Data Centers Go Green

Power-hungry data centers have some optically clear and innovative choices for optimizing energy efficiency.

By **Rosemarie Szostak** and **Margaret Fiore**

Greener data centers are no longer the novel concept of a tree-hugging IT manager. In an era of increased sensitivity to energy use and its associated carbon footprint, not to mention energy costs, computer data center managers must make choices that optimize energy efficiency.

Optic and photonic technology innovators are stepping up to this challenge.

That's because optical-based data centers have the potential to deliver more data per watt, which translates into better energy efficiency and lower costs for data providers.

Chasing Cheap Energy

Real estate cost is no longer the primary expense for data centers. It is energy. For every dollar spent on computing hardware, another dollar is spent on power and air conditioning.

Consider a typical data center. It can easily consume 1 MW of electricity, but today's mega-data centers can suck up more than 20 MW. With the cost of electricity ever on the rise, a change of only one cent per kilowatt hour translates to $8 million to $17 million a year in additional costs for energy.

Energy costs at Western European data centers are increasing at a particularly worrisome speed: 13% to 17% between 2006 and 2007, according to some recent studies. The European Union has established a voluntary "Code of Conduct on Data Centres Energy Efficiency" to reduce energy use and the associated carbon emissions.

With the world's thirst for more and more computer data, what's a data center to do?

One solution is to move operations to a place where the cost of electricity may not be cheap but where energy prices are stable. Google, for instance, built a huge data center in The Dalles, in Oregon, and Microsoft put a data center in Quincy, WA. Both U.S. locations are powered by more cost-stable hydroelectric energy. Recently, Google purchased 1000 acres of land in Council Bluffs, Iowa, for a new data center because of the potential to tap into wind energy in that state. Unlike fossil-fuel-based electricity, wind-supplied electricity costs are projected to be far more stable.

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Conserving Energy

For data centers that don't have the luxury of chasing cheap energy around the globe, most have chosen the path of improving the efficiency of their operations. Verizon is doing that by using highly efficient fuel cells and supplementing its energy needs with solar panels.

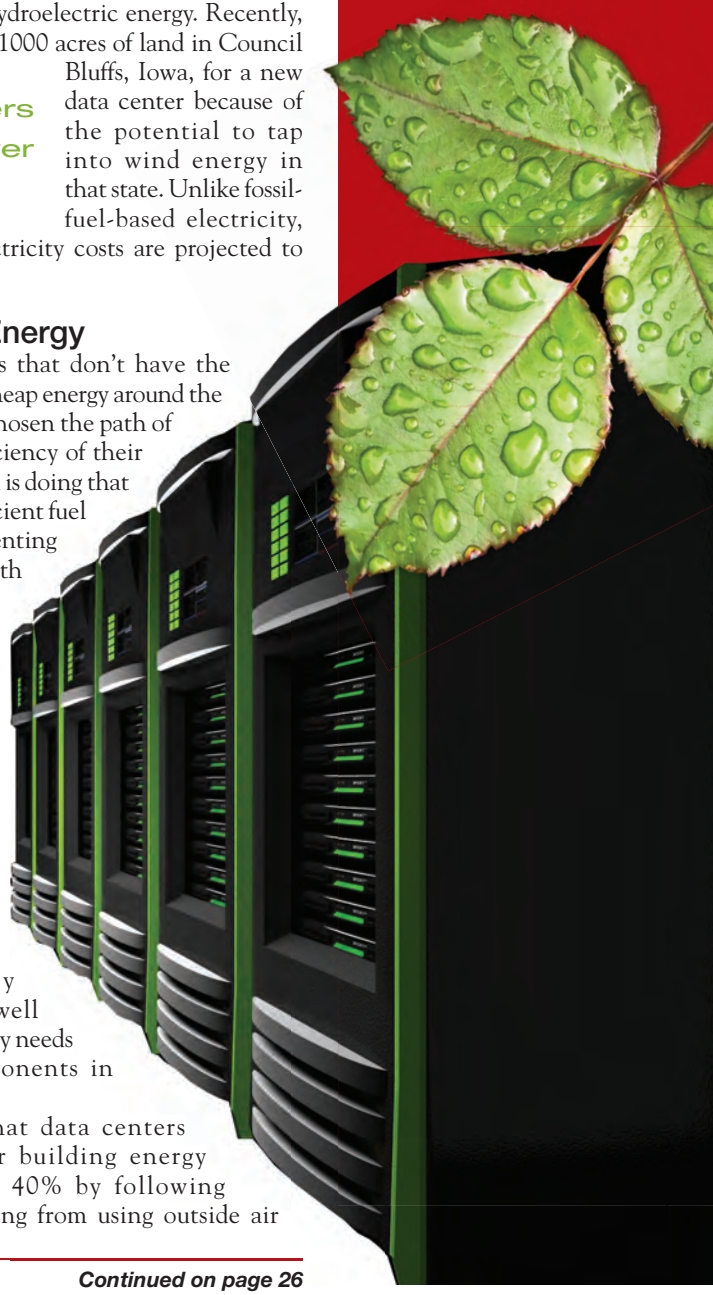
The key to data center power management is understanding where the energy is going and how much of it is really needed to run a building's air conditioning. Energy audits have identified building energy requirements as well as computing energy needs as primary components in energy use.

IBM claims that data centers can reduce their building energy requirements by 40% by following simple steps ranging from using outside air

Continued on page 26

Server Overhead

According to a study by IDC, unless organizations act on the infrastructure level to reduce power consumption, every euro spent buying new servers in 2012 will result in an associated €0.80 to power the existing data center infrastructure.



◀ Continued from page 11

to cool equipment, reusing the heat produced from the servers, to reconfiguring the server space. An IBM data center in Switzerland, for instance, uses waste heat to warm a community swimming pool. And Telehouse Europe, which provides data center facilities and connectivity to 700 customers in the UK, France, Asia, and the United States, opened a 19,000-square-meter data center in London earlier this year that will transform waste heat into energy for commercial and domestic residents in the community. This energy efficiency will reduce up to 1110 tons of carbon dioxide emissions per year while providing 9 MW of power to its neighbors.

Other methods of conserving the energy used by computers and monitors include installing software to remotely shut off computers not in use. Google has deeply analyzed its energy footprint and has taken its non-computing power needs down to less than 20% of the overall power required. Compare that to the standard data center which may consume more power in thermal control than in the actual computing.

Now that energy efficiency from the building perspective is well in hand, the challenge today is to achieve more computing power with less energy and to do so in a smaller space. The most energy-efficient approach, according to IEEE, is to transfer the data packets at the highest possible rate in the least amount of time.

Fast is in fact better. This is where optics is poised to play a critical role.

Seeing the Light

Photons can be a lot more efficient than electrons; fiber can carry greater bandwidth than copper and uses less power to do it. In the data centers, at the old 1 Gb/s rates, copper and fiber were both equally cost-effective.

However, as data centers increasingly migrate to links with speeds greater than 1 Gb/s, copper systems would need to replace ordinary twisted pair cabling with Cat 6A (Augmented) which is expensive and bulky.

Easily able to handle the higher bandwidth rates, fiber becomes far more attractive. These days, data centers are increasingly using laser-optimized multimode fiber such as OM-3 in their links.

The fiber transceivers in these systems need less than a quarter of the power of the conventional high bandwidth transceivers–and therefore generate less than a quarter of the heat. In addition, the data from multiple optical ports can be multiplexed out over a single fine high-bandwidth fiber, so that there are no bulky wire harnesses blocking the flow of ventilating air. A fiber system both generates less heat, and allows more efficient heat removal.

At high data densities, optoelectronic interfaces, photonic switches, and optical backplanes are lower in power consumption than the traditional electronic components. As a result of lower direct power consumption, they require less cooling, which is the other source of power consumption in the data centers.

As an added bonus, optical interfaces and optical waveguides reduce EMI issues in the dense environments of the data center racks and boards.

Cooling With Switches

Glimmerglass' photonic switches require 85W to power 192 ports, each providing 10 Gb/s connectivity. Standard switches require multiple kilowatts of power for similar configurations. But then there are the cooling requirements. Not only is the direct power consumption difference on the order of 100X, it is then doubled by the power needed for thermal control.

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ASHRAE guidelines indicate that an equal thermal unit of cooling is required for each kW of power. Verizon's TEEER metrics (Telecom Equipment Energy Efficiency Ratings) score Glimmerglass switches as 1000X greater efficiency than equivalent traditional equipment.

Luxtera has developed Blazar, an active optical cable that supports Ethernet, Infiniband, and Fibre Channel. This product has four permanently attached transceivers on a length of single mode cable up to 300 meters. It is intended for rack-to-rack or shelf-to-shelf interconnection, or other similar mid-range use, with low power and low cooling benefits. The Blazar cable, another example of optical innovation for the energy-efficient data center, won the top prize in the inaugural Prism Awards for Photonics Innovation earlier this year.

Going Small Is Big

As computing demand continues to increase, manufacturers are also working to increase the number of cores on a single chip. The cores are the "brains" of the computer. Presently these cores are connected via millions of fine copper wires.

Greener IT

A study by IDC, a global provider of advisory services in the technology, telecommunications, and consumer technology markets, found that green initiatives are becoming ingrained in the fabric of technology companies, with 71% of business and technology executives in 10 industrial countries rating green IT adoption as their highest priority. IDC's global Green IT survey also noted that Japan is a leader in green IT in many ways, having adopted many environmentally friendly policies years ago. Yet investment in green IT is lower in Japan than in other regions.

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- The SPIE Newsroom offers free technical articles and e-mail updates on solar and alternative energy (spie.org/news-solar) and optoelectronics and optical communications (spie.org/news-optoelectronics).
- Look for an article in the next issue of *SPIE Professional* about green entrepreneur Bruce Cheng, chairman of Delta Electronics. Delta is a world leader in supplying high efficiency power supplies for computers, data centers, communications, and consumer products. Environmental protection and energy saving is carried out in its product development and daily operations.

Even at chip level, moving electrons through the copper wire is power intensive and the amount of information it can transmit is limited.

If, instead of moving electrons around the chip, an optical network is used, less energy would be required and the chip would have greater flexibility in the amount of data it can handle. Optical switching devices have the potential to supply a bandwidth exceeding 1 Tb/s. Researchers at IBM have been working to develop on-chip optical network based on silicon nanophotonic integrated circuits. ■

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Nerac Inc. (www.nerac.com) is a global research and advisory firm for companies developing innovative products and technologies.

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Power Shares

A 2007 report by AMD shows that electricity used by servers in the United States and Europe comprises about two-thirds of the world's total, with Japan, Asia/Pacific and the rest of the world each falling at between 10% and 15% of the total. The United States' share of world server electricity use from data centers was 40% in 2000.

Photonics in Singapore

The Optics and Photonics Society of Singapore (OPSS, opssg.org), with roots in the former SPIE Singapore Chapter, was launched earlier this year as the small Southeast Asian country continues to nurture its reputation as business- and innovation friendly.

The Singapore government recently lowered several key tax rates on entrepreneurial activity, and the island nation was rated No. 1 in innovation leadership in a global innovation index in March. A broad research study produced by the Boston Consulting Group, the National Association of Manufacturers, and the Manufacturing Institute, all in the USA, cited Singapore's extensive support of manufacturing industries, technology, and education as reasons Singapore is the foremost international leader in innovation.

A 2008 report by ECA International, an organization of international human resource professionals, rated Singapore as the best place in Asia for internationals to live.

Singapore's welcoming attitudes, strong, educated workforce, and wide diversity of high-tech industries and educational institutions were acknowledged as former SPIE President Kevin Harding congratulated the new photonics society this spring.

"SPIE has been honored to enjoy the leadership and participation of members of the former Singapore regional chapter of SPIE in our activities promoting optics and photonics throughout the region and the world," Harding said.

OPSS aims to support greater interaction between the optics and photonics community in Singapore in both academia and industry by providing a forum for discussion and growth among the multidisciplinary groups, said OPSS Chair and SPIE Fellow Anand Asundi. He said the group plans to organize and participate in local and regional conferences and provide an educational outreach program for optics students and professionals.

Elected to the OPSS Executive Committee along with Asundi at a meeting in March were:

- **Robert Huang,** Vice Chair
- **Qian Kemao,** Secretary
- **Chee Oi Choo,** Treasurer
- **Ravi Kumar K.,** Standing Committee Chair for Education
- **Vijay Raj Singh,** Standing Committee Chair for Industry
- **Quan Chenggen,** Standing Committee Chair for Membership and Publicity

Zhao Liping and Huang Xuebo were appointed honorary auditors. ■

SPIE Fellow and recent SPIE Board member Anand Asundi is chair of the new Optics and Photonics Society of Singapore.