (http://www.asfhs.org/ASFHS/index.html) is to integrate energy reduction and security into the center. This beta project focus is a "green bus" concept that will permit integration of a variety of clean energy sources into a dc distribution system that can ultimately power the data centers of tomorrow. Resident Research Partners ATK, PMC, VCORE, and Rethf Testing are leading participants along with contributors that include AFCO Systems, ETAP, and QHI.

All the energy saving strategies and methods discussed throughout this column can contribute to national and global energy savings. These energy savings are realized by introducing cooling strategies, minimizing electrical conversions, and creating more efficient energy producing technologies. If implemented properly, we can reduce the total energy produced by all data centers significantly. ■

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