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White Paper

Grid Reliability and Power Quality Solutions for the Digital Economy with the Virtual Power Plant

Most of Wall Street and the mass business press have focused analysis on the ability of utilities to create sustained competitive advantage for investors, customers, and all other stakeholders. But suddenly – and with good reason – grid reliability and power quality have become themes in the analyst's research reports. The purpose of this white paper is to briefly explore the market dynamics of Digital Power and describe how a Quality of Service (QOS) solution that deploys Virtual Power Plant™ technology could leverage the fastest growing segment of the electricity market – High 9s Power Quality solutions.

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The confluence of several compelling forces – energy technology innovation, the deregulation of electricity, the proliferation of an electronic, e-commerce-based society, a greater demand than supply for electricity, an aging grid infrastructure, and customer choice – is beginning to transform the traditional power industry into a truly customer-focused business.

Most of Wall Street and the mass business press have focused analysis on the ability of utilities to create sustained competitive advantage for investors, customers, and all other stakeholders. Much has been written about utilities deciding their core competencies, seeking merger or acquisition candidates, launching non-regulated service subsidiaries, selling off non-core assets, investing in foreign markets being privatized, and becoming more eco-friendly. The recent and successful IPO of both Capstone Turbine and Active Power have spurred Wall Street's interest in the Digital Power market, with several investment banks covering the markets for Distributed Power and overall Energy Technology. Grid reliability and power quality have quickly become themes in the analyst's research reports.

An increasingly publicized paradigm shift is being driven by the same forces described above – it's called "Digital Power" – and it's helping to propel the much-hyped Distributed Power market from an emerging and fragmented market to a disruptive business with a much larger available market. This theme has been explored most effectively by the research team of Peter Huber and Mark Mills, in their ground-breaking "Digital Power Report." In it, they state quite correctly that "clean electricity is the fuel of the digital infrastructure …The value of electrons is now tied to the opportunity costs of doing without them." Since early this year, Huber and Mills have popularized the phrase "High 9s Power" to signify the sort of ultra clean and available power that runs the digital, networked economy. Traditional electric utility grid power ranges from 99 percent to 99.9 percent reliable over the span of a year (99.99 percent in some cases), which represents an infinity to digital infrastructure – Low 9s power, which may not even be acceptable for the average homeowner as high bandwidth, interconnected digital appliances continue to proliferate. Digital devices need digital electrons – the starting point for High 9s is 99.999 percent clean and reliable power, and some end users are now looking for nine 9s or more!

A Quality of Service Solution

Our view is that an intelligent, Internet-enabled power system can enable a truly integrated "Quality of Service" solution. Such a solution could drive the disruptive force of the Digital Power value proposition, and therefore deserves discussion as utilities and energy service companies jockey for position. The purpose of this white paper is to briefly explore the market dynamics of Digital Power and describe how a Quality of

Service (QOS) solution that deploys Virtual Power Plant™ technology could leverage the fastest growing segment of the electricity market – High 9s Power Quality solutions.

The explosive growth of the worldwide digital economy means that the velocity of information is accelerating, thereby underpinning the need for more and more Internet and telecommunications infrastructure. This digital infrastructure is comprised of microprocessors and routers whose power densities are increasing, with equally increasing heat dissipation requirements for all of this silicon. In summary, the intense buildup of digital throughput connotes an increase in the cost of power outages and thus, the value of power quality. Cambridge Energy Research Associates estimates that 30 percent of all electricity is currently being consumed by power-sensitive equipment, and by 2010 this level is forecasted by American Power Conversion (a leading provider of uninterruptible power supplies), to be between 50 and 60 percent. Meanwhile, the Electric Power Research Institute has estimated that annual power related costs reached $400 billion last year for all U.S. businesses – the result of spoilage and scrapped materials, lost productivity, lost sales, and the permanent loss of computerized data.

Reliability and Quality

Digital Power is a function of both power reliability and quality. Reliability is fundamentally a measure of the availability of electricity to users, while power quality is a metric of the usefulness of the delivered power. Grid reliability and power quality have always been overriding principles of the electric utility industry. However, these principles relied upon a regulatory and operational framework characterized by a central plant model, rate-of-return investments, and a vertically integrated delivery chain – from the power plant's smokestack to a customer's (read ratepayer's) meter. The transition to electric utility deregulation in the U.S. has created uncertainty for regulators, customers, and utilities as responsibility of managing reliability and quality shifts to the competitive marketplace.

A Third-World Grid?

The concern over a lack of power reliability and quality has prompted the U.S. Department of Energy to hold several summits throughout the country earlier this year, where Secretary of Energy Bill Richardson exclaimed, "America is a superpower, but it's got the grid of a Third-World nation." An increasingly underserved customer segment whose business demands lots of clean power is helping to elevate the power quality industry from a niche market to an industry pegged at $21 billion this year, $30 billion in two years, and $100 billion in five years according to the Digital Power Report. These market projections represent hardware sales and do not even include related installation, engineering, service operations, and peripheral equipment sales. The High 9s market is new, not well-tracked, and growing so quickly that it is difficult to predict a breakdown by product or market segment for AC versus DC power systems, hardware versus services, or type of technology for power generation, storage and conditioning. Nonetheless, dozens of companies are quickly building hundreds of Internet Service Provider facilities, data hotels, and telecom hubs that range in size from 10,000 to 1,000,000 square feet.

Although Digital Power has not been a mainstream commodity business because customer demand, core technology commercialization, business infrastructure, and deregulation have been formidable risk factors, the market for Digital Power has been served for decades mostly by standby diesel engine generators in niche markets such as hospitals, airports, and telecom hubs. Clearly, the digitization of the economy enables a much more robust market opportunity for a range of stakeholders – most notably the firms that develop power quality equipment, a new breed of turnkey, outsourced High 9s utility service provider, and innovative utilities that develop a customer-centric, QOS offering.

Making the Most of Digital Power

In our view, the great promise of Digital Power is best kept if it is integrated with, and supplemental to, the grid where it can provide the most value: in small increments, at the margin for production and delivery of capacity, energy, and ancillary services – specifically for power reliability and quality. However, just as in the case of other big industries that have deregulated such as telecom, gas, and railroads, the fundamentals of the power industry will not change overnight. With a market size of over $200 billion in the U.S. alone and relatively little innovation seen in the power industry since Thomas Edison, we are at least several years away from a cost-effective, mass-customized, and networked energy appliance you can buy at Home Depot and "plug n' play."

Digital Power is being enabled in part, by an old friend – the internal combustion engine, and a few new ones – the Internet, and advanced power storage and conditioning technology. Traditional, proven, and cost-effective power stalwarts such as the diesel engine generator may not hold the intrigue of a pure-play dot-com or high-tech start-up to investors, but a well executed "clicks-and-mortar" QOS strategy that follows herein could become an enabler for the Digital Power market.

The Virtual Power Plant

Indeed, the elusive "killer app" for Digital Power could be in its practical application as a Virtual Power Plant™, to simplify the task of managing a large number and wide variety of distributed energy resources – including engine generator sets, flywheels, uninterruptible power supplies, transfer switches, microturbines, fuel cells, and a variety of power conditioning devices. An open-architecture, Internet-enabled platform that is interoperable with all forms of energy technology provides the intelligence, scalability, and modularity requisite of an Enterprise Resource Management

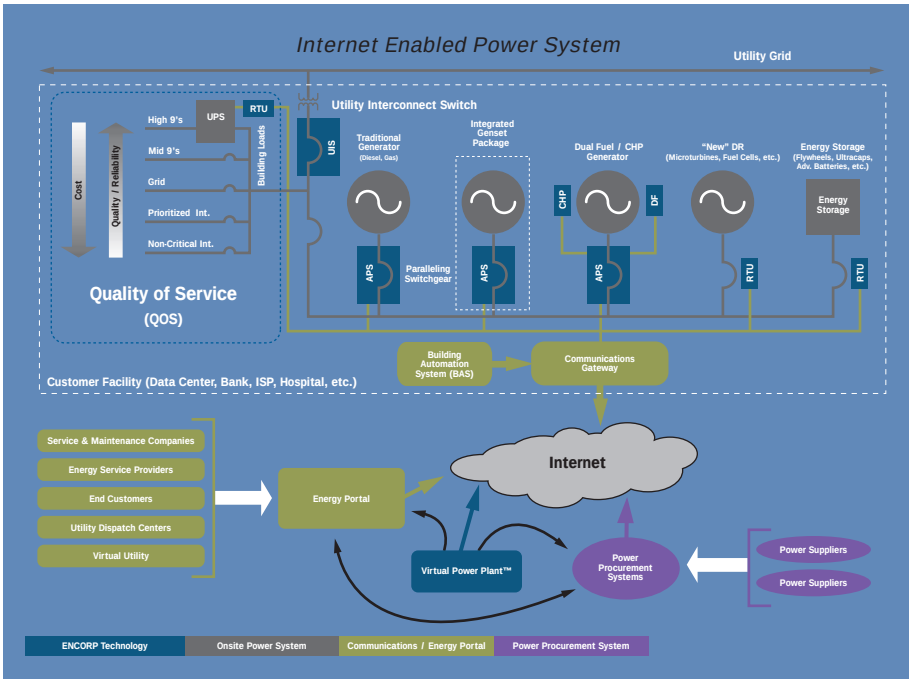

Figure 1 *Types of Energy Trading Exchanges (Source: AMR Research, 2000; courtesy of ENCORP, Inc. ©2000)*

system for Power QOS solutions. The ability to navigate seamlessly, behind the scenes in much the same way that CISCO is a backbone to the Internet, will be essential to create QOS solutions that are "mass customizations."

The QOS Solution

The QOS solution is a mix of power technology, intelligent software, various communications capabilities, field service, and the know-how to design, build, and operate the integrated package based on customer needs. Depending on the number, size, type, and criticality of loads within a customer's facility, the QOS solution can be classified as either Low, Mid, or High 9s power. For example, Low 9s power represents any non-critical loads that may be interrupted without consequence to safety or productivity. Such loads would take their power solely from the grid. Mid 9s power represents loads that cannot be subject to sustained power outages, and/or notable degradation of power quality. Such loads would be served by a standby power system, as well as short-term ride-through technology such as a battery back-up unit. High 9s power represents standby power + ride-through + power conditioning equipment. Within a given data center, Web host, or large commercial office building, dozens of unique loads will require varying degrees of 9s.

Clearly, a QOS offering requires a highly flexible hardware platform that is tightly integrated to the range of power equipment described, as well as seamless interoperability with existing building automation systems within the customer's facility. The QOS system must provide dynamic power and load control, remote monitoring, interconnection capability, and a communications gateway that spans each onsite power component, power suppliers and exchanges, and energy service providers. Last, the ability to aggregate hundreds of individual sites allows cost-effective "fleet management" for Application Service Providers such as Honeywell, Johnson Controls, Invensys, and energy service providers like Enron, Williams, or various unregulated utility subsidiaries.

The Virtual Power Plant™, as part of a QOS offering, enables a "plug and play network control" solution for utilities, energy service providers, the new wave of outsourced High 9s utility developers, and Digital Power equipment manufacturers. The Virtual Power Plant includes a single box that replaces up to 20 separate components made by many different companies that normally require a costly, time-consuming, and complex systems integration process that includes application engineering, factory wiring, and lengthy field installation. First-cost savings of this approach can exceed 75 percent of traditional clumsy power control and automation solutions. These capabilities include a programmable suite of utility-grade grid interconnection hardware, remote power aggregation, load control and dispatch, economic capacity management, real-time monitoring, metering, Web browser-enabled communications, intuitive operations, and maintenance software.

As the market for High 9s progresses, it will be absolutely essential for QOS providers to possess robust remote monitoring capabilities in order to predict, maintain, and guarantee equipment performance. Monitoring of equipment status, maintenance schedules, duty cycles, load changes, ambient parameters such as temperature and humidity, and remote troubleshooting on a 24x7 basis, must be combined with an experienced field service organization to ensure customer satisfaction. As a final note, the telecom industry already offers its own equivalent of the QOS – Service Level Agreements (SLAs), for many Internet access services. UUNET, a subsidiary of WorldCom, as well as AT&T, both offer backbone performance metrics for delay (or latency), loss (or its converse deliverability), and availability. The SLAs outline commitments to three key areas: network quality, service quality, and customer care quality. Since telecom is a large network industry that has been transformed by deregulation, as well as a prime facilitator to the digital economy, stakeholders of the electric power industry ought to closely examine SLAs as a benchmark and a bellwether to emerging QOS offerings for the growing Digital Power market.