

Verizon Lights the Path to Green Telephony

Fiber plays the central role in Verizon's push for energy efficiency. Other FTTH deployers can follow Verizon's guidelines and methodologies.

By Steven S. Ross ■ *Broadband Properties*

Operators of fiber networks already know these networks save a lot of energy. Price-waterhouseCoopers studies conducted for the FTTH Councils in Europe and in the United States have confirmed that fiber optic networks take fewer of Earth's resources to build than copper. These networks also require less power to run, and because they are more automated and easier to monitor, operators can fix many problems from the central office without a truck roll.

Policymakers also rely on reliable broadband networks to enable smart buildings, telecommuting, better home care for shut-ins, a more efficient electricity grid and other advances that will help reduce energy consumption.

"Look at our FiOS service," says Ludwig C. "Chuck" Graff, director of Network Equipment Building Standards (NEBS) compliance and quality assurance for Verizon. "The amount of effort we are putting into that network, the reliability. You will ultimately see real savings on the truck rolls because the service is built extremely well. We're replacing the entire network with fiber optics. We're part of a new era of technology. We feel the same as the guys that laid the copper years ago." He and a staff of five – mainly electrical engineers – guide the process from Verizon offices in Baltimore. The NEBS themselves, a set of industrywide requirements, have been managed by Telcordia since the Bell breakup in the early 1980s.

However, Verizon hasn't stopped with building a fiber network. The telecom giant is also using its brainpower



and its purchasing power to accelerate the trend toward more sustainable operations. Since mid-2008, it has set thermal and power consumption goals for equipment developers. It is already working on recommendations for sustainable architectural design – interior finishes, lighting, furniture and more.

APPLYING LESSONS LEARNED

Verizon's goal is a 20 percent reduction in annual energy consumption beyond what would be saved by simply replacing copper with fiber. It is the first telecom company in the world to set such a goal, which analysts estimate will yield it about \$1 billion a year in savings. Because Verizon is publishing its requirements and test results on its compliance Web site, www.verizonnebs.com, other companies, too, can benefit from its work – even operators of GEAPON networks, because much of the equipment covered by the standards is common to both GEAPON and GPON.

Verizon operates in about 30,000 separate facilities worldwide and has one of the largest private vehicle fleets in the country. Does its ambitious goal "scale down" to smaller telcos, or will bureaucratic costs and delays eat into savings? Are halfway implementations – cherry-picking Verizon's equipment choices – good enough for smaller operators?

Another question is whether smaller telcos can invest enough in network control software and training to cost-effectively achieve green goals. For instance, some vendors are offering great deals on older-style equipment. How does a smaller telco handle the value engineering calculations to determine whether the lower first cost is worth the added energy expenses over time?

Telcos may also have problems applying Verizon standards to different types of equipment. Although some of the standards Verizon has developed allow equipment designers to define efficiency and lay out some test protocols,

About the Author

Steve Ross is corporate editor of BBP LLC. You can reach him at steve@broadbandproperties.com.

GREEN TECHNOLOGY

those standards don't begin to cover all equipment types. And due to the outsourcing of manufacturing and design, not all vendors have the ability to run all tests.

Nor are generic standards much help to smaller telcos. Even though building codes may cover fire protection, life safety, lighting, heating, cooling and ventilation requirements, few codes apply specifically to central office and network infrastructure. New, more sustainable, paints and wall panels that perform well in most industrial or commercial

settings may, in fact, be unwelcome in telecommunications settings.

Says Graff, "If the smaller guys use our Web site and see something they can use, that's fantastic. I think the bottom line is that there is no single solution for everything. If someone asks me how to make a cellular site more energy-efficient, the first question I have to ask is, 'Well, is it in the middle of a desert or on the side of a mountain?' If I put it on a mountain with all kinds of trees around it, I'm not going to get any sunlight at all to power solar cells. So I think the key is for every-

one to look at their own situation and to find a solution that works for them."

A HISTORY OF GREEN INNOVATION

"We're proud to say that Verizon is the first telecom company in the world to actually come up with a new standard, an actual pass-fail criterion and an actual target of 20 percent energy-use reduction for new equipment," says Graff.

Of course, Verizon has the luxury of being able to experiment, within limits. In 2008, the company earned the federal government's prestigious Energy

THERMAL MANAGEMENT REQUIREMENTS

Verizon requires that thermal management be used as part of an integrated equipment design process to minimize and remove heat generated by the equipment when it is powered up and in operation. This ensures that the equipment functions at its optimum thermal operating point; has correctly sized fans for heat removal, if applicable; and results in the constituent components operating within their specific thermal constraints. The overall goal is to help reduce energy consumption and ensure equipment reliability, both in controlled environments such as central offices and in heated and cooled equipment vaults, and for uncontrolled outside plant and remote terminal equipment as well.

Verizon specifies thermal modeling simulation and test requirements but does not require that specific modeling software be used. The tests can be run by equipment manufacturers or by independent test labs that Verizon certifies. In general, the test methods themselves are specified in Telcordia Generic Requirements documents.

The Verizon requirements at present cover the printed-board assembly level and above. That is, they apply to boards and stand-alone circuit packs as well as to fully populated shelves, cabinets and other enclosures employing either natural convection or forced-air cooling. They do not currently ap-

ply to the internal thermal design of packaged components, such as semiconductor devices, or to customer-premises equipment such as set-top boxes and modems.

Verizon is not interested in intermediate design decisions, and specifically bars vendors from sharing test results.

At present, the requirements address only the cost of operating the equipment when it is powered up and executing its intended function. They do not consider the cost of removing the heat generated by the equipment from the room into which the generated heat is released.

IMPLEMENTATION

Equipment manufacturers would do well to consider thermal issues during the design phase. In general, equipment manufacturers would first complete the appropriate circuit and logic design to accomplish the desired performance and then adjust component placement and physical layout of the board to optimize its thermal efficiency. After boards are integrated into the end-use enclosure, vendors test again and modify as necessary.

The complete 28-page document can be downloaded free at: www.verizonnebs.com/TPRs/VZ-TPR-9208.pdf.

Examples of Commercially Available Computational Fluid Dynamics Thermal Modeling Software

Software	Vendor	Web Site	Location
WinTherm, RadTherm	ThermoAnalytics Inc.	www.thermoanalytics.com	Calumet, MI
SINDA/FLUINT	C&R Technologies	www.crtech.com	Boulder, CO
Sauna	Thermal Solutions Inc.	www.thermalsoftware.com	Ann Arbor, MI
Coolit	DAAT Research	www.daat.com	Hanover, NH
COSMOSFloWorks	Dassault Systèmes SolidWorks	www.cosmosm.com	Concord, MA
FloTHERM	Flomerics Group (Mentor Graphics)	www.mentor.com	Wilsonville, OR
Ansys Fluent, Ansys CFD, Icepak	Ansys	www.ansys.com	Canonsburg, PA
STAR-CCM+	CD-Adapco	www.cd-adapco.com	Melville, NY
NX I-deas ESC	Siemens PLM Software	www.plm.automation.siemens.com	Plano, TX

GREEN TECHNOLOGY

Verizon has been experimenting with fuel cells and solar power at several facilities. These power sources are expected to become cost competitive in the future with increasing scale.

Star Award for operating the nation's largest fuel cell site of its kind, at a call-switching center and office building in Garden City, N.Y. The facility, built in 2005, uses seven fuel cells that help reduce dependence on commercial electric power and provide another layer of network reliability in the event of natural disasters, power outages and periods of peak commercial power demands.

Natural gas piped in from the local gas company provides the hydrogen for the cells to generate direct-current elec-

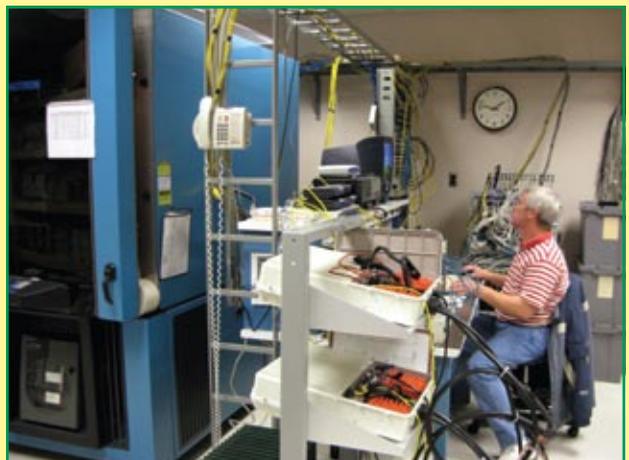
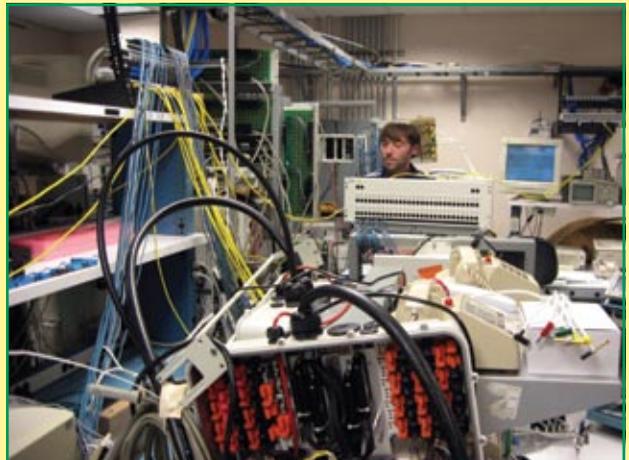
trical power. Each of the seven fuel cells is capable of generating 200 kilowatts of electrical power per hour, enough to supply the energy needs of about 400 single-family households. The cells provide as much as 80 percent of the facility's power. Heat and water (created when the hydrogen combines with oxygen from the air) are then removed from each cell, and the direct current is converted to alternating current for use in the building. Waste heat created by the fuel cells generates 75 percent of the

energy required to heat the facility and a third of the energy required for cooling.

By using fuel cells at this site, Verizon avoids emitting the 11.1 million pounds of carbon dioxide a year that a similar-sized fossil-fuel-based power plant would have put into the atmosphere. Why doesn't everyone do this? The fuel cells are so much more expensive than conventional power that at present they cannot be justified on the basis of cost alone. But Verizon is gaining invaluable experience with fuel cells in Garden City and in smaller telephone switching offices in Missouri, New York, Texas and Washington, where fuel cells provide emergency backup power.

Verizon is experimenting with solar power in its Carrollwood, Fla., central office, where it installed a 140-panel system at a cost of \$300,000. Peak output is about 20 kilowatts, or perhaps 100 to 200 kWh a day, worth between \$10 and

Large vendors such as ADTRAN, which manufactures and tests much of what it sells, would seem to have a natural advantage meeting Verizon's energy and thermal goals because in-house testing allows faster turnaround times. These pictures of thermal, fire and electrical hazards testing were taken at ADTRAN's Huntsville facility this fall.



\$60 depending on day of the year and possible tax breaks. The \$10,000 annual savings isn't enough to cover interest on the installation's cost. But again, equipment like this is expected to be cost-effective in the near future as installation costs come down and the cost of nonrenewable energy climbs.

WORKING WITH VENDORS

The two requirements Verizon has issued so far – one for energy efficiency and one for thermal performance – are summarized in the sidebars and can be downloaded free (see the sidebars for details). They are real requirements, and in that sense coercive. Companies that want to sell equipment to Verizon must meet the specifications. But the specs do not apply to existing equipment models. The energy requirements come into play only when a vendor modifies an existing design or produces an entirely new design after January 1, 2009. The thermal rules take hold mid-2011.

As of yet, the requirements apply only to the energy the devices use directly and not to the extra energy needed to cool them, despite the fact that Verizon says 35 to 45 percent of central-office expenses are for air conditioning. And so far, the only measures are energy consumption and heat.

Comprehensive rules for sustainability are a bit further down the road. "Verizon has really stepped up with a corporate sustainability program," Graff says. "We're focusing on what we have to do across the board, and we're starting to put together some nice metrics that we'll hopefully get out sooner or later. It's really taking off. We're looking at every aspect of the business – not just electronics, not just the building, not just air conditioning but every piece of it. Network design will be part of it. We have subject-matter experts from all the different [Verizon] business units, and we're beginning to develop lists of different opportunities, what's the best we can get in savings."

Graff's team at Verizon is also targeting existing equipment. He says, "We know that the stuff that's in the field today you can't make more energy efficient, but you can try to get more

energy-efficient behavior, maybe, by turning it down when you're not using it, consistent with reliability and customer service goals."

When it started the program early in 2007, Verizon went out of its way to enlist cooperation and solicit input from its suppliers. Verizon spokespeople say (and we confirmed) that the company did not issue final requirements until suppliers had a chance to review and comment.

The process was neither as universal nor as open as is the norm in consensus standards-setting organizations such as the American Society for Testing and Materials or the Institute of Electrical and Electronics Engineers. But Graff insists, "This is a shared opportunity, and we are realistic. If vendors don't go for it, it isn't going to happen. So although we want to push them a little bit, we want their input ... on trucks and cars, buildings, electronics."

"We're not going to change their design processes," says Graff. "We're trying to say that in their design process, if they find that they are not meeting the specific criteria we set down, they have to re-lay out the boards." Vendors, of course, always complain that telcos want smaller, more compact equipment that runs faster and faster and uses higher-density integrated circuits that run hotter. But Verizon offered a compromise: Although the boxes must fit into standard equipment racks – in the United States, these are usually 23 inches wide and 7 feet high – they can use enclosures as deep as 42 inches.

"That gives them some real estate to go back a little bit," said Graff. "It may cost us a bit more in capex, but we're going to save it in opex. I think people are starting to get that argument – the cost of the equipment initially versus what it is going to cost to power it. Manufacturing and engineering really don't want to talk to one another. Neither do the capex and opex people. Now we're going to start to talk together."

Verizon personnel say they are not looking for proprietary information from vendors on such matters as thermal design. But, admits Graff, "We want to know how they fixed it to get rid of the hot spot. We're not looking for propri-

etary information; we're just requiring a standard questionnaire they fill out, that we'll be able to decipher, saying they had a problem and they did this or that to solve it. We're saying that when you have a choice between component A and component B, when A is more energy efficient, use that one. But we're not going to specify the kind of values you should be seeing in component A or B or whatever."

Graff also says that if someone comes up with a new widget that doesn't fit the requirement's model, "We sit down with them and come up with something that works for them." The energy requirements document has already been modified four times (see sidebar).

LEADER OF THE PACK

The near-collapse of the Copenhagen summit on climate change (ironically, held at the same convention center where the FTTH Europe conference was held last winter) suggests that new policies will not be easy to achieve. But telecommunications companies seem to be out in front of the issue. "I sit on committees in Europe," says Graff. Telecom has the "same issues in Japan, London, New York. We all come from same heritage, and we all are beginning to look at sustainability across the board. We all have the same issues and the same common goal."

Graff also says vendors in China see an opportunity to grab market share. "They are claiming they can meet this with their eyes closed. I haven't verified that. ... but they say they can be double digits ahead of our goals." That means energy savings on new equipment of more than 30 percent.

Many American companies that have issued top-down mandates for sustainability have stumbled at the bottom of the management pyramid, where these policies are executed. How does Verizon get lower-level managers to sign on to sustainability goals if they do not expect to remain in their positions long enough to recapture implementation costs?

Verizon is attempting to spread the word and set the tone with its corporate sustainability council, which includes leaders from each of the business units who get together and hash out problems. That's no easy task; what a fleet

ENERGY EFFICIENCY REQUIREMENTS

Verizon's energy efficiency requirements document defines a Telecommunications Equipment Energy Efficiency Rating (TEEER) methodology for procuring equipment assemblies used in Verizon networks. The intent is to foster the creation of more energy-efficient telecommunications equipment by Verizon's supplier community, thereby reducing energy requirements for Verizon networks. Verizon first published the document in June 2008, modifying it a few months later to include baseline values for base transceiver subsystem equipment, point-to-point microwave and set-top boxes. In August 2009, the power equipment category was expanded to include inverters and converters and the section on external power supplies was expanded. Media gateways and ONT power supplies were added.

The methodology is applicable to, but not limited to, shelf, frame and cabinet-mounted network equipment to be installed in environmentally controlled locations, outside plant, and at the customer premises. As of this time, the document covers these equipment categories:

Transport

- Optical transport system
- Video transport system
- Point-to-point microwave transport

Switches/Routers

- Digital switches
- Soft switches
- Enterprise routers
- Core routers
- Edge routers
- Backbone routers
- Feature application routers

Gateways

- Media gateways

Access Equipment

- DSLAMs
- OLTs

Power

- Rectifiers
- Converters
- Inverters
- Uninterruptable power supplies

Data Center Equipment

- Servers

Customer-Premises Equipment

- External power adapters
- Set-top boxes
- ONT power supplies

Wireless Equipment

- Power amplifiers

MEASUREMENT APPROACH

For testing, Verizon requires that all equipment be configured as in a typical installation, fully loaded, with all card slots populated with functioning modules and all redundancies in

place, and with all cables installed as in a typical deployment. All system functions or features that increase power consumption must be activated during testing. If the equipment has any energy-saving features that are controlled by internal software, they should be enabled for testing.

The equipment is tested at 100 percent duty cycle, 50 percent, and turned on but not actually operating (idle or sleep mode). The three energy-use states are weighted differently for different kinds of equipment. Although most telecommunications equipment does not have an idle/sleep mode, Verizon tended to give a relatively high weighting value for it; this may be the area of greatest savings in terms of reduced power consumption.

The total average power, P_{Total}, calculated from these measurements and weightings is used to determine what Verizon calls the Telecommunications Equipment Energy Efficiency Rating (TEEER). The TEEER for an entire system can be calculated by using the results for the type of equipment that most closely resembles the equipment tested. The efficiency definitions, by equipment type, are shown in the table.

Equipment Type	TEEER Formula
Transport	$-\log(P_{Total} / \text{Throughput})$
Switch/Router	$-\log(P_{Total} / \text{Forwarding Capacity})$
Media Gateway	$-\log(P_{Total} / \text{Throughput})$
Access	$(\text{Access Lines} / P_{Total}) + 1$
Power	$(P_{Out Total} / P_{In Total}) \times 10$
Power Amplifiers (Wireless)	$(\text{Total RF Output Power} / \text{Total Input Power}) \times 10$

For example, the TEEER of a 160 Gbps switch or router would be calculated this way:

$$\begin{aligned}
 P_{max} &= 4320 \text{ Watts} \\
 P_{50} &= 3000 \text{ Watts} \\
 P_{sleep} &= 1500 \text{ Watts} \\
 P_{Total} &= (0.35 \times 4320) + (0.4 \times 3000) + (0.25 \times 1500) \\
 &= 3087 \text{ Watts} \\
 TEEER &= -\log(P_{Total} / \text{Forwarding Capacity}) \\
 &= -\log(3087 / 160,000,000,000) \\
 &= -\log(0.0000001929375) \\
 &= 7.71
 \end{aligned}$$

CPE EQUIPMENT

Testing of customer-premises equipment that is supplied with either an AC-to-AC adapter or AC-to-DC adapter follows the procedures of the most current version of the federal Energy Star requirements for external power adapters (www.energystar.gov). An external power supply must meet or exceed a minimum average efficiency for Active Mode, which varies based on the model's nameplate output power. The model's single average Active Mode efficiency value is calculated by testing at 100 percent, 75 percent, 50 percent and 25 percent

GREEN TECHNOLOGY

of rated current output and then computing the simple arithmetic average of these four values as specified in the Energy Star test method.

Based on the model's nameplate output power, Verizon selects the appropriate equation from the table below and calculates the minimum average efficiency. If the model's actual average efficiency is greater than or equal to the minimum average efficiency, the model has satisfied the requirement.

Energy-Efficiency Criteria for AC-AC and AC-DC External Power Supplies in Active Mode: Standard Models Nameplate Output Power (Pno)	Minimum Average Efficiency in Active Mode (expressed as a decimal)
0 to ≤ 1 watt	≥ 0.480 x Pno + 0.140
> 1 to ≤ 49 watts	≥ [0.0626 x Ln (Pno)] + 0.622
> 49 watts	≥ 0.870

Set-top box equipment efficiency also is judged against Energy Star requirements. A set-top box model must meet or exceed a minimum average efficiency for base functionality, plus allowances for specific additional functionalities present across a duty cycle. To calculate the allowance for a given device, the sum of the base functionality allowance and all applicable additional functionalities allowances are added and then compared to the measured values following the Energy Star set-top box test procedures.

For example, for a high-definition cable set-top box with DVR:

$$\text{Annual Energy Allowance (kWh/year)} = \text{Base Functionality} + \text{Additional Functionalities}$$

Base Functionality Annual Energy Allowance Base Functionality	Tier 1 Annual Energy Allowance (kWh/year)
Cable	70
Satellite	88
IP	45
Terrestrial	27
Thin-Client/Remote	27

Annual Energy Allowance Additional Functionalities	Tier 1 Annual Energy Allowance (kWh/year)
Additional Tuners	53
Additional Tuners – Terrestrial/IP	14
Adv. Video Processing	18
DVR	60
High Definition	35
Removable Media Player	12
Removable Media Player/Recorder	23
Multi-Room	44
CableCard	15
Home Network Interface	20

$$\begin{aligned} \text{Annual Energy Allowance (kWh/year)} &= 70 + 60 + 35 \\ \text{Annual Energy Allowance (kWh/year)} &= 165 \end{aligned}$$

The complete 23-page document can be downloaded at: www.verizonnebs.com/TPRs/VZ-TPR-9205.pdf

manager does to save gasoline is not the same as what a network manager does with a switch. But in telecommunications, everything is interrelated, networked. Spending more on a smarter switch should save truck rolls later.

Nevertheless, Graff says, developing a corporatewide approach to energy savings is tricky. "You can't really combine these as such. What we do is pick areas such as electricity use, water, waste and so on and put the metrics together. ... It takes energy to do everything. So if we go to the power level and calculate what we

save by saving water, waste and so forth, [we can] come up with a ... database that will put together all of these things and have kind of a corporate number. Ultimately, we all come out with a global number that combines it all."

Graff admits that cost is important. "There is a balance you have to deal with as you look at the off-the-shelf products, and you have to make some hard economic decisions – it is the way we work. We're trying to balance it. We look at a lot of different opportunities. By going to the core of the manufacturer's

design elements and having them design in a manner that will be more energy-efficient than what it was yesterday or the day before, we are trying to go beyond the surface level. If it is in the design level, it becomes the norm, and the entire company and the world will be the better for it."

Graff says Verizon stands out as a leader in this area "because we have the responsibility to be a leader. We're a large company, and with that comes a lot of baggage. We have to be standing out in front and seeing where we have to go so that the little guys ... don't have to think about these things. We know that a lot of work we do in this area will be used by a lot of folks who don't have the wherewithal to get there themselves. So as a corporate citizen we have to be leading the pack so the smaller guys know where to go." **BBP**

"If it is in the design, it becomes the norm, and the entire company and the world will be the better for it."