WHITE PAPER

Low Voltage Direct Current Power Distribution in Commercial Offices

ABSTRACT

As commercial offices look to develop their workplaces of the future, a low voltage direct current (LVDC) power distribution design has the potential to enrich workspace flexibility and integration with future workplace technologies. Transitioning from a traditional, stationary space configuration to a more flexible and fluid space design will be vital in ensuring an efficient and future proof workplace setup. Utilizing a direct current distribution design with direct current-powered devices will also provide benefits in energy reduction as office spaces continue to implement renewable energy resources and strive towards Zero Net Energy.

LVDC power distribution design provides offices with the following key benefits:

- *Lenient installation requirements for LVDC wiring when compared to traditional wiring.*
- *Installation and modifications to the LVDC wiring may only require a licensed low voltage contractor.*
- *Installation and modifications to the LVDC wiring may not require an intensive permitting process.*
- *Energy reduction by utilizing native DC loads.*
- *LVDC system can be easily integrated into Zero Net Energy buildings utilizing DC powered renewable energy sources.*

ABOUT RSP

RSP Architects has emerged as one of the country's most trusted, diverse and agile architecture and design firms.

RSP's Mission Critical Group was established in 2018 to serve a growing roster of clients who required a higher level of technology infrastructure. The group focuses exclusively on creating flexible, sophisticated environments that support and enhance data management, computing operations and the systems that underpin and backup those functions.

APPROACH

Alternating current (AC) power distribution has been the primary method of generating and distributing power since the advent of electricity in the late 1800s. AC power offered the benefits of generating and distributing power over far greater distances than direct current (DC) power could offer at the time. However, DC energy has been on the rise as energy sources begin to transition from central AC distribution plants to local DC microgrids. These microgrids utilize DC energy-producing resources such as solar photovoltaics and battery energy storage systems. Additionally, with continual advancements in power electronics, it is more common to see internally DC based commercial office user end-loads, such as LED lighting, electronic devices and computers, and electronic commutator direct current (ECDC) HVAC motors. This progression forecasts a proliferation of devices in the industry that will operate directly via DC distributed power. And as devices continue to progress towards DC-based designs, which require less energy overall, it provides the opportunity to supply these devices utilizing an LVDC power distribution scheme. Utilizing a LVDC distribution design for a commercial office can provide some key benefits to the overall design, construction, and utilization of the space in terms of flexibility and simplicity of the design, as well as a reduction in energy consumption.

WORKPLACE OF THE FUTURE AND LVDC APPLICATION

Most offices have many spaces that can utilize devices with internal native DC components:

- Employee Workstations: Computer desktops, LED monitors, laptops, USB outlets, and VoIP phones.
- Conference, Huddle, Quiet Room, and Collaboration Areas: Laptops, WiFi / Wireless Access Points, USB outlets, Wireless Charging Stations, LED TVs, and LED lighting.
- Open Office and General Purpose Areas: LED lighting, WiFi / Wireless Access Points, Printers, Copiers, LED Digital Signage, and Motorized Shades.
- Mechanical Systems: Exhaust fans, Variable Speed DC Motors

As traditional office devices evolve from stationary, hard-wired equipment to flexible, interconnected wireless devices, LVDC design architecture will become crucial to future device layouts. For example, it is feasible to replace a traditional computer desktop set-up with a laptop configuration that requires less energy consumption and can be powered directly via USB or wireless charging stations. With 5G networking and edge computing on the horizon, high-speed user connectivity will improve current functions like video conferencing, but also create new ways of working through unlocking the full potential for Virtual Reality (VR) and Augmented Reality (AR) applications. These expanding technology applications all provide a sense of mobility to the workplace environment, where connectivity is seamless and employees have instant access to information.

INSTALLATION AND LOGISTICS

Existing commercial office buildings are typically only provided with incoming AC power from the Utility, meaning the AC power must be converted to LVDC to serve DC-powered devices. This conversion process from the building's 208V/ 480V AC to 24V/ 48V DC occurs via central AC-DC rectifiers located in the associated floor's Electrical Rooms. The LVDC supply will be distributed across the office from the DC panelboards in the electrical rooms. Equipment operating at a lower DC voltage, such as USB outlets, will need to convert the DC voltage to the equipment's utilization voltage via a DC-DC converter. AC power will be provided where traditionally powered AC plug loads and receptacles are required. Refer to *Figure 1* for a reference LVDC Distribution design schematic.

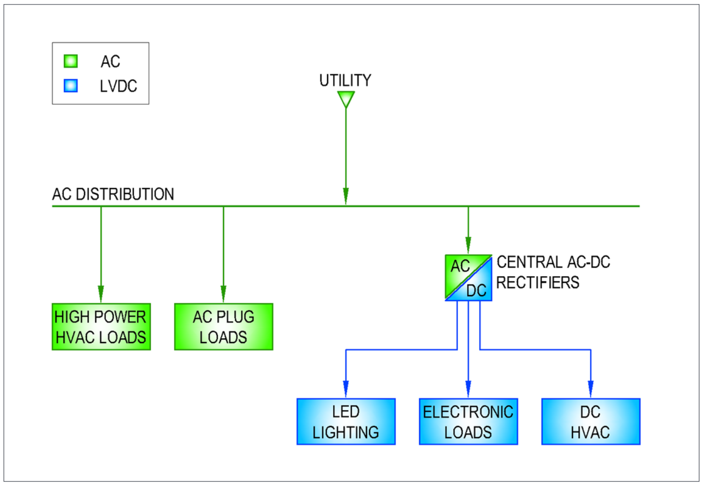

Figure 1: LVDC Distribution

For the HVAC design, a Variable Refrigerant Flow (VRF) or Variable Refrigerant Volume (VRV) system would serve the office space well, as it is one of the most energy-efficient technologies available in an ever-evolving office setting. These systems allow for simultaneous heating and cooling of adjacent zones without having a chiller or boiler in operation. VRF systems utilize internal variable speed DC motors to reduce the energy consumption, offering compatibility with a LVDC distribution design. The higher capacity outdoor units can be provided with standard AC power. Utilizing refrigerant piping rather than ductwork for the HVAC units within the tenant floor space requires lower ceiling space requirements. This also allows for more design flexibility, since units can be relocated as needed with piping modifications, rather than reworking ductwork.

CHALLENGES TO IMPLEMENTATION

With DC technology and appliances in the early phases of implementation, there are still a few barriers for adopting a fully DC-powered office utilizing LVDC appliances. Even though high-power DC designs have been utilized in the Utility and transportation markets for many years, the application has yet to be fully developed for commercial market applications. For example, while many standard office equipment operates off internal DC components, most equipment providers only offer an option of AC input power. However, the commercial market is starting to adapt to DC-powered equipment, such as LVDC lighting systems. Organizations like Lawrence Berkeley National Laboratory, NextEnergy, and Sidewalk Labs, as well as various HVAC manufacturers, are pushing the industry to develop DC ready appliances for commercial applications.

KEY BENEFITS

One key benefit for LVDC distribution is flexibility and simplicity of design. Since the power is being distributed to the end use devices at a lower DC voltage, the National Electric Code (NEC) provides some leniencies with the wiring methods required with traditional 120V AC wiring. Installations involving less than 50V shall only be required to comply with Article 720 of the NEC, and are not subject to the stricter wiring and conduit requirements of Chapters 1-4. The LVDC cabling can simply be routed exposed and supported with J-hooks or cable tray, in lieu of the traditional 120V AC conduit and wiring methods. This installation leniency is what provides flexibility to easily reconfigure areas within the office space.

> **Native DC-based devices will operate more efficiently with an LVDC system since the devices will not waste energy converting the incoming AC voltage to the devices' internally operating DC voltage.**

Code requirements and enforcement can also be more lenient towards LVDC installations, often requiring minimal permitting and inspection requirements (and resulting total cost) when performing space reconfigurations. Depending on the requirements of the local code authorities, certain low voltage applications do not require a licensed electrician or permit to perform minor modification work. If a larger renovation project is being performed, the low voltage wiring and infrastructure being relocated could be simply performed by a licensed low voltage contractor rather than a licensed electrician. This allows for more flexibility on the avenues in which a space renovation project can be pursued. OSHA and NFPA 70E also list minimal safety hazards associated with installation at less than 50V. Due to the new technology application of this design, a discussion with the local Authority Having Jurisdiction (AHJ) would be beneficial to determine the exact wiring and permitting leniency allowances.

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Native DC-based devices will operate more efficiently with an LVDC system since the devices will not waste energy converting the incoming AC voltage to the devices' internally operating DC voltage. Reducing the plug load power requirements throughout the space with efficient DC-powered devices will in turn reduce the amount of heat load, lowering the overall cooling capacity required to serve the office workspace. Using a generic 30,000-SF commercial office space as a template, based on the typical number of workstations, RSP calculated an overall cooling load reduction when utilizing efficient DC powered office equipment of approximately 7% for the interior tenant space's HVAC cooling capacity, leading to a potential 15% energy savings. Couple this with the estimated 2-8% reduction of electrical consumption by eliminating AC to DC conversion[1] can decrease a building's overall equipment sizing and initial capital costs. This energy savings would be even further realized when implementing renewable energy sources.

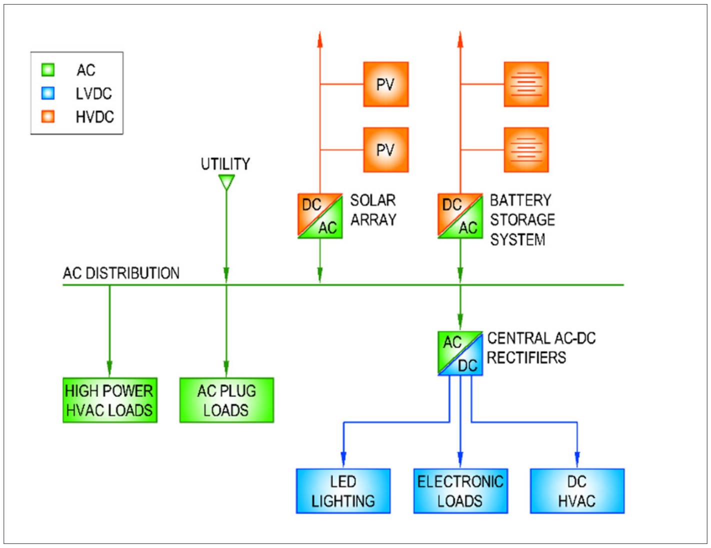

Figure 2: Year 2030 Zero Net Energy LVDC Distribution Design

FUTURE IMPLICATIONS OF DC POWER

Implementing DC-powered devices is essential in the pursuit of Zero Net Energy (ZNE) buildings. A ZNE building is a building with annual consumption less than or equal to the amount of on-site energy generated from renewable energy resources. Per the California Energy Efficiency Strategic Plan, all new California commercial construction, as well as 50% of existing commercial buildings, shall be ZNE by 2030. Utilizing on-site renewable energy sources, such as solar and battery energy systems, will be critical in achieving efficient ZNE building designs. Refer to *Figure 2* for a ZNE distribution schematic utilizing the LVDC design.

TAKING THE NEXT STEP TOWARD LVDC

RSP recommends working in conjunction with LVDC stakeholders and manufacturers to develop a conceptual office space design utilizing LVDC powered office space devices. The conceptual LVDC design can then progress into developing a proof-of-concept mockup space with funding support from organizations such as Lawrence Berkeley National Laboratory.

[1] D. Denkenberger, D. Driscoll, E. Lighthiser, P. May-Ostendorp, B. Trimboli, and P. Walters, "DC Distribution Market, Benefits, and Opportunities in Residential and Commercial Buildings," Pacific Gas & Electric Company, Oct. 2012.

ABOUT THE AUTHORS

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