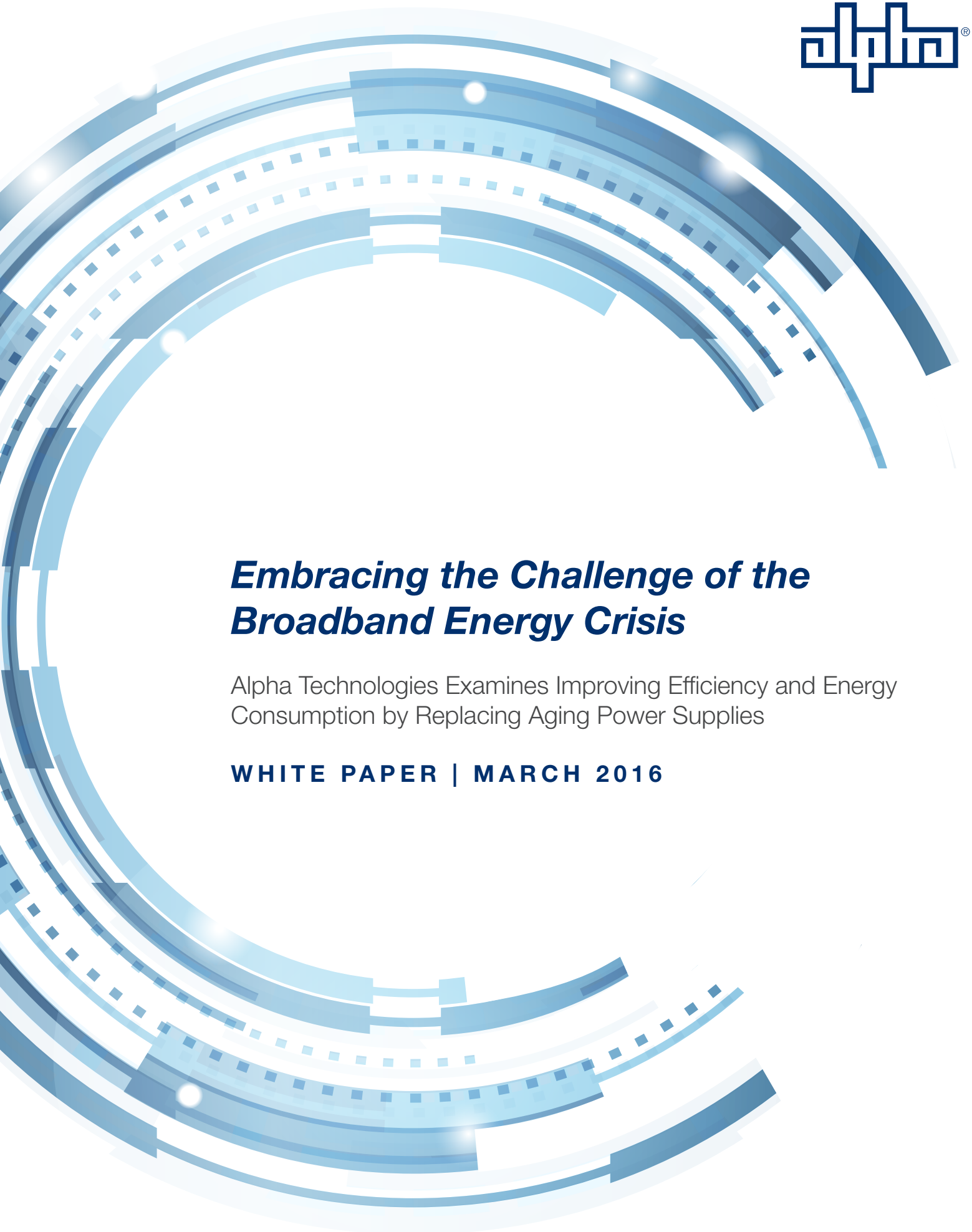


Embracing the Challenge of the Broadband Energy Crisis

Alpha Technologies Examines Improving Efficiency and Energy Consumption by Replacing Aging Power Supplies

WHITE PAPER | MARCH 2016

EXECUTIVE SUMMARY

The number of broadband subscribers continues to grow worldwide, while the offerings provided by cable operators is also growing. Between network growth and increased offerings, energy consumption and energy costs are at an all-time high. In just North America, broadband energy usage is estimated to grow four-fold, to as much as $4 billion by 2020. Industry leaders in Europe and North America are taking the lead on implementing standards to help improve network energy efficiency on a global scale.

SCTE's analysis of energy consumption among a cross section of major operators shows that roughly 75 percent of cable's overall energy consumption is by hubs and headends, "as well as the access network power supplies powering the active equipment on the HFC network".

The majority of energy savings relevant to active equipment are expected to be found through increased equipment efficiency in the headend and outside plant. Though outside plant power supplies will consume relatively low amounts of energy per unit, they are distributed in large numbers throughout a network. Therefore, great energy savings and efficiency can be found in the outside power supply chain.

> ***In just North America, broadband energy use is estimated to grow four-fold, to as much as $4 billion, by 2020.***

Since the introduction of cable powering supplies in the early 1970's, broadband/cable TV networks have become dramatically more sophisticated and efficient, especially over the last few years. However, since the majority of

Technologically advanced and ***more efficient*** power supplies are a **key component in dramatically increasing energy efficiency** on a global scale.

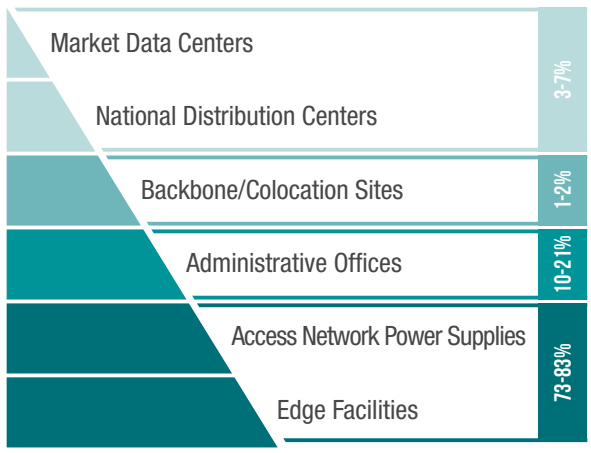
the millions of power supplies deployed around the world are between five and 32 years old (with a large portion of those well beyond their design life), it's clear that maximizing the outside plant efficiencies will produce enormous savings for MSOs.

Our research shows that technologically advanced and more efficient power supplies are a key component in dramatically increasing energy efficiency on a global scale. Outside plant energy reductions will be improved through evaluating the age and condition of legacy power supplies and developing a plan to determine when and where to deploy newer power supplies. The broadband industry needs to target the outside plant power supply as part of their larger goal to curb energy consumption and reduce costs.

GROWING DEMAND

As the demand for global broadband continues to grow and networks become more sophisticated, energy consumption and energy costs are also growing from the headend to the home. Even though the broadband industry is largely focused on the rapid global expansion of broadband networks and its offerings, growing energy consumption has not gone unnoticed. Industry leaders in Europe and North America are taking the lead on implementing standards to help improve network energy efficiency.

CABLE OPERATOR POWER CONSUMPTION PYRAMID



Source: SCTE analysis of available Energy 2020 participating MSO data.

The Society of Cable Engineers (SCTE), European Telecommunications Standards Institute (ETSI), CENELEC (European Committee for Electrotechnical Standardization), as well as government agencies are working towards defining energy efficiency metrics to reduce this increased demand on the power grid. The majority of energy savings, as they pertain to equipment, are expected to come through increased equipment efficiency in the headend and outside plant. While all aspects of the networks are consuming more energy, this article will focus on outside plant powering.

> ***The number of broadband subscriptions worldwide has grown by more than a quarter billion subscribers every five years since 2005—there will be 794 million subscribers globally by the end of 2015.***

According to the International Telecommunications Union, the number of broadband subscriptions worldwide has grown by more than a quarter billion subscribers every five years since 2005, with estimates that there will be 794 million subscribers globally by the end of 2015.

As the number of broadband subscribers grows, so are the offerings. Internet access, Wi-Fi, Voice over Internet Protocol and many other internet-enabled devices are significantly adding to the need for increased bandwidth and power. The growth of reliable high-speed broadband access is changing our world both socially and economically for the better, while creating the challenge of curbing increased energy consumption.

Analysis of broadband energy usage in North America, which can be extrapolated for the industry worldwide, estimates that energy usage for broadband could grow four-fold by 2020.

In Europe, the European Commission Institute of Energy Consumption believes broadband equipment will “contribute considerably to the electricity consumption of households in European Community in the near future.” Both European Directives and CENELEC are calling for energy saving targets.

The SCTE and industry-leading MSOs are looking to equipment manufacturers for help improving energy efficiency. The SCTE 2020 Energy Initiative is establishing global standards to reduce demand on the power grid by 2020.

SETTING THE SCTE 186 STANDARD FOR EQUIPMENT MANUFACTURERS

1. ***Replace existing gear*** from the outside plant and headend with more efficient equipment as part of normal operation maintenance.
2. ***Design and deploy*** more efficient equipment for outside plant and headend.

SCTE's analysis of energy consumption among a cross section of major operators shows that "between 73 percent and 83 percent of cable's overall energy consumption is by hubs and headends, as well as the access network power supplies powering the active equipment on the HFC network".

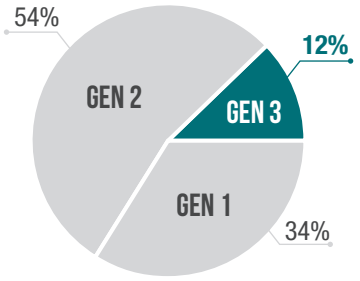
Within the Energy 2020 Initiative, the SCTE 186 Standard is looking for a two-pronged equipment approach as it pertains to equipment manufacturers. First, "the replacement of existing plant and headend gear with more efficient equipment as part of normal operational maintenance" to improve energy efficiency and reduce operating costs. Second is "the design and deployment of more efficient equipment".

To that end—though only one piece of the bigger picture—great energy savings and efficiency are to be found in the power supply that pushes power from the headend through hundreds of miles of broadband network in any given community.

Found along roughly every two and a half miles of a network, a broadband power supply uses the utility power from the power grid and reduces it to 48, 60, 75 or 90VAC to provide clean, stable power to the broadband network, and in most networks, to provide backup power during outages. Though each power supply will consume relatively low amounts of energy, they are distributed in large numbers throughout a network. Conservative estimates have shown that just a five percent gain in power supply efficiency (at 11 cents per kilowatt), when multiplied over 200 power supplies, can result in an annual power cost savings of $11,400 U.S. per year—or $57,000 over five years.

Due to the harsh environment and the reliability required to maintain adequate services to customers, the cable industry has relied on ferro technology to power their networks for more than 50 years. It's been nearly 40 years since

POWER SUPPLY CASE STUDY



Source: Alpha preventative maintenance service group surveying over 11,000 sites

Alpha Technologies introduced the first-ever standby power supply for cable television. Since then, broadband/cable networks have become dramatically more sophisticated. In turn, Alpha has continued developing and manufacturing the industry's most technologically advanced broadband powering equipment, including the

THE EVOLUTION OF NETWORK POWERING SINCE 1984

Power Supply	Gen 1		Gen 2	Gen 3	
Years	1987-1997	1994-2006	1999-2001	**2012-**	
Line Efficiency	86	86	89	**94**	→ **Utility OpEx Savings**
Inverter Efficiency	76	76	84	**91**	→ **Increased Battery Runtime & String Count Reduction**
Output (VAC)	60	48/63/75/87	48/63/75/87	**63/89**	→ **Reduced Network Cable Loss**
Output Regulation	-5/+5	-5/+5	-5/+5	**-2.5/+1**	→ **Greater Power Supply Reach**

recent industry-changing advancement of ferro transformer technology.

Based on the most widely deployed power supplies still in service today (post-1984), the outside plant power supply evolution can be divided into three generations based on improvements in efficiencies. Generation 1 power supplies (1984-1997) are single output tap ferro transformers with line efficiencies of 86 percent, and have push-pull inverter technology with an inverter efficiency of 86 percent. From 1994 to 2006, came the introduction of the multi-output tapped ferro transformers in Generation 1 power supplies. Generation 2 power supplies (1999-2011) saw the introduction to line interactive ferro technology with line efficiencies of 89 percent and full bridge rectification inverters with efficiencies of 84 percent. Most recently (2012 – today), Generation 3 introduced the industry to advanced line interactive ferro technology, achieving line efficiencies as high as 94 percent, and the reconstruction on the ferro transformer, reducing inverter transformer conversion losses and delivering 91 percent inverter efficiencies.

With a majority of the millions of power supplies deployed around the world being Generation 1 and Generation 2 power supplies, it is clear that maximizing the outside plant efficiencies will produce enormous savings for MSOs.

In support of this idea, in 2014, Alpha's preventive maintenance service group completed a case study of roughly 11,000 outside plant sites of one North American MSO. Out of the 11,000-plus sites, 34 percent were using Generation 1 power supplies, 54 percent were using Generation 2, and only 12 percent were using Generation 3 power supplies. Based on these figures, Alpha engineers determined that an annual utility savings of $625,000 could be realized by replacing the Generation 1 and 2 units with the more efficient Generation 3 power supplies.

The biggest advancement in ferro design topology was designed and deployed to the market with the launch of the XM3-HP by Alpha Technologies in 2012. This Generation 3 platform achieves the highest line and inverter efficiencies, tightest output regulation and the highest level of inverter line isolation protection available in the market.

As technology advances, Generation 3 broadband power supplies offer several

> ***The upgrade to 90VAC can reduce the total I^2R loss in the hardline cable for that network by more than 60 percent.***

opportunities for increased energy savings and efficiency. This newest-generation power platform maximizes network efficiencies in at least three specific areas:

LINE EFFICIENCY

Line efficiency is the percentage of source power converted to available load power, and improvements equate directly to reduced energy consumption. The newest generation of higher-efficiency ferroresonant transformers incorporate intelligent tap switching at the input that optimizes the power supply's performance, resulting in significantly reduced utility power consumption, by minimizing the secondary saturation energy loss of the ferro transformer while it regulates the output voltage. The intelligent tap switching also extends the brown out utility operation under less-than-full load operation. As long as the ferro can keep the output in regulation, it will stay in line mode, which minimizes the battery discharge cycle, thus maximizing battery life. Extended line mode operation also improves the utility efficiency by preventing the charge cycle required after battery discharge cycle.

INVERTER EFFICIENCY

Inverter efficiency is the percentage of battery power converted to available load power, and improvements will increase battery runtime and reduce battery string count. Alpha Technologies has made the biggest leap in ferro technology by moving the inverter winding to the output side of the ferroresonant transformer. Isolating it from the input winding gives the inverter power electronics the same 1000:1 attenuation protection from utility spikes and surges as the output has always had in the ferro design. In addition this change has significantly improved the inverter efficiency by minimizing the conversion losses typically wasted in the transformer. This improved inverter efficiency also has reduced the overall operating temperature of the power supply eliminating, the requirement of an internal fan to maintain a safe operating temperature.

OUTPUT VOLTAGE AND REGULATION

Output voltage and regulation reduces network cable loss, giving greater power supply reach. In North America, MSO's have been successful in reducing power used in their outside plant by reducing hardline I^2R losses in the outside plant by upgrading to the maximum allowed voltage (90VAC).

For example, a case study of a small neighborhood plant upgrade from 60VAC to 90VAC, powered by three Generation 2 power supplies (with one fiber node, 10 amplifiers and three line extenders) shows the upgrade to 90VAC can reduce the total I^2R loss in the hardline cable for that network by more than 60 percent and reduce the total input power consumed in the plant by 9 percent.

Additionally, with the longer reach of the 90VAC power supply, more actives can be powered

off of a single power supply, reducing the total number of power supplies required in this example to only two, which reduces the total consumed power in the plant by 12 percent.

Around the world, the maximum allowed operating voltage of CATV network power is limited by various national regulations. In North America, the maximum operating voltage is 90VAC (National Electric Safety Code, definition of communications lines), in Europe the maximum is 65VAC (EN 60728-11 section 8.1, Remote Power Feeding in Cable Networks) and other countries that adopt IEC 60728-11. Japan has a national deviation in IEC 60728-11 to allow 90VAC plant power. Some cable operators may run their plants at lower voltages (48, 60 or 75VAC are typical voltages) either due to company policy, equipment, standardization, or municipal regulations. Unless some of these standards and regulations are changed to allow the higher 90VAC standard, some countries will not be able to benefit from this power reduction created by reducing I^2R Losses through increased outside plant voltage.

For more on the move up from 60V line power supplies, see Alpha's white paper: ***Broadband Powering Methods: A natural engineering choice***

Generation 3 power supplies have other advantages, which equate to better network efficiency as well as reduced maintenance-

CASE STUDY CONVERTING 60V POWER PLANT TO 90V
EXTEND POWER SUPPLY REACH, REDUCE POWER SUPPLY COUNT

Network Plant	(3) Gen 2, 60VAC Power Supplies			(3) Gen 3, 90VAC Power Supplies		
Location	**Site A**	**Site B**	**Site C**	**Site A**	**Site B**	**Site C**
Output Voltage	60	60	60	89	89	89
Output Current	6.3	11.3	7.9	9.2	7.4	0
Cable I^2R Loss (W)	39.2	67.5	60.6	74.1	27.1	0
Output Power (W)	375.3	699.5	472.5	822.1	659.1	0
Input Power @ Vin Nominal	491.7	816.1	591.7	931.0	746.0	0
Total Cable I^2R Loss (W)	167			101		
Total Output Power (W)	1547			1481		
Total Input Power (W)	1899			1677		

Load Redistribution Eliminates 1 Power Supply

60V to 90V Allows for Redistribution of Loads

12% Decrease in Total Power Requirement

Total Utility Power Saved (W): **222** **Annual Power Saved** (kWh): **1945**

related costs. A multiple-stage charger provides optimized charge current and multiple battery voltage regulations to maximize the battery life and to optimize the charging cycle. Monitoring and managing the current flowing to each battery assures all of the batteries in the string are under the same state of charge to get the extended life benefit from the multi-stage string charger. Terminating the battery discharge cycle based on individual batteries will prevent the over-discharging of a weak battery in the string, preventing damage to the weak battery.

POWER SUPPLY MONITORING

Intelligent power supplies within broadband networks provide status monitoring and valuable information before, during and after power outages. Before an outage, status monitoring identifies faulty batteries, problems with connections between the batteries and power supply and potential charging system issues. During a power outage, accurate measurement of the individual battery voltages is a requisite to creating accurate, real-time predictions of remaining run time (autonomy), which is critical to decisions on where to dispatch service personnel.

Further optimization of the power supply and the broadband network is achieved through internet-enabled monitoring. Since the broadband UPS is connected directly to the broadband network, it can transmit and receive data via a hardened built-in modem, allowing for status monitoring, historical data analytics and direct firmware updating.

CONCLUSION

With the advances in technology already available, Generation 3 power supplies are a key component in reaching energy efficiency milestones on a global scale. Outside plant energy reductions will be met through evaluating the age and condition of legacy power supplies and developing a simple algorithm to determine when and where to deploy new Generation 3 power supplies. The broadband industry needs to target the outside plant power supply as part of their larger goal to curb energy consumption and reduce costs. Through the guidance of industry leaders and participation of equipment manufacturers, we can deliver a more energy efficient future for the broadband industry.