Making Better Use of On-Site PV Generation: Direct Distribution of DC Power in Buildings

ASES SOLAR 2019
Minneapolis, MN
August 6, 2019
NREL/PO-5500-74447

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Why DC?

DC Power most effective with Local Generation and Storage

- Energy Efficiency: Lower conversion loss with natively DC loads (LEDs, electronics, variable speed motors)
- Cost: Lower equipment capital cost (once market size increases)
- Non-energy benefits: easy local reliability, better power quality, flexibility
- Communication: New capabilities - plug-and-play for generation & storage

Power over Ethernet (PoE) can serve as the distribution network for the low voltage DC power in the building

- Energy Efficiency: Lower conversion loss with natively DC loads (lighting and miscellaneous electrical loads) along with device level control for operational savings.
- Cost: Lower installation and maintenance costs with low voltage DC power.
- Non-energy benefits: flexibility with installation, networked system operation and integration, and opportunity for increased building intelligence (IoT).
- Communication: Ethernet connectivity provides device level operation and management over the local area network (IP addressable).

Potential impact of DC power distribution

- Reduces electricity use by 5-13%
- Significantly decreases life cycle cost
- Improves safety, power quality, and resilience
- Price-based control creates scalable network organization

Current DC Power-Related Research Projects

Building-Level DC Distribution Technologies and Systems
Richard Brown, PI, Lawrence Berkeley National Laboratory

Through this research project, NREL and LBNL are assessing the energy and cost performance of DC distribution systems in real buildings to establish DC-system evaluation methods and metrics, document real-world performance, assess technical barriers inhibiting robust adoption of DC systems, and identify opportunities to optimize DC-system performance.

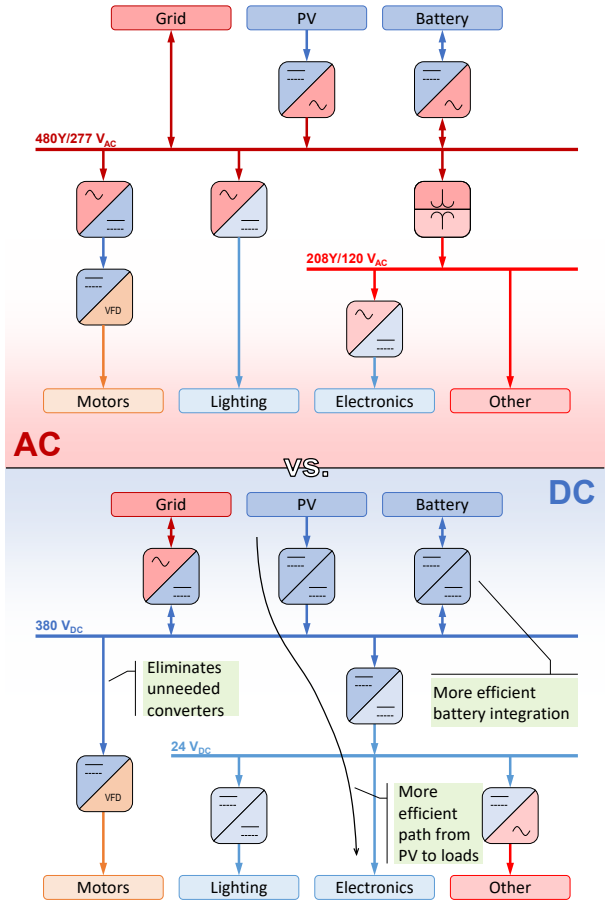
Energy Design and Scoping Tool for DC Distribution Systems
Stephen Frank, PI, National Renewable Energy Laboratory

This DOE-sponsored tool will model and analyze the energy performance of building distribution systems to support cost/benefit analysis for DC distribution.

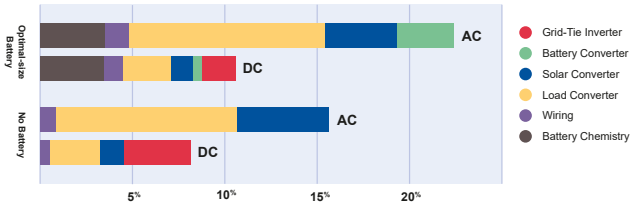
Field Demonstration of Power over Ethernet (PoE) Technologies
Lester Shen, PI, Center for Energy and Environment

This DOE- and State of Minnesota-funded project is evaluating the energy savings opportunities of PoE technologies (including lighting, plug loads, and HVAC) at a number of commercial building sites in the United States.

AC vs. DC



Energy Loss for Medium-Size Commercial ZNE Building



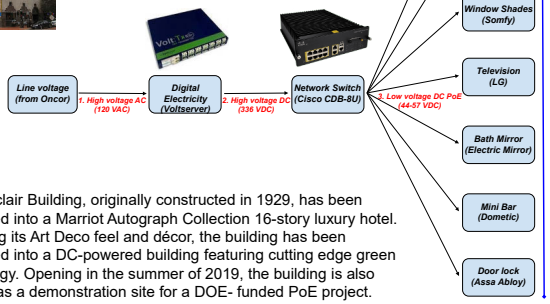
DC End Uses

Device Group	Avail	DC Voltage(s)	Availability Comments
Small Appliances	▲	12V, 24V	Low power devices may be powered directly with low-voltage DC; some available for RV market
Large Appliances	■	380V	Direct-DC dishwashers, clothes washers, etc. have been tested by manufacturers
Other Motor Loads	■	24V, 48V, 380V	Motor drives could be adapted to use a variety of DC input voltages; higher power requires higher voltage
Small Portable HVAC	▲	12V, 24V	Portable fans, heaters, etc. typically have low efficiency (not DC-internal) motors and heating elements
Full-Scale Cooking	■	380V*	Cooktops and ovens typically use resistive elements (DC-indifferent), but high power requires high voltage
Water Heating	■	380V	Direct-DC heat pump water heaters not available but currently at demonstration phase
Small Facility Infrastructure	▲	PoE, 24V	Timers, garage doors, window shades can be powered with low voltage DC, and offer resiliency benefits
Large Facility Infrastructure	■	380V*	Process and other large equipment would require high voltage DC
Compressor-Driven Loads	▲	12V, 24V, 380V	Refrigeration equipment at low capacities is available; larger equipment using variable speed compressors is in development
Tools w/ Batteries	▲	12V, 24V	Battery charging equipment can be supplied with low voltage DC or higher, depending on battery capacity
Large & Small Vehicles	▲	380V	Vehicles supporting DC fast charging can be supplied with DC (unlike level 1 or 2 charging)
Small, Portable Electronics	●	USB, PoE	Most are DC-ready; could be powered via PoE or USB; USB input is more common
Office Equipment	▲	USB, PoE, 12V, 24V	Most are DC-internal; input voltage varies; some are available with adapters for automotive or RV/marine markets
Small Hard-Wired/Networked Devices	▲	PoE, 12V*, 24V*, 48V	Some equipment available for PoE or 48V (telecom) standards; hardwiring to a DC distribution system with battery storage could provide resiliency benefits
Displays, Entertainment, & Audio	▲	USB, PoE, 12V, 24V	Most products currently are not DC-ready
Data Centers	●	48V, 380V	Several DC data centers available but benefits not rigorously quantified; telecom equipment available at 48V
Specialized Business Equipment	■	PoE*, 24V*, 48V*, 380V*	Hardwiring to a DC distribution system with battery storage could provide resiliency benefits
Distribution Equipment	▲	Various	For certain equipment (e.g., DC breakers) there are significant cost and technological barriers

Availability: ● Available ▲ Limited Availability ■ Not Available

*Voltage standard is suitable, but no known products available or in development

The Sinclair, Autograph Collection Fort Worth, TX



The Sinclair Building, originally constructed in 1929, has been converted into a Marriot Autograph Collection 16-story luxury hotel. Retaining its Art Deco feel and décor, the building has been converted into a DC-powered building featuring cutting edge green technology. Opening in the summer of 2019, the building is also serving as a demonstration site for a DOE- funded PoE project.

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308, in part by Lawrence Berkeley National Laboratory, operated for the DOE under Contract No. DE-AC02-05CH11231, and in part by Center for Energy and Environment, operated for the DOE under Contract No. DE-EE0008191. Funding was provided in part by the DOE Assistant Secretary for Energy Efficiency and Renewable Energy Building Technologies Program Emerging Technologies Subprogram and in part by a grant from the Minnesota Department of Commerce, Division of Energy Resources, through the Conservation Applied Research and Development (CARD) program, which is funded by Minnesota ratepayers. The views expressed in the poster do not necessarily represent the views of the DOE; the U.S. Government; or the Minnesota Department of Commerce (Commerce), its employees or the State of Minnesota (State).

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