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POWER-OVER ETHERNET DC DISTRIBUTION



Safe, Easily Installed, Cost-Effective Power and Data Distribution

Power and data delivery over a single cable enables Power-over-Ethernet (PoE) technologies to consolidate networking and infrastructure, simplify systems controls, and facilitate data-driven energy and building management. PoE systems lay the groundwork for grid-integrated, smart buildings by linking Internet of Things (IoT) devices, data, and building controls.

Remediating energy losses is key to optimizing PoE efficiency.^{1,2} A previous CEBT study found standby losses particularly prohibitive to deployment. In collaboration with Lawrence Berkeley National Laboratory (LBNL), CEBT evaluated PoE direct current (DC) distribution with two lighting systems, focusing on reducing standby losses, whole-system efficiency, and energy reporting accuracy.

PoE performance continues to improve with real-world evaluations and collaboration with industry partners. With preliminary findings indicating excessive standby consumption, the vendor and partners developed port shut-off (PSO) functionality to reduce losses by as much as 4% and improve whole-system efficiency. Efforts were also made to reduce costs and system complexity. With simpler, less labor-intensive installation, PoE lighting was less expensive than an equivalent alternating current (AC) alternative. Researchers recommend further evaluation to determine the potential for incorporating PoE into demand-based HVAC controls.

INTRODUCTION

PoE switch specifications
and use cases

Use Cases	Nominal Voltage	Distribution	Equipment Capabilities	Wiring
Lighting, sensors, cameras, security systems, HVAC controls, teleconferencing	48V DC	Up to 57V DC	Minimum 44V input	NEC Class 2

Evaluated PoE lighting
system configurations and
design considerations

	Evaluated Layout Design	Hardware
Gateway-based installed at WIL, 5,662 SF	Gateway powers up to 4 LED drivers, each with its own luminaire (typical 25 W)	PoE switch, power distribution unit (PDU), gateways (38), LED drivers (81), occupancy sensors (19), PC
Node-based tested at Flexlab, 250 SF	Nodes with built-in drivers, each can power 2 luminaires (typical 25 W)	PoE switch, PDU, nodes (2), occupancy sensor, PC

“After the introduction of the PSO software feature, we saw reduced standby losses, highlighting the potential for control-based strategies to improve the efficiency and performance of PoE systems.”

–Joshua Banis
Branch Chief
Technology and Innovation
U.S. General Services Administration

What Is This Technology

SINGLE CABLE PROVIDES LOW-VOLTAGE, DC POWER AND DATA

PoE provides low-voltage, DC power distribution and the convenience of a single cable for both power and data. Powered by either AC or DC, a PoE switch converts the input to 48-57V DC and delivers power and data to PoE loads. Two PoE lighting systems were evaluated: a gateway-based and a node-based PoE system. In the gateway-based system, a gateway distributes power to the LED drivers, while the node-based system consolidates the gateway and drivers into a single unit. To reduce standby losses, PSO disables most ports at night, while occupancy sensors enable the ports and activate lights when people are detected in the lighting zone. Some benefits of PoE systems include touch-safe low voltage and safety enhancements, reduced infrastructure costs, simplified installation, data and system integration, remote monitoring, and improved energy management. The technology for this evaluation was provided by Cisco with lighting systems from the vendor’s partners, Molex and MHT Technologies.

What We Did

EVALUATED EFFICIENCY, ENERGY REPORTING, AND PERFORMANCE OPTIMIZATION

Evaluations were conducted at two sites: GSA’s Workplace Innovation Lab (WIL) and a Flexlab space at LBNL. The gateway-based system was installed at WIL and was designed for layout flexibility. The node-based system was evaluated at Flexlab and was designed to reduce energy consumption after high standby losses were found in the first system’s gateways. PSO was developed after data collection at WIL, leading researchers to evaluate the gateways with PSO in the lab. An equivalent, high-performance AC LED lighting system was modeled to serve as baseline. Researchers considered two additional scenarios: a DC-coupled solution to eliminate AC conversion losses, and a lighting-only system optimized for energy savings using market-available devices, potentially from other vendors.

FINDINGS



WHOLE-SYSTEM EFFICIENCY The gateway-based system without PSO had the most standby losses and was 9% less efficient than the equivalent AC system. The node-based system was 6% more efficient than AC, and the system optimized for lighting only was 18% more efficient with the fewest standby losses.



MAJORITY OF STANDBY LOSSES FROM GATEWAYS More than half of all standby losses in the gateway-based system were from the gateways and LED drivers (133 W).



PSO CRITICAL TO REDUCE STANDBY LOSSES PSO improved standby consumption by up to 4%, with the most improvement in the gateways.



SUFFICIENT ENERGY REPORTING Results for the switch's output port testing showed less than 5% error in measuring port power above 20 W.



LESS EXPENSIVE THAN AC PoE systems are typically ~11% less expensive than comparable AC systems, primarily due to lower labor costs. (Assumes UL 924 certification expected in mid-2026.)



MORE CABLE RUNS REQUIRED PoE cabling is less expensive than AC, but requires more runs due to power limits. PoE can generally accommodate two to eight luminaires per run (typical 25 W). As wiring accounts for around 12% of total costs, material expenses are mostly balanced between AC and PoE, with AC having slightly lower material costs.



DC COUPLING IMPROVES PERFORMANCE Efficiency can improve by 4% with an optimized PoE system with PSO and DC power input and storage.



NO MAJOR INFRASTRUCTURE CHANGES The system used existing network closets and required no additional ventilation. The most significant task was to remove 800 lbs. of armored cable that previously powered AC luminaires. No major maintenance costs or additional modifications are expected.

System Design Impacts Efficiency

Gateway-based system is more flexible but less efficient

	Efficiency vs. Equivalent AC	System Standby Consumption
Gateway-based without PSO	9% less efficient	210 W
Gateway-based with PSO	4% less efficient	200 W
Node-based with PSO	6% more efficient	135 W
Optimized for lighting only with PSO	18% more efficient	83 W
Optimized for lighting only with PSO and DC input	22% more efficient	Not tested

CONCLUSIONS

These Findings are based on the report, “Performance of Power over Ethernet DC Distributions,” which is available from the GSA website, www.gsa.gov/cebt

For more information, contact GSA’s Center for Emerging Technologies
cebt@gsa.gov



Footnotes

¹ Connected Lighting Systems Efficiency Study - PoE Cable Energy Losses, Part 1, https://www.energy.gov/sites/prod/files/2019/01/f58/cls_poe-cable-pt1.pdf

² Connected Lighting Systems Efficiency Study - PoE Cable Energy Losses, Part 2, https://www.energy.gov/sites/default/files/2018/11/f57/cls_poe-cable-pt2.pdf

Technology for testbed measurement and verification provided by Cisco with lighting systems from the vendor’s partners, Molex and MHT Technologies.

Reference above to any specific commercial product, process, or service does not constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof.

What We Concluded

IMPROVED EFFICIENCY WITH PSO AND STRATEGIC SYSTEM DESIGN

PoE DC distribution continues to evolve through performance optimization and industry partnerships. Early findings identified significant standby consumption, prompting industry partners to develop PSO, effectively reducing energy losses. Even with PSO, node-based lighting systems are expected to be more efficient than gateway-based systems, although system design and use cases also factor into efficiency. Lighting-only PoE systems were the most efficient and DC power further improved performance by eliminating conversion losses. A less than 5% error rate for energy reporting is effective for implementing data-driven energy management strategies and participating in transactive energy markets, two high value use cases for GSA. Networked building systems, facilitated by PoE’s power and data integration, optimize building management. Strategies may include occupancy-responsive lighting and mechanical systems. Highly connected, smart buildings rely on accurate and abundant data, flexible controls, remote monitoring, and IT-level management, all inherent to PoE functionality.

Lessons Learned and Best Practices

PoE is recommended in new construction or major renovations. Minor retrofits may not achieve significant returns on investment, especially if extensive rewiring is needed for installation.

PoE scales easily floor-by-floor. A network closet with sufficient power for a PoE rack is required, but retrofits generally scale with square footage.

Some existing luminaires may be compatible with PoE drivers. Keeping luminaires can lower costs if the drivers can be easily swapped

Standby losses continue to impact efficiency. Request manufacturer data on standby losses and look for PSO capabilities to reduce them.

Install PoE lighting with clear zoning and entrances and exits to enhance whole-zone occupancy detection and PSO capabilities.

Low-voltage electrical installers usually have lower rates, which saves installation costs. Check for specialized low-voltage installation firms in your area.

Teleconferencing capabilities were added to the PoE system installed at WIL. While not the focus of this evaluation, occupants were satisfied with the capabilities.

Confirm PoE switch compatibility with the network.

PoE systems are part of IT infrastructure. Seek guidance from IT.

Opportunities for PoE occupancy data and HVAC controls integration are being explored. Researchers recommend further evaluation.

Consider opportunities for smart buildings. Connecting multiple IoT devices and systems may add value to PoE DC distribution.

Check for updated technologies. Since the evaluation, vendors have developed new devices to power more luminaires and to reduce standby consumption.