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Unlocking Microgrids

Taming the Beast: Microgrid Strategies for Effective Cost Management of your Electrical Infrastructure

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The proliferation of Smart Grid technologies, upgrades to the communication grid, and cheaper distributed generation offer significant commercial and reliability advantages to an optimized electrical infrastructure solution in a micro setting.

In 2010, then EDSA Corporation, now Power Analytics Corporation, presented a white paper at the Uptime Symposium entitled ***"The Enterprise Data Center as a Microgrid."*** That paper outlined the strategic imperatives that, when combined, make the enterprise class data center very well suited to take a leading role in the evolving microgrid market as part of a holistic approach to energy management and transforming energy demand into a managed asset. In this paper, we take the next step by laying out a generic technology roadmap for development of an operational Microgrid. And perhaps just as important, a review of basic elements of an overall energy and related services management plan. In many ways, the microgrid concept is simply a logical end to a macro energy roadmap.

Unlocking Microgrids

Taming the Beast: Microgrid Strategies for Effective Cost Management of your Electrical Infrastructure

The Problem

The increased energy demands of IT hardware and mission critical facility infrastructures continue to drive utility costs higher and higher - and there is no end in sight.

Astute companies are looking for competitive advantages and recognize that increased revenue margins are dependent on effective operating cost containment, leveraging of resources, optimization of infrastructure, and uncompromised reliability of their mission critical electrical network. For many organizations, power is the largest operational expense, yet remains the least managed commodity - even with significant upgrades in software solutions, physical infrastructure, and the addition of distributed generation. Enterprise-wide power savings of just a few percentages can deliver millions to the bottom line.

Today's digital world provides operators with technology solutions that deliver competitive value. Unfortunately, many times the cost of this competitive edge, the sexiest new thing, increases energy consumption with potentially significant negative impact on total cost of ownership (TCO). Often times, companies only recognize the increased TCO for their "sexy solution" after the fact, and after the investment.

Basic Elements of an Energy Management Plan

Energy Services

The most critical first step in managing your energy costs is to understand your power usage. The more you know, the better prepared you are to develop effective strategies to reduce energy costs. In many ways energy services are very well understood, in other cases improved insight into your power network and management of your energy contracts represent a significant opportunity to reduce costs.

- Determine if you are purchasing power at the lowest unit cost
- Negotiate rate adjustments and accurately audit utility bills with confidence with historically accurate knowledge of system performance and capability
- Proactively manage power bills by simulating power network configuration changes to determine cost of power effect
- Proactively manage power network with intelligent infrastructure maintenance
- Develop a comprehensive energy strategy
- Implement new forms of energy generation and storage that contribute both to the data center overall load needs as required and are available for bulk grid market applications
- Provide an energy road map for green alternatives such as photo voltaic, fuel cells and wind.

Energy Experts

The ability to manage energy, implement new strategies, evaluate existing strategies and appropriate activities are not dependent on the data center management. A growing infrastructure may benefit from professional consulting and advisory services, freeing the organization from the need to become energy market experts. In many cases, these expert resources are already well known to the data center operations and executive management and this service is a logical extension to the expertise and support they have already been providing. Organizations such as SunGard, Accenture, HP, IBM, Booze Allen Hamilton are just some of the many energy experts capable of providing this counsel.

In addition to the economics driving energy decisions, carbon reduction mandates, and the desire to be good corporate citizens are driving conscientious enterprises to look for ways to implement “green” solutions. The concept of renewable distributed energy generation (solar, wind, etc.) and electric vehicle services are enticing, However, among the issues of how to optimize and integrate these renewable energy sources, reliability becomes even more important.

Just imagine an enterprise class data center or university campus with numerous buildings, several generation sources, and multiple building automation systems. Now consider adding in electric vehicle charging stations, a solar farm, micro-windmills, and energy efficient HVAC and water units. Implementing these new energy efficiency solutions without understanding and optimizing the power network could result in premature power equipment burn outs, significant loss of commercial revenue, and an unreliable substructure of the campus grid. Is there a way to integrate, optimize and manage such a scenario?

The Microgrid Opportunity

With the proliferation of Smart Grid technologies, including Advanced Meter (AMI) technology, upgrades to the communication grid, electric vehicles, and cheaper and cheaper distributed generation, the reality of optimized and reliable electrical infrastructure solutions in a micro setting offers significant commercial and reliability advantages.

There are currently many definitions about what constitutes a Microgrid, but one thing they all have in common is the inclusion of on-site generation. A strong argument can be made for inclusion of energy storage both to manage the intermittency of generation and to optimize the use of energy both for the facility and as an energy market instrument.

For the purposes of this paper, our working definition of a Microgrid is even more specific for a data center. This type of Microgrid has as its primary mission high availability - under no circumstance can availability or quality of power be at risk. With this qualifier, the data center Microgrid takes advantage of the inherent robust electrical infrastructure to optimize and manage energy.

Characteristics of a Data Center Microgrid:

- Critical power availability
- High reliability
- 7x24x365 performance
- On-site generation

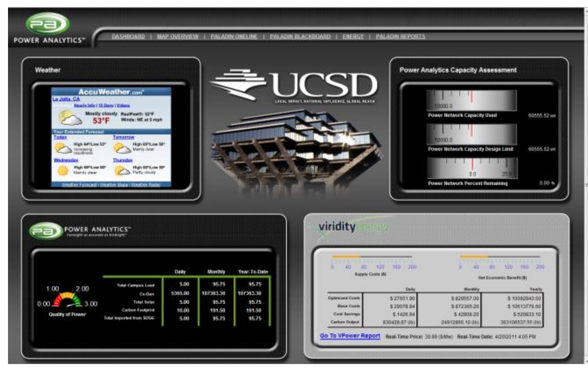
More than supply side

In the United States, Microgrids not only benefit the supply side, but also help manage demand and ensure reliability of grid functions in real time through demand response (DR) and other load shifting, load optimization, load shedding, and load cycling approaches. To date many Microgrid solutions are limited to large implementations, and to only using manual or semi-automated processes for obtaining minor capacity credit from structured markets and/or minor changes to rate structures.

Even with the billions of dollars spent on Smart Grid and energy efficiency infrastructure and software solutions, many companies have been unable to fully realize the commercial value, reliability, or understanding of their energy consumption. Because of this, many companies are only taking advantage of the limited value of their investment. A key benefit of a Microgrid is the ability to provide additional energy, capacity, and ancillary services to the energy markets, resulting in commercialized value to the Microgrid owner.

Another Microgrid advantage particularly relevant to the mission critical data center operator is the ability to react quickly to changing utility reliability conditions. Currently, the Microgrid's universe specifically pertaining to reliability can be divided into three distinct segments: (1) large industrial and commercial demand response, the largest commercial segment in the U.S., primarily manifested as load shedding or load curtailment; (2) supply-side, as in back up generation or battery storage; (3) mixed asset configurations including the potential for a variety of generation and loads. Ultimately, a Micro-grid should bring together distributed generation and load, providing energy, capacity, ancillary services, and the ability to assist with frequency control during reliability events.

Without any large-scale fundamental infrastructure upgrades, Microgrids can stretch utility supplies and secure customer reliability using existing utility DR programs -- delivering greater value to the Microgrid owner, while also creating benefits to the host distribution utility and transmission grid operator.



Microgrid Dashboard from University of California at San Diego

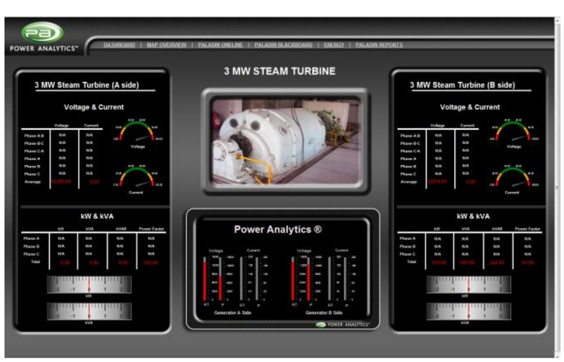
Microgrid solutions are defined as a subset of load and generation equipment and software systems that traditionally reside on the customer side of the meter. Equipment can include any number of electrical grid structures for load optimization, generation optimization, environmental credits, conservation programs, HVACs, pumps, heating systems, or any number of business initiatives that companies turn to maximize commercial value, enable new sexier solutions, or create a "greener" image. The promise of Microgrid software systems or the "enterprise" class Microgrid master controller is to efficiently manage an increasing diversity of electricity generation, energy storage, net metering, and demand assets.

There are varying levels of energy management and optimization outlined in the following sections. The levels outlined are generically correct, and reflect increasing effort, cost and return. The starting point can vary based on strategic and other objectives.

Energy Generation

There are many variables that are part of any decision to utilize on-site generation for more than just emergency back-up power. Generally speaking however, this excess capacity or generation is balanced against the absolute need for high availability.

Today, energy generation resources are more than just traditional diesel generation. Green energy sources such as photo voltaic, fuel cells and even wind are quickly becoming mainstays in mixed distributed generation strategies.



Distributed generation Microgrid resource

Depending on the location and access to markets, generation can include the types of virtual power plants associated with a campus. For example buildings can be energy storage when modeled correctly.

Energy Storage

One of the greatest potentials here is advanced battery energy storage (such as Lithium-Ion) external to the data center. With as little as .5Mw (half a megawatt) of available storage, energy markets allow consumers to participate in both voltage stability and frequency stability markets. In addition, battery storage appears to the data center as a very high quality generation source, transparent to the rest of the facility but available in the event of problems with other generation assets. This strategy allows the operator to “drop” out of market participation to use the battery energy for an hour and then come back to the market when the energy is no longer needed for local demand.

Automated Demand Response (Auto DR)

Active Demand Response programs are those where the customer adjusts their utility load when the regulatory body or independent system operator (ISO) manually sends out information due to reliability events. Traditionally Active Demand Response programs are not a good response to reliability events due to the manual operations and lack of real time automation design, monitoring, and forecasting capabilities.

As Demand Response programs evolve and reliability events increase due to the proliferation of distributed generation and the increasing demand of electric vehicles, organizations will look to Automated Demand Response (Auto DR) as a way to mitigate external reliability threats.

Automated Demand Response (Auto DR) is an important Microgrid application that is already established to some degree in the commercial and industrial markets. A fully automated solution that programmatically shifts generation or load to address market and reliability events, Auto DR is a tool that co-optimizes local resources and load as well as provides modeled output for commercial decision making. It is becoming an important resource in several jurisdictions and markets when response time is critical for reliability requirements, including additional capacity and frequency control.

In an Auto DR solution, a customer, typically supported by automated controls and information technology solutions, installs equipment that enables demand reduction in response to wholesale or reliability events or system reliability needs as signaled by a utility or ISO. The versatility of these solutions is that they provide products that can be leveraged into the market to address immediate reliability and commercial requirements.

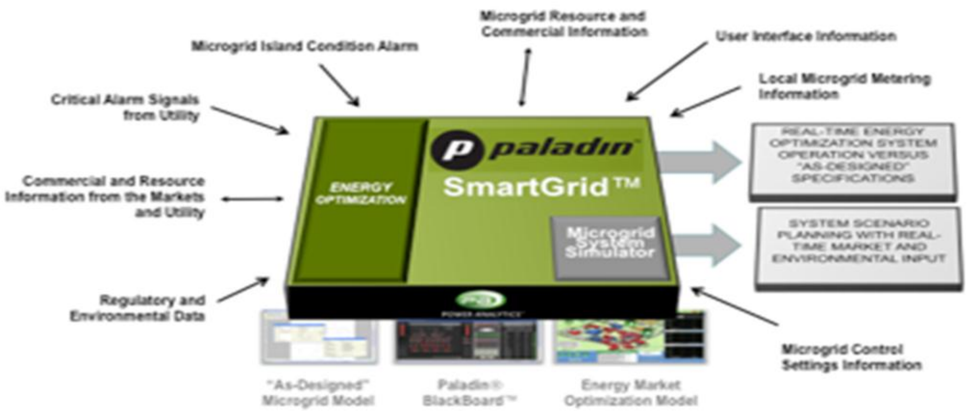
Automated controls solution industry giants, have entered this market as full-service providers, as have new IT-oriented competitors. These companies typically provide a suite of services including design of control installations and telemetry, remote management of energy equipment, management of response to calls for demand reduction, and fulfillment of technical and administrative requirements, such as monitoring and verification of performance.

However, it should be stated that it is not currently possible to determine from market and program records, the degree to which automated response systems—as opposed to occupant actions—actually control building operations during demand response events. Therefore traditional demand response programs fall short on their ability to reliably respond to real time market and reliability events.

Indeed, the ability to participate in these markets is dependent on the ability to model the Microgrid, transport the data feeds, and monitor performance. If these capabilities exist, then customer – and utility in turn – are rewarded for demand reduction performance in accordance with dispatch instructions including energy, capacity, and frequency response.

The ultimate goal is to provide reliability and commercial based products to the energy consumer or energy producer without the customer ever noticing a change to their conditions.

can also use the building itself as a source of thermal storage, for instance, by "pre-cooling" the building in early morning hours to enable reduced energy consumption later in the day at peak hours (Load Shifting). However, many of these demand response solutions lack the capability to make real time adjustments for reliability events due to the lack of telemetry, performance of



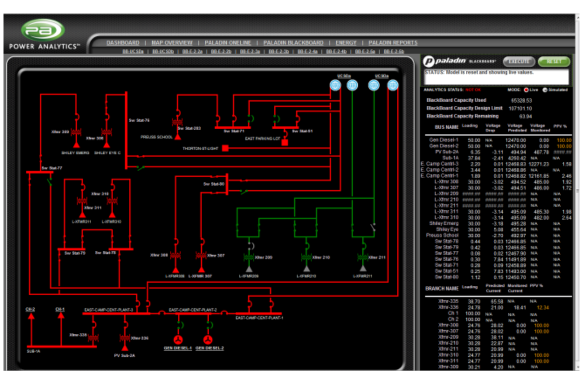
The Need for Co-Optimization

Larger commercial and industrial customers have increasingly deployed building energy management systems or, indeed, industrial process management systems capable of responding to reliability event and/or real-time pricing demand response signals, and also capable of providing information and validated response data back to aggregators and market operators. More sophisticated building management systems are even able to manage on-site thermal storage. They metering signals, security concerns, and/or any number of software solution issues.

In the near future, with the introduction of cutting edge secure software solutions and advanced meters, these consumers will have the potential to combine and process energy usage, on-site building generation, thermal and electric storage, and even electric vehicle charging. They will be able to co-optimize all resources against forecast weather conditions, basic usage demand, market reliability information and energy and capacity market prices, so as to minimize the impact of reliability events and leverage excess capacity.

One of the keys to achieving Renewable Portfolio Standard ("RPS") mandates will be the use of demand response as a form of system reserve, real-time dispatch, frequency control, and other ancillary services. These services require a quick response (< 10 seconds) and "certainty" in the response provided. Advanced solutions can provide continuous updating of what is available and factor the potential revenues and market events from ancillary service provisions into the co-optimization.

Additionally, these systems will need to be modeled down to the individual equipment level, provide operators with "what if" capabilities to factor in risk, and also provide monitoring of the equipment in real time to mitigate any real time deviations.



Microgrid Operator Dashboard showing the power network

Laying the Foundations for the Virtual Power Plant

Utility executives, policy makers, and regulators at the federal and state levels mostly agree on the barriers to broader integration of auto demand-side solutions into grid operations and the complex next steps necessary to overcome them. FERC has recently adopted a policy to pay demand response solution providers on par with generation providers. The following points identify some key elements of a policy and regulatory agenda to support the development of Microgrids:

- Identify reliability event mechanisms to guide the development and deployment of demand resources wherever possible to minimize reliability events.
- Develop consistent, long-term customer incentive and technical assistance programs to support the development of key elements of the Microgrids.
- Within jurisdictions, coordinate the marketing and operation of demand response with energy efficiency programs conducted by system operators, utilities, and government agencies.
- Develop and disseminate frameworks for consistent inclusion of demand-side resources in forecasts used for supply planning.

- Development of standard reporting and aggregation of data for utility and regulatory consumption.

Mixed Asset Value Proposition—Microgrids

The future of demand response solutions – providing real time capabilities to solve reliability events – are on the brink of becoming a reality. Significant advances in software and telecom technology have greatly increased performance, modeling, and data monitoring capabilities in a secure communication mechanism. Opening up Microgrid customer classes to provide demand response solutions for greater grid reliability and commercial value could be used in capacity sparse, frequency deviation, or any number of reliability and commercial event situations. This would be a watershed event for our power grid. The greatest value of these solutions is the ability for utilities to draw energy, capacity, and ancillary services from Microgrid operators without a significant effect on the end use customer.

Future Outlook for Utilities and Their Customers

The utility business model, functions, and relationship with the customer change significantly when customer energy loads are tied to customer resources. Furthermore, the utility's overall role in regard to management of the energy grid will change as distributed generation (solar, wind, geothermal) and storage technologies are implemented in Microgrid settings.

With this concept in mind, mixed asset Microgrids, as they grow and attract customers, are uniquely positioned to take advantage of reliability and commercial events with real time constraints and provide organizations with more security on grid management and long term stability. While there are a number of regulatory, commercial, and political decisions that need to be made, the future of demand response utilizing mixed asset and Auto DR capabilities in a Microgrid setting address a number of growing issues in the electric markets today.

Summary

The ability to optimize infrastructure, cost, availability and energy demand are classic examples of a complex economic optimization.

Microgrid Energy Management Dashboard with "What If" environment.

This complexity is well worth the effort to resolve because the stakes are so high.