Medium Voltage AC: Big data?
Big power isn't far behind

Context: An evolving standard for power distribution

Data center operators are under intense pressure to maximize the efficiency of data centers. To maintain competitiveness in a race in which rack density increases and power consumption keeps pace to meet increasing demand for service delivery, data center operators are looking for ways to improve the efficiency of supporting infrastructure, including power distribution and management and HVAC.

In larger data centers, medium voltage AC power systems – defined as units managing feeds of 1000-38,000 volts – are becoming a de facto standard for power distribution. Medium voltage AC units address several different data center objectives. Relative to low voltage systems, they provide a compact means of dealing with data centers' burgeoning power requirements, thereby increasing the proportion of total facility area that can be dedicated to 'white space' rather than 'gray space'. They reduce CAPEX expenses in new data centers by reducing expenditures on cables, conduits and other facility components. And they reduce OPEX (and improve PUE) by providing for more efficient power distribution within the facility.

Business issues: Densities driving demand

Constantly-intensifying demand for data center services is driving demand for technologies and management approaches that improve efficiency. In a large number of cases, rack densities are increasing in response to new workload demands; this in turn creates the need for more power and more cooling to the rack/row/floor. Data center operators are also dealing with floor space constraints, and are looking to use all available area to deploy racks within a facility. And when rack density and deployment are maximized, operators are faced with the need to commission new facilities, and to ensure that these facilities use capital (CAPEX) funds wisely while also minimizing the operating (OPEX) expenses that account for the vast majority of overall expense associated with a data center. Meanwhile, data centers are using power usage efficiency (PUE), which highlights the overhead cost of the energy consumed by power distribution and cooling, as a key measure of operational efficiency.

In new facilities, use of highly-efficient designs and power and cooling equipment often yield compelling PUEs of 1.35 or less. However, a rethink of power supply strategy in existing data centers, or in new equipment deployments housed within existing shells, such as conversion of warehouses or industrial buildings to data center facilities, may also be an important retrofit: today's data centers may well draw thirty times as much power as yesterday's textile mills, and power supply is a gating factor on IT equipment deployment. As Dave Sterlace, market development manager for data centers and critical power at ABB company Thomas & Betts, notes, "power equipment in a 'brownfield' [existing facility] is the last thing people think about upgrading…but increasing data center densities require a rethink of power." Instead of using a "band-aid" approach of incremental, piecemeal upgrades, Sterlace argues for deployment of state-of-the-art equipment. The benefit of modern power management gear is evident in new 'greenfield' facilities; Sterlace finds that "the case is becoming more and more compelling" for significant power upgrades in brownfield environments as well.

Technology capabilities: Intelligent relays provide for efficiency and safety

Medium voltage AC power is defined as AC power that is between 1000 and 38,000 (38K) volts. Medium voltage AC systems are comprised of four main components:

- Sheet metal enclosures: "Frames" made mainly of highly reflective 14 gauge double wall galvanized steel with an air gap between sheets preventing the second layer from combusting due to internal fire.
- Bus bars: Large plates made of copper that conduct electricity from the utility through the circuit breakers and to the equipment.
- Circuit breakers: Gates that opens and closes to regulate the flow of energy. Circuit breakers can be built around multiple technologies (such as vacuum and sulphur hexafluoride gas) and can be tailored for indoor and outdoor applications.
  - Circuit breaker design differs significantly between low and medium voltage systems. Low voltage circuit breakers contain both the switching mechanism and the overcurrent protection in a single device. In contrast, medium voltage circuit breakers contain only the switching mechanism to open/close but lack an integrated overcurrent protection device. Medium voltage breakers separate these functions out into discrete devices including transformers and protective relays. These devices provide the overcurrent protection. This separation of function allows for much more intelligent digital relays for safer and more efficient operation and maintenance for safer and more efficient operation and maintenance
- Protection and control devices: The relaying systems that provide the intelligence within medium voltage AC units supervise the network and trigger appropriate switching elements in normal and fault conditions. Frank Burgess of ABB likens protection and control devices to "a small computer sitting inside the switch gear," highly-programmable devices that are "always analyzing, always thinking about what needs to happen based upon current conditions." Leading vendors like ABB mount protection and control devices in dedicated low voltage compartments that are completely isolated and segregated from high voltage compartments. This ensures safety for operations and maintenance personnel while they work on control and auxiliary circuits.

Relative to low voltage systems, medium voltage power distribution is highly efficient in terms of both connection requirements and power distribution. Low voltage systems may require 8 to 10 times more cables and conduits than medium voltage systems. As a result, the CAPEX advantages of more efficient medium voltage distribution can be significant – in a data center requiring a 500 foot cable run, a medium voltage system may require nearly one mile less of wire and conduit, and will reduce ancillary expenses in areas like fire suppression materials used around wall openings. Additionally, the greater transmission efficiency of medium voltage systems (vs. low voltage systems) provides ongoing OPEX benefits in the form of reduced power costs. "With long cable runs and low voltage, there will be voltage drop – that's a known phenomenon," Burgess observed, and this in turn leads to "less efficient use of power."

Technology capabilities: Squaring the macrogrid and renewables circles

Defined as a subset of load and generation equipment at an enterprise site, microgrid for data center may include electrical grid structures for load or generation optimization, conservation programs, heat and/or HVAC management. Regardless of the use case the key component in microgrid implementations is the master control system, a sophisticated hardware and software solution that aims at efficient management of a diversified mix of onsite generation (wind, solar, thermal power, bio fuel, fuel cells or even heat recovery) and its integration with local load demand. In more sophisticated solutions, the software combines modelling and forecasting capabilities with cost optimization capabilities – advanced modelling to predict fluctuating energy demand and local generation potential which can be offset against real time energy pricing market information from the utility or ISO, generation production costs and local environmental data (for example, site specific interior building and exterior temperatures over a 24 hour period) to support decision-making around the facility's dispatch of local generation (renewable, diesel or natural gas based) vs. access to resources delivered via utility grids. In many cases, this analysis can be automated to take best advantage of the spread between production and consumption costs associated with different resources, and automated demand response applications within microgrid can optimize for cost and for reliability in cases where additional capacity and frequency control are needed – especially in jurisdictions where timely response is a critical factor. Interface capabilities for interaction with the primary grid are another feature of most microgrid solutions.

Another key input in microgrid management of power reliability is advanced battery storage such as Lithium-Ion, which may be marshalled to offset fluctuations in renewable generation or even to participate in voltage or frequency markets where utilities purchase power to regulate their own supply. Given data center focus on power quality, this capability is an important component of microgrid technology. ABB, for example, combines its advanced microgrid integration of renewables and diesel generation with a PowerStore Stabilization system, a flywheel or battery unit that acts as a grid stabilizing generator, with software that controls power flow to smooth out grid frequencies and manage voltage fluctuations.

Interestingly, another approach to resolving issues with renewables hails from the data center industry itself. Researchers are currently investigating ways to apply cloud technologies to shift loads within the data center to address fluctuations in supply. HP Labs, for example, has created a data center architecture that features supply and demand management and the colocation of workloads to shape demand to match capacity: according to HP, the architecture generates an 80+ percent reduction in reliance on utility grid power when used with a manageable renewable infrastructure.

Implementation challenges: Greenfield vs. Brownfield deployment

In a greenfield environment, medium voltage AC is easily incorporated in the data center design, and pays immediate dividends through cable and conduit reductions, more efficient power management, more scalable power delivery and reductions in gray space allocated to power conditioning units.

As Burgess and Sterlace point out, "you can't avoid medium voltage AC" in new facilities – but there are different approaches to deployment. Systems offering relatively greater reliability, safety and efficiency are initially more costly, but can help avoid downstream problems associated with problem management and resolution.

In existing brownfield facilities, migration to medium voltage AC – or indeed, to any kind of switch gear upgrade – can be difficult. A medium voltage system is space-efficient relative to multiple low-voltage systems, but the units themselves are physically bigger, which can make them hard to install in tight brownfield spaces. There are also human issues to deal with: medium voltage AC may require new skills for installation and management, and there are individuals who are unnerved by the concept of higher voltages, regardless of whether these systems are in fact more dangerous than low voltage alternatives.

Power planning for medium voltage AC follows much the same logic as power planning for data center facilities generally. It depends on the availability of commercial-scale power feeds, which are becoming more common: for example, until recently, electrical service in New York City was delivered at 120/208 volts, but now, 15,000 volts is typical in industrial-grade setting, and 27,000-38,000 is available.

Benefits: Space, cost and reliability advantages equal lower TCO

Medium voltage AC addresses three primary issues: space, cost and reliability. The first two are tightly linked. Medium voltage AC demands less 'gray space' than is needed for low voltage systems, increasing the total proportion of the facility available for IT equipment deployment. The greatly-reduced requirements for cable and conduit have a positive impact on CAPEX, and reduce cabling complexity. And more efficient power distribution reduces electricity loss and has a positive impact on PUE.

Medium voltage AC also offers implementation benefits. Ultra-modular medium voltage switching gear provides data center operators with the ability to mix, exchange or upgrade modules without affecting overall system operation, while racking system enclosures facilitate maintenance of critical parts away from the energized primary and secondary circuits.

Advances in medium voltage AC have increased reliability in other ways as well. For example, over time, ABB's systems have been redesigned to reduce moving parts – from 307 in earlier technology generations to 7 today. Fewer moving parts means less maintenance and failure in the field. ABB switching gear contains significantly fewer active parts than in more traditional designs, contributing to the lower total cost of ownership delivered by medium voltage AC solutions.

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