SCTE® | STANDARDS

Energy Management Subcommittee

SCTE STANDARD

SCTE 287 2023

Right-Sizing Outside Plant Power Supplies

NOTICE

The Society of Cable Telecommunications Engineers (SCTE) Standards and Operational Practices (hereafter called “documents”) are intended to serve the public interest by providing specifications, test methods and procedures that promote uniformity of product, interoperability, interchangeability, best practices, and the long-term reliability of broadband communications facilities. These documents shall not in any way preclude any member or non-member of SCTE from manufacturing or selling products not conforming to such documents, nor shall the existence of such standards preclude their voluntary use by those other than SCTE members.

SCTE assumes no obligations or liability whatsoever to any party who may adopt the documents. Such adopting party assumes all risks associated with adoption of these documents and accepts full responsibility for any damage and/or claims arising from the adoption of such documents.

NOTE: The user’s attention is called to the possibility that compliance with this document may require the use of an invention covered by patent rights. By publication of this document, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer. SCTE shall not be responsible for identifying patents for which a license may be required or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Patent holders who believe that they hold patents which are essential to the implementation of this document have been requested to provide information about those patents and any related licensing terms and conditions. Any such declarations made before or after publication of this document are available on the SCTE web site at https://scte.org.

140 Philips Road
Exton, PA 19341

Document Tags

☐ Specification	☐ Checklist	☐ Facility
☐ Test or Measurement	☐ Metric	☒ Access Network
☐ Architecture or Framework	☐ Cloud	☐ Customer Premises
☒ Procedure, Process or Method		

Document Release History

Release	Date
SCTE 287 2023	*11/30/2023*

Note: Standards that are released multiple times in the same year use: a, b, c, etc. to indicate normative balloted updates and/or r1, r2, r3, etc. to indicate editorial changes to a released document after the year.

Table of Contents

Title **Page Number**

List of Figures

Title **Page Number**

List of Tables

Title **Page Number**

1. Introduction

1.1. Executive Summary

In a cable broadband provider's effort to become more energy efficient there is an opportunity to right-size an expanding arsenal of ferroresonant power supplies and to ensure the most efficient placement of those power supplies.

By increasing efficiency in placement, providers may benefit from reductions in operational and capital expenses, reduced Scope 2 emissions through less transmission loss to inefficient transformation, and extended runtimes. This creates potentially less need to deploy portable generators which can impact Scope 1 emissions.

1.2. Scope

This operational practice defines methods for the most efficient placement of ferroresonant power supplies. Considerations are made to:

- recognize the cost to transform power,
- separate runtime needs for battery charging,
- include architecture agnostic load-based power supply sizing,
- describe thresholds for triggering new power supply additions.

1.3. Benefits

Operators have often deployed ferroresonant based power supplies without considering the opportunities to maximize device performance or environmental impact which results in carrying multiple power supply models and potentially deploying a high-capacity power supply with a low load. An outcome is the inefficient use of the ferro ability to transform power. While there are many architectural needs, there are benefits that can be found by considering the site and power supplies to be deployed during the design processes.

The operational benefits of these considerations

- can lead to decreased energy consumption
- drive down operating costs
- improve accounting for environmental impact
- provide original equipment manufacturers (OEMs) the capacity to foresee potential demand by understanding operator deployment practices
    - to allow focus on performance and optimization of devices
    - drive OEMs towards improved technologies.

1.4. Intended Audience

The intended audience for this operational practice includes

- OEMs and cable broadband providers who manage access network power,
- HFC planning design and deployment,
- network architects and analysts,
- field operations,
- energy management, and
- those responsible for measuring energy performance.

1.5. Areas for Further Investigation or to be Added in Future Versions

Future investigation would specify telemetry metrics and show how to use metrics to aid calculation of a right-sized power supply location.

2. Normative References

The following documents contain provisions which, through reference in this text, constitute provisions of this document. The editions indicated were valid at the time of subcommittee approval. All documents are subject to revision and, while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

No references are applicable.

2.2. Standards from Other Organizations

2.3. Other Published Materials

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

[SCTE 278]	ANSI/SCTE 278 2022, Standard Data Fields for Outside Plant Power
[SCTE 238]	ANSI/SCTE 238 2017, Energy Metrics for Cable Operator Access Networks
[SCTE 211]	ANSI/SCTE 211 2020, Operational Practice for Measuring and Baselining Power Consumption in Outside Plant Equipment and Power Supplies

3.2. Standards from Other Organizations

GHG Protocol – https://ghgprotocol.org/corporate-standard

3.3. Other Published Materials

SAS Output (eia.gov)

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified ***shall*** never be used.
should	This word or the adjective "*recommended*" means that there *may* exist valid reasons in particular circumstances to ignore this item, but the full implications *should* be understood, and the case carefully weighed before choosing a different course.
should not	This phrase means that there *may* exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications *should* be understood, and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" indicate a course of action permissible within the limits of the document.
deprecated	Use is permissible for legacy purposes only. Deprecated features *may* be removed from future versions of this document. Implementations *should* avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

CO_2	carbon dioxide
DOCSIS 4.0	Data Over Cable Service Interface Specification version 4.0
EMS	element management system
FTTP	fiber to the premise
GHG	Greenhouse Gas [Protocol]
HFC	hybrid fiber coax
kWh	kilowatt-hour
OEM	original equipment manufacturer
OSP	outside plant
PFC	power factor correction
PS	power supply
SAIDI	System Average Interruption Duration Index. It is the minutes of non-momentary electric interruptions, per year, the average customer experienced.
SAIFI	System Average Interruption Frequency Index. It is the number of non-momentary electric interruptions, per year, the average customer experienced.
SCTE	Society of Cable Telecommunications Engineers
SKU	Stock Keeping Unit
US	United States of America

5.2. Definitions

Definitions of terms used in this document are provided in this section. Defined terms that have specific meanings are capitalized. When the capitalized term is used in this document, the term has the specific meaning as defined in this section.

amps	Amperage is listed in units called amps (or amperes). Amperage is the "rate" that current is flowing through the circuit or the number of electrons moving through the wire.

6. Background

Legacy industry practices typically deploy only a few models of devices without consideration for power supply efficiency. A commonly deployed device is capable of 15-amp draw and is deployed in a variety of loading situations, some of which are quite low. Power supplies exhibit their best powering efficiencies closer to their loading capacity. Some operators focused on standby runtime, or based on limits set, deploy a power supply at lower loads to not increase the load of an existing power supply when plant extensions or redesigns are required.

Legacy power supply options have been limited, however, modern power supplies offer a variety of output loading options. A deployment model based on powering loads would provide the best solution for efficiency, decreased operating costs and environmental impact.

7. Right-Sizing

More choice equates to more products needed to be available for maintenance and repair, requiring additional storage considerations for daily operations. An operator reduces SKUs and focuses on 1 or 2 models that cover current hybrid fiber coax (HFC) needs, optimizing models vs efficiency gains.

Below is an estimated distribution of power supply loading across North America (Figure 1). By using this data in combination with the knowledge of the efficiency curve of plant power supplies (Figure 2) we can determine the optimized model plan for plant efficiency, while still considering operational demands created by stocking multiple models.

Based on the current state of this data and the assumption that there could be some increase in power consumption soon with the implementation of DOCSIS 4.0 and the progression to 10G, the data suggests that there is a need for three power supply models.

First, and most important is the need to create a model that optimizes efficiency in the center of the bell curve to maximize gains where there is the biggest quantitative impact. Next, because of the significant drop off in powering efficiency for power supplies at lower than 30%-40% of maximum capacity, it is advisable to utilize a model that optimizes efficiency at these lower loads. This has recently become more important as rural connectivity initiatives are increasing the number of lightly loaded rural sites.

Lastly, it is necessary to have a model that addresses the upper end of the curve to ensure coverage today and into the future as power needs evolve.

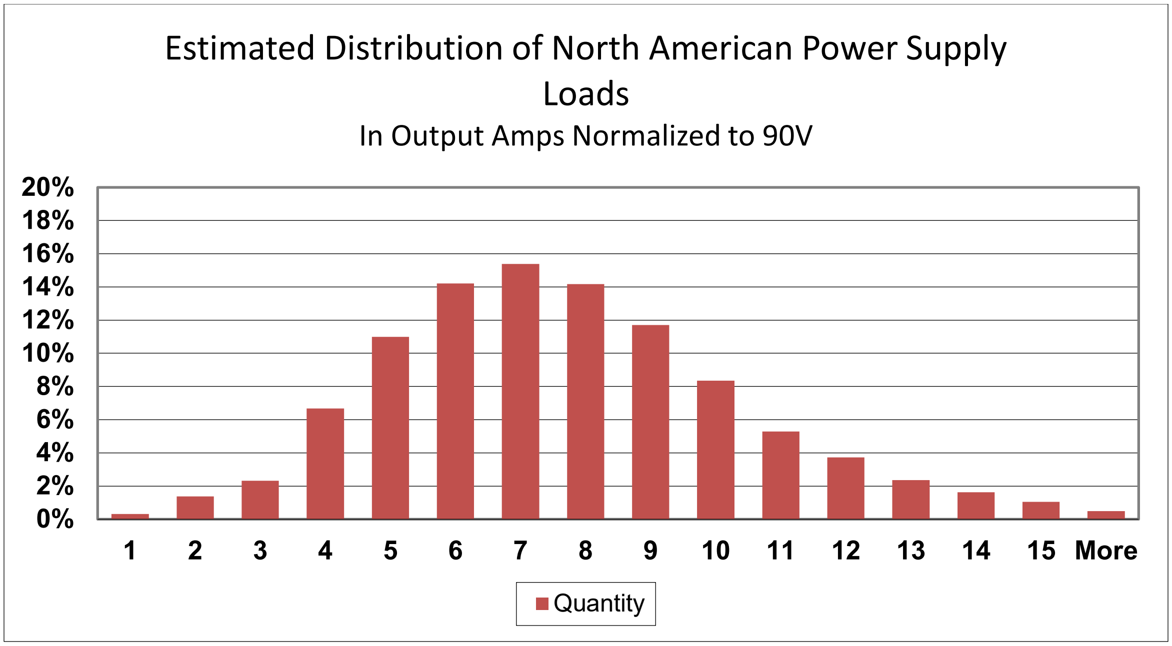

Figure 1 - Estimated Distribution of North American Power Supply Loads

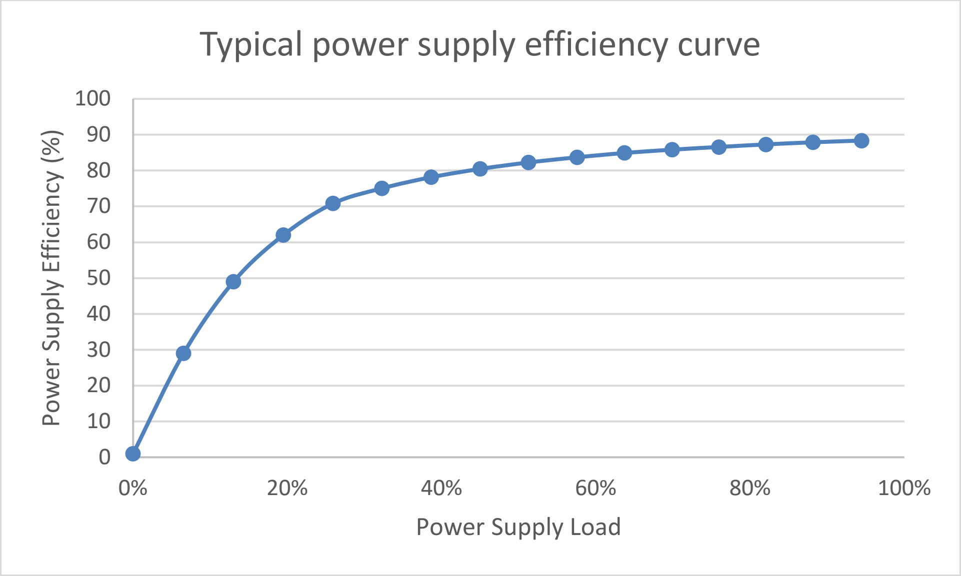

Figure 2 - Typical Power Supply Efficiency Curve

According to Figure 2- the efficiency of a power supply increases as the output load (as a percentage of its name plate rated load) increases. This is driven numerically by the inherent overhead power required for both the tank circuit, and the iron core saturation, which provide the device with its high resiliency from transients as well as tight output voltage regulation.

Right sizing might reduce capacity for network growth, which will need to be considered when adjustments to plant design are required by both design and plant network technicians. One solution would be to utilize a low draw model of power supplies (PS) in the last mile and upgrade during network expansion.

Power supplies are thoroughly tested and vetted at 100% of their rated loading and while not recommended for longevity of the device, can generally run at up to 105% - 115% of their rated load for several months with little impact to the rated life or function of the power supply. This means that if the load on a power supply were guaranteed to never change once installed, these devices could run as close to 100% load as possible to maximize efficiency. Increasing power supply loading above the 115% threshold might exceed the current limit of active devices on the plant. Higher currents above 150-180% of rated can exceed internal power supply component ratings and risk damage.

It is important to consider temperature variation on the plant and power fluctuations due to loads with variable power draw and headroom for incremental growth. In an area with constant power loads, power supplies can generally be loaded 90-95% of their rated capacity at 25°C and have enough headroom to account for load change due to temperature variation in the plant. For devices with dynamic loads such as wi-fi or small cell radios, the plant *should* be loaded based on steady state draw, but one *should* also consider the frequency, duration, and scale of peak draw using Table 1 below as a guideline.

Table 1 - Recommended Duration of Overload Conditions on a Ferroresonant Power Supply

Power Supply Load	Recommended Max Duration of Load
>180%	Power supply folds back (limits) output to less than 20A instantaneously
150% to 180%	10 seconds
125% to 150%	10 Minutes
115% to 125%	30 Minutes
<115%	Many Months

Ferroresonant power supplies are generally very resilient to temperature and have a wide operating temperature range, generally -40°C to +60°C. However, extended periods at high temperatures can degrade thermal insulation in the transformer, lowering its efficiency due to additional heat loss.

Ferroresonant power supplies *should not* be run at loads lower than 5% of the rated load. In this scenario the transformer can become unstable and cause output voltage fluctuations.

7.1.1. Recommended Loading

Based on a recommended loading, what is the efficiency and potential kWh (cost) between the different power supplies to choose from on an annual/monthly basis?

Below, Table 2 estimates power savings from right sizing power supply deployments. These values are derived by multiplying the difference in efficiency percentages between devices at various loads by the output load.

Example: At 2A and 90V output a power supply with a low output rating is 78.41% efficient and a power supply with a mid-output rating is 66.91% efficient. We will assume a power factor of 1 for simplicity's sake so that Output VA = Output W. To calculate the power savings, we have:

- $W_{Saved} = (Efficiency_{Low} - Efficiency_{Mid}) \times V \times I$
- Power Savings = (.7841 - .6691) x 90 V x 2 A = 20.7 W

Table 2 - Power Savings in Watts

	Power Savings in Watts		
Amp Load	Low to Mid	Low to High	Mid to High
1	13.4	18.5	5.0
2	20.7	30.0	9.3
3	26.5	38.3	11.8
4	27.1	39.4	12.3
5	27.8	41.6	13.8
6			15.9
7			15.7
8			15.8
9			15.9
10			14.8

Once a power supply is loaded to the sweet spot, the battery string charging will have a minimum impact. As the utility comes back, the power supply will take more input power to charge the battery string in addition to power the load. This additional power will push more load on the ferro therefore pushing the ferro to a higher efficiency point. The charging energy will be around 120% of the discharged energy. During the inverter mode the power supply does not use the utility power so the net power loss due to charging power is around 20% of the discharged power. That minimizes impact since utility failure is a rare occurrence in the US and long utility failure is even lower. Most recent calculations of average yearly outage duration (SAIDI) and frequency (SAIFI) show a total of 475 minutes per year and 1.436 outages per year. https://www.eia.gov/electricity/annual/html/epa_11_01.html

The difference in efficiency between 120 and 240 VAC input is negligible. Any small efficiency gains from lowered current and I^2R losses through the short power cord of the power supply are offset by additional copper required to down-convert 240VAC to plant powering voltage.

After a regular health test (every 30 days for 10 minutes) the recharged energy is 20% of the discharged energy, so if we normalize around the discharged energy, with the charge energy at the same level of discharged energy, normally takes an additional 2 minutes per every health test. 2 minutes per 30 days results in very minimal impact.

Currently most operators use lower and higher amperage models, but generally higher amperage is what is deployed in a majority of sites today. It uses 3 batteries as a standard. Lower power models, like a 3A or 5A power supply can use between 1 and 4 batteries, although wired in parallel instead of in a series like a standard 3-battery, 36V string.

Because of the many complexities involved, operators *should* consult with the power supply manufacturer for guidance on extended backup operation beyond 24 hours. Backup time *should* be determined based on unique operator business practices and unique site needs. For example, a site backing up more critical loads from a business or public safety perspective may need greater backup time. Similarly, rural sites that are a significant distance from service centers or sites that have government requirements for backup may also have greater runtime requirement needs.

7.1.2. Inrush loading on plant startup –

- Most power supplies have been tested for this with current broadband plant.
- Future loads on plant with longer power supply output waveform transition settling time (>20 ms) will have to be qualified to work with the existing plant power supplies.

7.1.3. Dynamic loading devices (Such as cell sites) –

- In this scenario, there is a need to size the PS to the maximum cell sites configuration.

7.1.4. Power factor corrected plant amplifiers –

- Ferroresonant power supply regulation is done with passive components (Ferro inductance and the oil capacitor) tuning around the utility frequency.
- The power factor correction (PFC) power supply design for use in actives *should* adjust their regulation and the active start up controls to work with a ferroresonant power supply.
- A full qualification of the actives' PFC power conversion with a ferroresonant power supply is recommended prior to field installation as improperly implemented PFC controls can overreact to the inherent behavior of a ferroresonant power supply and cause plant instability.

7.2. Telemetry

Modern power supplies offer status monitoring of performance and fault metrics. Cable operators *should* utilize device telemetry to measure energy use. Current operating efficiency for outside plant power supplies is defined in [SCTE 278] *Standard Data Fields for Outside Plant Power.* Power supply power reading accuracy is useful as an estimating tool but is not calibrated to utility meter standards.

Depending on methods used, there is potential to capture when a site is not operating the same as other sites. For example, repeat utility outages would result in a continuous recharge of batteries, which may increase cost and impact on the environment. Multiple truck rolls increase operational expense and carbon emissions. A power supply device may indicate a utility problem. If telemetry is recorded over an extended period, strategic forecasting of maintenance needs can be accomplished. There are standard conversions that may help calculate energy emissions available at https://www.eia.gov/electricity/data.php.

1 watt of power savings = 8.76 kWh annually = 7.45 lbs. of CO_2

7.3. Network Reliability

An important concern for cable operators is to ensure reliability of the access network. Right sizing a power site is a step towards longevity. It improves outage response time by understanding battery backup runtimes. It improves an operator's understanding of cost of ownership with a more consistent cost per location. By better understanding data and having a defined process for measuring and computing telemetry, it allows operators to build more structured operating plans for outside plant powering.

A cable operator could, through telemetry and monitoring, get an understanding of the footprint in terms of reliability by analyzing the frequency each site goes into standby mode. Areas of infrequent battery use could offer cost savings by using lower capacity battery deployments, while areas that are frequently impacted would require higher capacity batteries.