The Green Advantage of 10G Optical Fiber

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What is the definition of "Green?"

"Green." The word invokes natural images of deep forests, sprawling oak trees and financial images of dollar bills. The topic of green has been gaining momentum across international, commercial and industrial segments as global warming and greenhouse gas effects hit headlines. Green is succinctly quantified in financial terms, but the definition is more evasive when referring to other areas. Each segment and sub-segment is attempting to define green through measures appropriate to their materials and operations.

Examples include the U.S. Green Building Council's institution of a third-party certification program (LEED®) in the 1990s establishing building metrics around water usage, energy usage, site disturbance, material consumption and environmental air quality. Energy Star is an EPA-driven initiative with the goal of reducing energy consumption and pollution in commercial buildings, homes and electronics through product-specific specifications.

Within the telecommunications industry, TIA TR-42 has initiated a study group for green initiatives in telecommunications infrastructures. The study group suggests creating a technical service bulletin (TSB) that includes measures to make telecommunications infrastructures "greener." The TSB would suggest desirable solutions in informative language that can serve for consideration when standards are rewritten. For example, language for an easement that would drop the mandatory telecommunications room (TR) per floor in commercial buildings and permit telecommunications enclosures (TEs) instead with lower cooling requirements and "hardened" components is being considered.

Specific to the data center segment of the telecommunications industry, the green metric is reduction in energy consumption and ultimately CO_2 emission reduction. The Green Grid is a global consortium dedicated to improving energy efficiency in data centers and business computing systems. One work stream of this group is to define metrics for energy efficiency improvements. A recent paper by The Green Grid identifies one measure, Data Center Energy Productivity (DCeP), being equivalent to the "useful work produced" divided by the total data center energy consumed producing the work. At 10G, optical fiber can play a significant role in the denominator of the equation vs. 10G copper by reducing network operational and cooling energy.

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Green and the Data Center

Data centers have come under increased scrutiny over the past two years since the United States Environmental Protection Agency (EPA) reported that the energy use of U.S. data centers doubled from 2000 to 2006, with the 2006 level accounting for 1.5 percent of the country's electricity consumption. Put into perhaps a more tangible message, this equates to the electricity consumed by over 5 million U.S. homes. Of further concern, the EPA report suggests that data center energy usage could again double by 2011.

Drivers for the growth in data center energy requirements include increased needs for storage and data processing as well as the move to blade servers to facilitate virtualization. While the use of blade servers will reduce the total number of servers in a data center, they require significantly more power.

The time is now for 10G optical connectivity with laser-optimized 50 µm multimode fiber (OM3) in the data center to enable energy consumption reductions and thus CO_2 emission reductions. 10GBASE-SR optical connectivity enhances green data center installations by utilizing high-port-density electronics with very low power and cooling requirements. Additionally, an optical network provides premier pathway and space performance in racks, cabinets and trays to support high cooling efficiency when compared to 10GBASE-T copper connectivity.

OM3 Fiber

OM3 fiber is an essential building block to the success of 10G optical connectivity. The fiber is optimized for laser-based 850 nm operation and includes a minimum 2000 MHz•km effective modal bandwidth (EMB). The OM3 fiber 2000 MHz•km EMB supports 10G data rates to 300 m, while CAT 6A is limited to 100 m. The laser-optimized fiber provides a migration path for supporting even higher data rates such as 16G and 32G Fibre Channel and 100G Ethernet where CAT 6/CAT 6A has no migration beyond 10G per industry experts.

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10G Electronics and Cooling – The Optical Advantage

10G optical switch electronics and server adapter cards require less power to operate compared to 10G UTP copper. The high insertion loss of copper cables at the extended frequency range needed to support 10G and the required electronic digital signal processing (DSP) noise-reduction circuitry means that energy consumption will inevitably be higher than that of low-loss fiber interconnects.

10GBASE-SR SFP+ optical transceivers consume a maximum of 1.0 watt (typical 0.5 watt) per port compared to 8-10 watts per port for a 10GBASE-T copper switch. SFP+ chassis line cards are intended to support up to 48 ports, while 10GBASE-T cards are expected to have 6-8 ports. 10GBASE-SR server adapter cards typically use less than nine watts to service up to 300 m; while announced 10GBASE-T cards use 24 watts to service up to 30 m. Experts have stated that 10GBASE-T over CAT 6A or 7 twisted pair can extend up to 100 meters, but power requirements hinder its cost-effectiveness.

A 10G optical system requires far fewer switches and line cards for equivalent bandwidth capability of a 10G copper system (Figure 1). Fewer switches and line cards translate into less energy consumption for electronics and cooling. One optical 48-port line card equals six 8-port line cards. 10GBASE-SR optical server adapter cards typically use less than 9 watts power to transmit up to 300 m. The optical adapter is easily powered from the server PCI-Express slot without an external power feed. Ethernet adapters were announced in late January 2007 to support 10GBASE-T. The adapter cards consume just less than 25 W to reach a maximum transmission distance of 30 m. Since the PCI-Express slot can only provide up to 25 W, greater service distances would require an additional electrical feed to power the copper adapter card. As with the 10G copper switches, the 10G copper server adapter card's high power consumption and cooling needs result in higher operational costs.

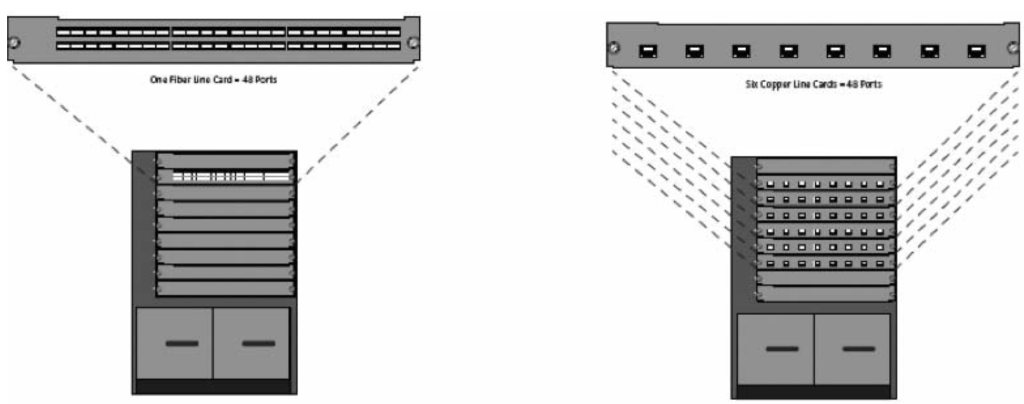

Figure 1 – Line card port density in a 10G optical system (left) vs. copper system (right)

Silicon chip development will be required to reduce the power consumption of 10G copper. Major Tier 1 switch manufacturers are not expected to offer 10GBASE-T commercial products until mid to late 2009; as silicon chip manufacturers continue to address issues with power consumption and heat dissipation. Industry 10GBASE-T expectation is that four to five watts per port will be the lowest achievable power consumption. Such low power levels are not expected for three to five years, if not later.

High fiber density, combined with the small diameter of optical cable, maximizes raised floor pathways and space utilization for routing and cooling. Optical cables also offer superior pathway usage when routed in aerial cable trays. A 0.7-inch diameter optical cable would contain 216 fibers to support 108 10G optical circuits. The 108 copper cables would have a 5.0-inch bundle diameter. The 10G twisted-pair copper cable's physical design contributes to major patch panel and electronic cable management problems. The larger CAT 6A outer diameter impacts conduit size and fill ratio as well as cable management due to the increased bend radius. Copper cable congestion in pathways increases the potential for damage to electronics due to air cooling damming effects and interferes with the ability of ventilation systems to remove dust and dirt. Optical cable offers better system density and cable management and minimizes air flow obstructions in the rack and cabinet for better cooling efficiencies. See Figure 2.

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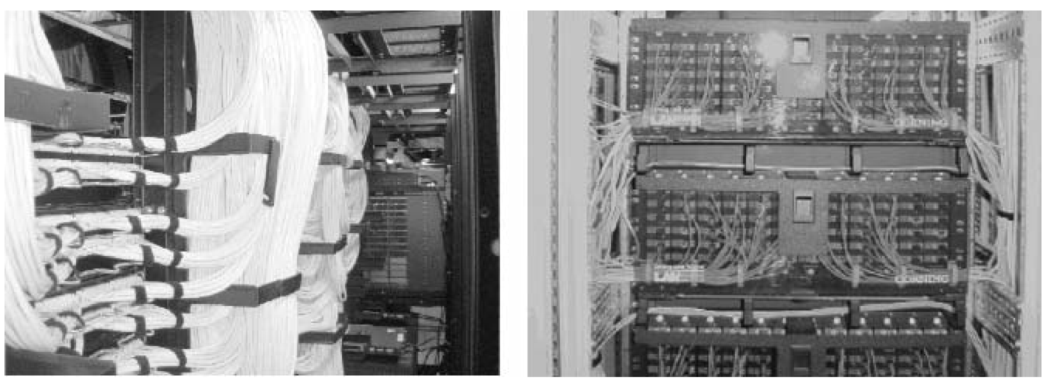

Figure 2 – Lower port density for 10G copper electronics and larger copper cables result in crowded pathways and difficult cable management compared with fiber optic cable

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The Green Correlation (kW-hr, CO_2 Emission and the Dollar)

Figure 3 illustrates cumulative energy savings as a function of 10G optical and copper chassis switch electronics and cooling energy consumption. According to recent industry sources, for every kW-hr required to power 10G electronics, 2-2.4 kW-hr of power is typically required for cooling.

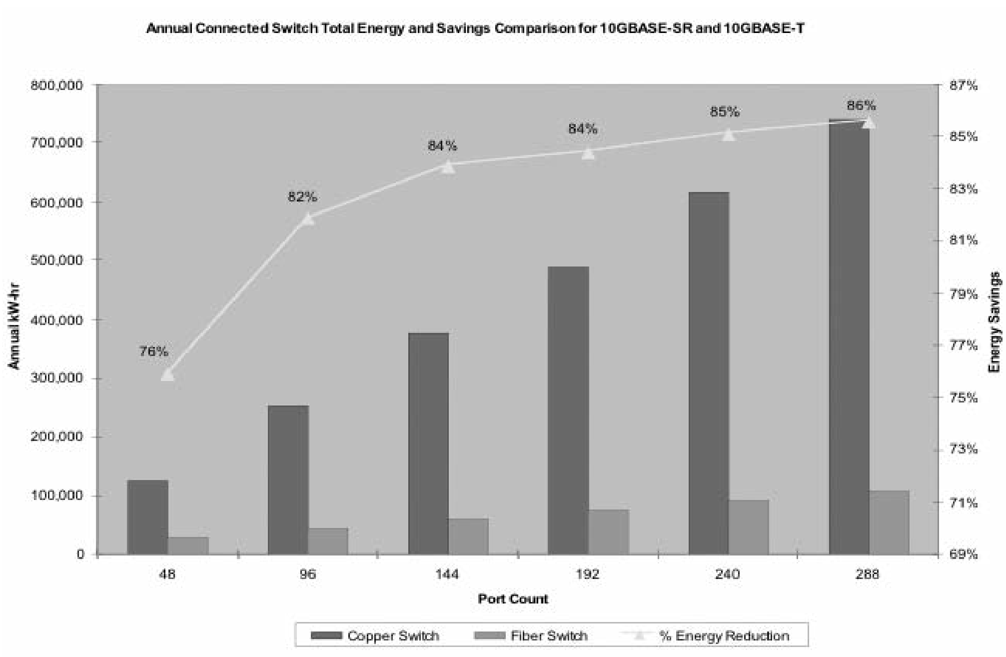

Figure 3 – Energy savings comparison

10G optical connectivity's lower energy utilization contributes to a more environmentally friendly performance compared to 10G copper. Lower energy consumption equates to lower carbon dioxide (CO_2) emissions. According to the EPA, one kW-hr is equivalent to 1.6 lbs of carbon dioxide CO_2 emissions. Therefore, CO_2 emission is 201,900 lbs for a 48-port 10G copper switch compared to 48,600 lbs for a 48-port 10G optical switch. In tangible terms, the reduction in CO_2 emissions through use of one 48-port 10G optical system equates to 13 fewer automobiles on U.S. highways. The impact at 288 ports is obviously more significant and equates to a reduction of 85 vehicles per year through use of 10G optical connectivity vs. copper (Figure 4.)

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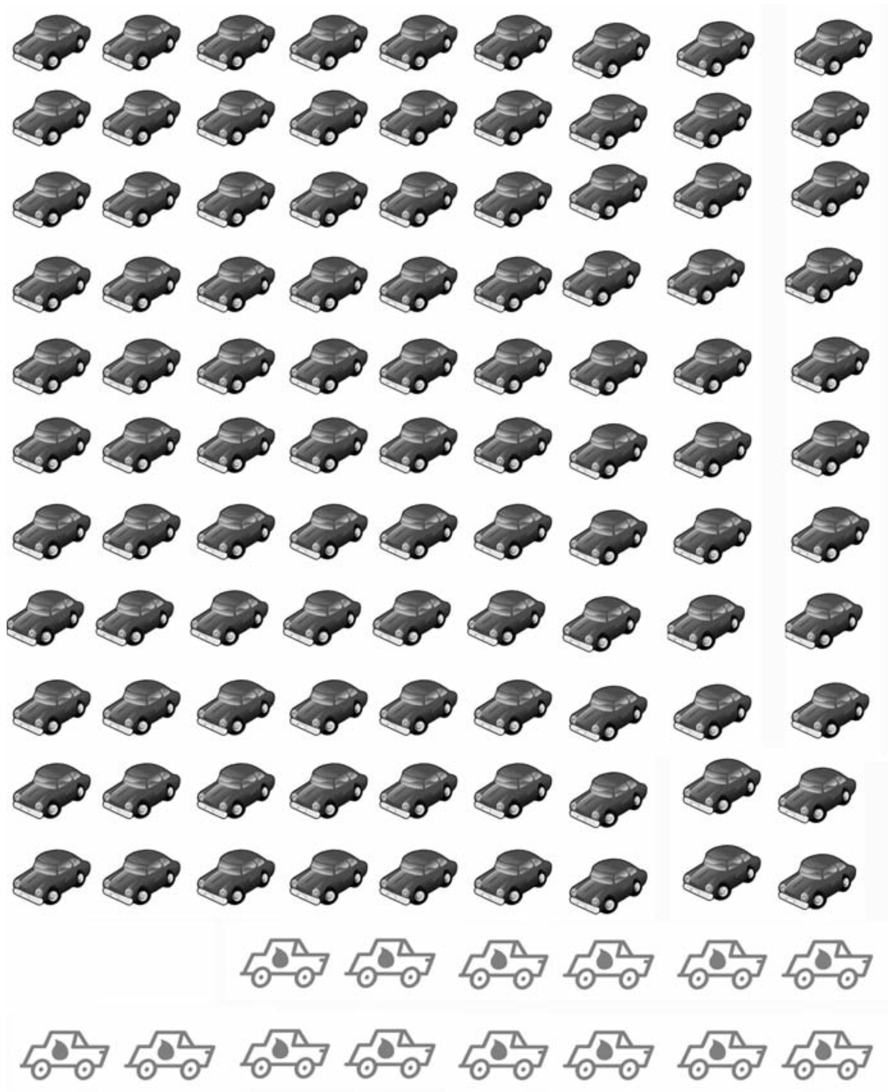

Figure 4 – Carbon dioxide emission equivalency for 288-port 10G copper vs. optical connectivity; 99 vehicles (copper) vs. 14 vehicles (optical)

Another common comparison is carbon dioxide emission equivalency to U.S. household electricity consumption. The EPA conversion for CO_2 emission based on electricity usage for a single-family home is 7.55 metric tons of CO_2 per home per year. Therefore, the CO_2 emission associated with a 48-port optical vs. copper switch is equivalent to the annual electricity use of three homes vs. 12 homes. At the other end of the scale, the CO_2 emission impact of a 288-port 10G optical system compared to copper connectivity is equivalent to the electricity consumption of 10 homes vs. 72 homes. That's the difference in electricity use of a small neighborhood!

Let's take a look at the other green measure; the financial impact of energy consumption associated with 10G optical vs.10G copper connectivity (Figure 5). A regional average $0.147kW-hr rate was used in the calculation. Annual savings range from 76 percent to 86 percent depending on port count which translates to a $93,000 savings for one 288-port optical switch vs. a copper switch.

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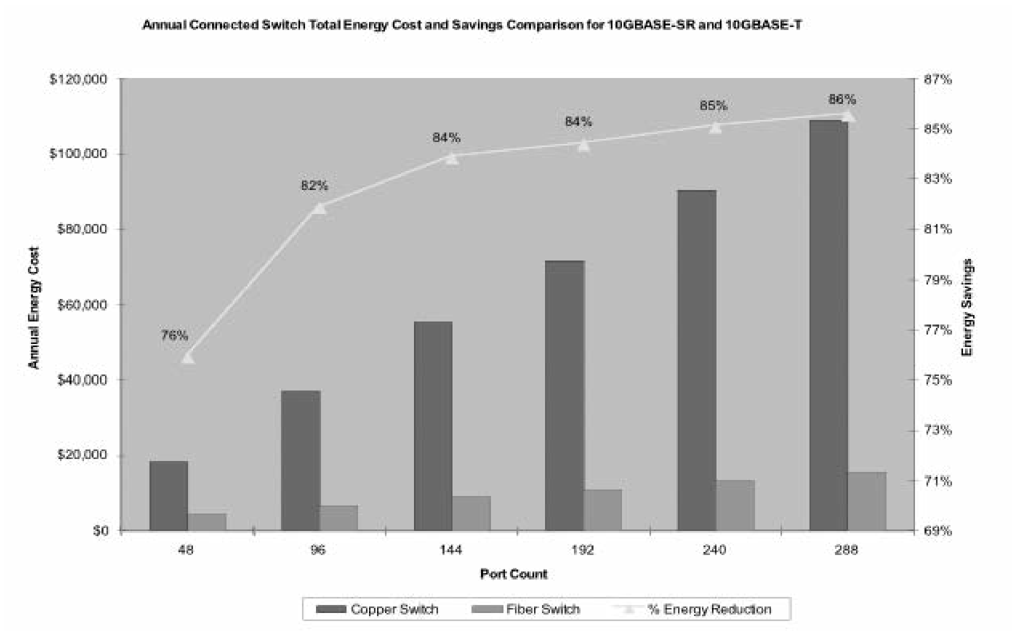

Figure 5 – Financial impact of energy consumption

Summary

Data center electrical energy consumption is projected to significantly increase in the next five years. Solutions to mitigate energy requirements, to reduce CO_2 emissions and to support environmental initiatives are being widely adopted. 10G optical connectivity supports the growing focus on a green data center philosophy. Optical cable with laser-optimized 50 µm OM3 fiber provides bandwidth capabilities that support legacy and future-data-rate applications beyond 10G. Optical connectivity provides the reduction in power consumption (electronic and cooling) and optimized pathway space utilization necessary to support the movement to greener data centers.

Sources: McKinsey & Company. Uptime Institute Symposium, Revolutionizing Data Center Efficiency

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