WHITE PAPER

BRIDGE POWER

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Mission-critical installations are routinely protected with standby power generation equipment. These mission-critical installations (e.g. data and network operations centers (NOCs), communication centers, high-value manufacturing processes, etc.) require continuous power with absolutely no interruptions. Fuel cells are recently becoming a viable option for standby power, and are being adopted by telecommunications companies in their ongoing efforts to make their systems more reliable. Super-critical installations are using waterfall architectures in which multiple power sources are available for backup power.

BRIDGE POWER.

Bridge power describes the short-term power necessary to "bridge" from one long-term power source to another. Bridge power is needed because typical standby power generation equipment is not instantly available, and takes time to be brought online. The classic example is a diesel generator set (genset) used to back up a hospital facility. During a utility outage, the installation as a whole may experience power failure, including lighting and the loss of non-critical loads. Batteries or capacitor banks are employed locally to temporarily feed power to mission critical equipment (as either a stand-alone uninterruptible power supply (UPS) or integrated into equipment such as monitors and infusion pumps), until a generator set can be started and brought online. The combination of both bridge and long term power generation is necessary because the cost associated with extending bridge power beyond a few minutes is high, and maintenance and reliability issues where batteries are employed may make a single "long-term bridge" prohibitive.

THE NEED FOR RELIABLE BRIDGE POWER.

According to Steve Fairfax, an industry consultant, "The telecommunications industry has generally adopted the wrong conceptual framework for looking at the problem…They talk about availability. They should be talking about reliability. Availability is only concerned with down time, so many minutes per year in which the system is down. …well, the number of minutes is much less important than the number of incidents. In a computing environment a half cycle, that is, a hundredth of a second power interruption, will probably crash the system. A hundred such interruptions would only constitute a single second of downtime, but spread out over the course of a year, they would be catastrophic."

In this context, reliable bridge power between continuous power sources is critical to the robustness in these mission-critical environments.

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FUEL CELLS.

Fuel cells have been getting a lot of attention as a solution for vehicles. A simple web search brings up sites of myriad non-profit and government organizations touting the benefits of fuel cells in transportation. This vision has merits; however significant improvements in size, weight, cost, and fuel availability are required to make fuel cells a real-world solution, not just demonstration, in vehicles. Standby power, on the other hand, is a current market for fuel cells, particularly for high-value operations that require more duration than typical UPS systems can provide.

To meet the needs of true standby power, a fuel cell (FC) backup system must be able to instantaneously deliver power at the full demand of the load. In some installations, the FC system is operating in parallel with the utility, delivering power to the system full-time, while the utility provides load leveling and backup. (When this architecture also uses the waste heat to heat the facility, they are referred to as Combined Heat and Power (CHP) systems.) In a standard FC CHP system, when the grid is lost, the FC system does not have adequate response time to handle fast transients, and therefore is not considered as a backup system. In other installations, the FC system is augmented with integrated energy storage to provide fast transient response. When tied with the grid, energy storage is a “bridge” from one continuous power source to a second.

In a stand-alone fuel cell system (one that is independent of the grid), the fuel cell can deliver the maximum power required by the load, but cannot respond fast enough to smoothly deliver power through transients; in this case, energy storage “bridges” across the transients. Bridge power is the lynchpin of a robust fuel cell standby power system. Numerous companies are putting fuel cells into the field to make their systems more robust. According to Citigroup Research’s report “Switch Signals: Fuel Cells in Distributed Telecom Backup,” based on interviews with 50 telecommunications industry members, the telecom industry identifies reliability as one of the main benefits of fuel cells, despite an inaccurate perception that fuel cells are more expensive than standard lead-acid battery backup power systems. A key factor contributing to the telecom industry’s perception of reliability is the fact that fuel cells have already racked up more than 1 billion hours of operation over 10 years, in applications such as hospitals, mail processing facilities, landfill and wastewater treatment plants, and credit card processing centers. CEA Telecom recently began offering fuel cells to their customers, remarking that “…our telecom customers are looking for reliable backup power solutions which offer better value than traditional energy storage solutions for their critical communication applications…”

Life cycle costs are another key consideration when specifying backup solutions. Citigroup’s research report also included data that revealed the replacement costs of batteries at telecom sites run from $3,600 to $8,000, depending on power level, backup duration, and warranty period. The report noted "fuel cells are 32% and 35% less expensive than battery backup power solutions based on a 10- and 15-year useful life and a five-year battery replacement cycle." Even without tax credits, the report notes that fuel cell lifecycle costs are 12% and 18% less expensive on the same bases.

WATERFALL ARCHITECTURE.

Historically, a single power generating solution, typically a diesel generator, was used with a simple battery-fed inverter uninterruptible power supply (UPS) as a bridge. For installations where a minor power glitch was only a nuisance, this is adequate, considering that the typical UPS only can supply the load for 8-20 minutes. One of the major issues with diesel generators and battery UPS systems is reliability and maintenance. Telecom companies require much more reliability that a typical genset/battery combination provides. More complex architectures are now being fielded to address the growth of telecommunications and data systems and factory processes that cannot tolerate any power interruption. "Waterfall" systems use a cascading set of different continuous power technologies (e.g. engines, fuel cells, micro-turbines), bridging between each transition with short-term bridge power technologies (e.g. batteries, ultracapacitors, flywheels). With the many options in bridge technology, one must consider the overall reliability requirement. With the maturation of the ultracapacitor industry, ultracapacitors are highly competitive with, and in many cases superior to, older legacy bridge technologies.

ULTRACAPACITORS PROVIDE FUNCTIONALITY.

Ultracapacitors offer the functionality, life cycle costs, and reliability necessary to make mission-critical power backup systems successful. Since the ultracapacitor is used strictly as a bridge, its high power density is ideally suited to supply high power for short periods of 30-100 seconds. A battery is more typically sized to deliver power over longer periods, making them larger than necessary. If a battery is sized for the actual duration required, it may have difficulty supplying the necessary power. Additionally, since ultracapacitors operate on a different principle than batteries, the ultracapacitor is capable of sitting on a charge voltage for extended periods without any loss of capacity. Batteries are notorious for loosing capacity when held on charge for extended periods.

Ultracapacitors have another distinct difference when compared with batteries, which makes them ideally suited to support fuel cells. A fuel cell's output varies with load (which is then regulated by power electronics). A battery's output is fairly fixed, and therefore will affect the fuel cell's performance by loading the fuel cell's output (unless it is employed on the output of the power electronics in a DC system, in which case the battery output is then unregulated). An ultracapacitor, on the other hand, has no fixed operating voltage, and therefore can operate directly across the output of the fuel cell, directly into the power electronics.

ULTRACAPACITORS REDUCE LIFE CYCLE COSTS.

In the previously cited Citigroup report, battery replacement cycles range from three to five years, and are highly dependant on temperature fluctuations. Considering that the useful life of a battery is based on an ambient temperature from 75°F to 78°F, the operating temperature in an installation can vary much more than this. Ultracapacitors have an operating life well in excess of 10 years, with a much wider temperature operating range, significantly reducing the operating and maintenance cost of the system.

ULTRACAPACITORS PROVIDE RELIABILITY.

One key challenge with batteries is the difficulty in measuring their state of charge. Numerous algorithms and circuits are employed to give the operator an indication of how much capacity remains in a battery. An ultracapacitor, on the other hand, is measured solely by its voltage; know the voltage, know the state of charge. Combined with the wide temperature range, long life, and flexible voltage range, ultracapacitors provide an extremely reliable solution for bridge power.

HOW DO YOU GUARANTEE RELIABLE POWER?

According to Steve Fairfax, the problem is compounded because the electric power grid is less reliable than in the past. "For a number of reasons grid supplied power is less reliable than was the case in the past, and we're predicting that reliability will further decline." Experts differ on how to guarantee power availability. "You just go the extra mile," says Jay Adelson, president and founder of Equinix, a co-location service. "You check each UPS every week. You install redundant generators, and you sign three fuel contracts for diesel so that if the grid does fail you can go on indefinitely."
With new fuel cell and ultracapacitor technologies now commercially available and technically viable, Mr. Adelson's needs will be easier to meet. Ultracapacitors reduce or eliminate the need to check the UPS every week, and fuel cells have proven more reliable than generators. With new reformer technology in development (which strips the hydrogen from hydrocarbons), a CHP fuel cell can be fed with natural gas

piped into a facility, rather than from bottled hydrogen, ensuring 24/7 power availability without the need to truck in diesel fuel.

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