UNDERWRITER CASE STUDY

Uptime Institute Symposium 2010

The Enterprise Data Center as a Microgrid

By Kevin Meagher, Chief Technology Officer, EDSA

Mention Smart Grids, global warming or oil prices and you will set off a tidal wave of opinions and perspectives. Regardless of your perspective, the reality is that energy costs are increasing; energy use is increasing; and opportunities to create new industries in and around energy is here to stay. What we are suggesting today is that the global "enterprise class" data center is an ideal environment for at least one aspect of the Smart Grid – the microgrid.

The Enterprise Data Center as a Microgrid

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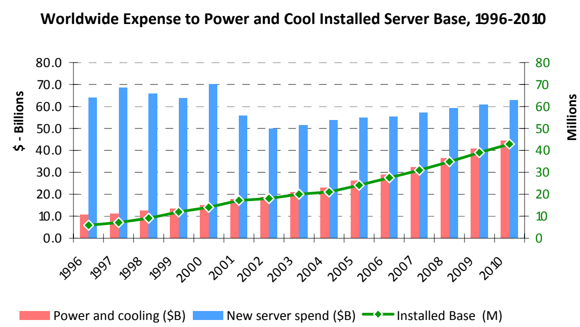
In just over three years since the term Smart Grid was originally used (credited to Andreas Carvallo, April 2, 2007), the term has come to symbolize a green revolution for the U.S. economy and a focus of the global community. Billions of ARRA stimulus funds (American Recovery and Reinvestment Act) have been committed to this simple idea of linking the electric grid + communications network + hardware + software.

In parallel with the growing interest in the “Smart Grid”, research was underway by the Environmental Protection Agency, Uptime and others focused on the growing energy use of data centers and the clear trends that indicated intervention was required. This for an industry that was largely concerned only with availability was a significant change.

In 2007 the EPA published their final Congress (August, 2007) that specifically identified data centers as major consumers of energy (61B kWh in 2006) with the potential to double at least every five years then projected to reach 100B kWh by 2011.

These initiatives along with other work from the Green Grid and the Department of Energy (including emission trading or cap and trade) are all serving to focus the future of energy impacts around the data center.



Source: IDC, 2007

The Micro Grid: Two Worlds

1. ***The utility side of the meter*** - Generally speaking, micro grids that are part of utility managed solutions (or “embedded micro grids”) serve to provide both a “dispatch able” load and generation. In fact, many demand response (DR) solutions are micro grids by this definition. A common approach to demand response is to signal local generation (i.e. at a shopping center) to turn on, thus allowing the local utility to “island” the user and reduce peak power generation requirements. The *user* benefits from local power and reduced rates based on this type of micro grid, and the *utility* gains flexibility and distributed control over stressed generation resources; especially during high demand times like hot summer days.

2. ***The customer side of the meter*** - The other type of micro grid is the area that we are addressing. This type of micro grid is typically more complex because the “operator” is the customer. This type of micro grid can involve making generation decisions for multiple on site generator options, as well as coordination with the utility. The coordination is critical because simply going on and off the main grid (islanding) can create huge system problems for the main grid. These additional requirements are the primary reason for another key technology, the **“master controller”**.

The master controller is the core technology associated with assimilating, analyzing and understanding what is going on with the micro grid. In other words, the master controller has the overall responsibility for managing the micro grid. For EDSA, the master controller is software responsible for interfacing to a variety of devices (meters and equipment), data acquisition systems and building management systems, as well as providing the software platform for micro grid Power Analytics™.

Power is a Network

EDSA is in the business of developing software to design and manage power networks. Managing power networks means making sure that the primary mission, availability, is never compromised. The method for accomplishing this begins with an extremely accurate model of the power network. The model that is typically created during the design phase of the power network is then used to manage the network. This model, (typically created by the engineering firm that designed the power system) is embedded into a data acquisition network to deliver real time power network management.

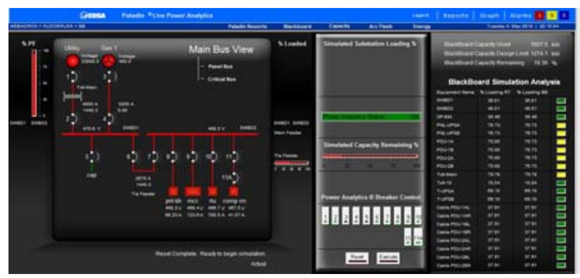
This embedded power model continuously compares how the network is performing with how it should be performing based on the current conditions. This simple idea is unbelievably powerful in practice.

As an example, imagine you are driving down the highway and sitting in the passenger seat of your car is the chief engineer who designed every critical component of your cars' drive train. At 40 mph, everything is fine, but then you enter the interstate and as you are accelerating, the engineer leans forward and tells you something is not right. No dashboard warning lights are on, you do not hear or see anything, but the engineer who designed the system is concerned because she is very familiar with all the systems and what should be happening. This is very analogous to how EDSA Power Analytics manages the power network: comparing what *is* happening, to what *should be* happening.

From Co-Pilot to Simulator

Now imagine that this same engineer is sitting with you in front of your high definition screen and your driving simulator. You want to try a maneuver and the engineer tells you to go ahead and try, but that the car will crash. You want to try anyway because there is no penalty for this type of simulation plus the simulation is very real.

This same capability (Blackboard in Paladin) extends the "what-if" planning so you can compare and contrast a change before you invest the time and risk. Will the change increase energy efficiency or decrease it? Is it even possible to make the change, or will critical systems become overloaded?



The Data Center as a Micro Grid

Clearly managing a mission critical network is essential to the overall availability of a data center. This is true whether you are sending data packets or power. Essential elements of security and power for any data center are the quality and reliability of power. This one fact differentiates the requirements of a data center beyond all other potential micro grid environments

One of the top research programs on micro grids is part of the Lawrence Berkeley National Laboratory (LBNL), led by Dr. Chris Marnay. Dr. Marnay and his micro grid team (http://der.lbl.gov) published a paper in 2009 titled: "Added Value of Reliability to a Microgrid: Simulations of Three California Buildings" (April 2009, http://eetd.lbl.gov/EA/EMP/emp-pubs.html). In their analysis, the team considered three different types of buildings; a nursing home, a high school and a data center.

The unique power quality requirements of a data center were central to their overall findings.

The principal finding of this study is that the data center represents the highest financial return primarily because of the power density and the associated power quality requirements. The unique power quality requirements of a data center were central to their overall findings, paraphrased and summarized here:

"The major outcome of the analysis is that the consideration of critical loads and PQR (power quality) can make a significant difference to micro grid adoption depending on the previously installed equipment and the strength of need for high PQR…The data center yields the unquestionably most spectacular results…."

CHARACGTERISTICS OF THE CALIFORNIA TEST BUILDINGS

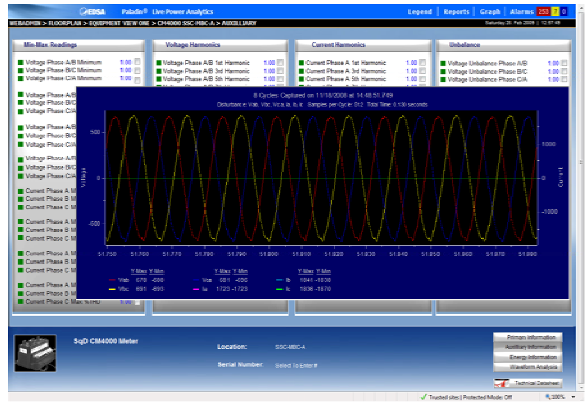
	floor-space ($000m^2$)	electricity peak load (MW)	annual electricity use (MWh)	annual NG use (GJ)	$F_{s,base}$	$F_{s,peak}$
nrsng. home	32	0.96	5 762	20 542	0.5	0.1
school	18	0.88	1 509	2 626	0.25	0
data center	0.6	1.8	11 421	0	1	1

[See References section for detailed view]

Power Quality not only drives the significant financial performance of the data center as a micro grid, but is at the center of the other key and unique attributes of the data center.

Smart Meters

The vast majority of focus on the Smart Grid over the past 12-24 months has centered on smart metering technology. These intelligent measurement devices are a basic requirement of any Smart Grid. In fact, the deployment of Smart Meters is frequently the first major hurdle to advance Smart Grid technology. In the data center, intelligent meters are typically already available. The wide spread use of these high end power quality meters not only provide critical energy management data, but also provide high resolution analytical data (such as harmonics and wave forms) which is important to the overall operation of the data center. The point is that most enterprise class data centers already have state of the art power meters and are not dependent on the development and deployment of advanced metering technology so critical to the residential Smart and Micro grids.



Distributed Generation and Islanding

For more than 20 years, mission critical data centers have recognized that unplanned loss of power, especially from the main grid, must be prevented if at all possible. To accomplish this, data centers have long relied on site standby power generation such as diesel generation capable of assuming the critical load in sufficient time to ensure critical processes are not interrupted.

To handle this transition, and frequently to condition the power, high speed switching technology is deployed along with uninterruptable power supplies (UPS technology) to handle the interruption of power.

Finally, local energy storage typically in the form of battery technology is also installed to provide sufficient run time and standby power while on site generation is brought online. The process of recognizing a main power grid loss, along with transparent transition to other sources off the main grid is what the Smart Grid world refers to as islanding. Just as coming off the main grid is part of normal, designed operation in the event of power problems, knowing when and how to go back on the grid are also well defined, understood and deployed technologies in the data center. In fact, many mission critical data centers proactively go off grid (or island) if they suspect the potential for a problem is likely. Local onsite power generation, local onsite energy storage and islanding based on grid conditions are all part of the normal lexicon of data center operations.

Power Quality, Reliability, Power Management, Energy Management

All of the attributes that are inherent in the 21st century Tier 2, 3 and 4 data center combine to make the ideal micro grid. A mission critical power system with the requirement of high quality power, and a management infrastructure that is designed for accurate metering and management. This managed power network is the perfect environment to deploy the energy management and promise of the micro grid.

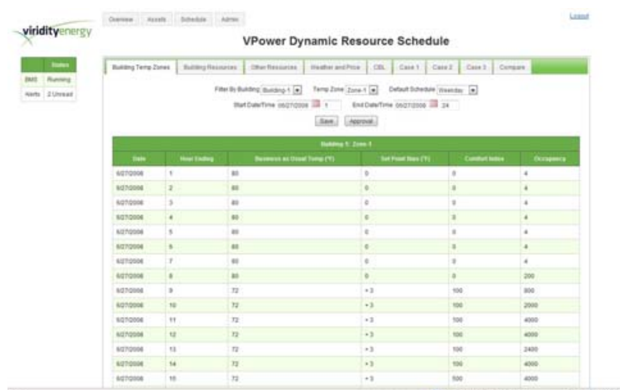
Tier Level	Requirements
1	• Single non-redundant distribution path serving the IT equipments • Non-redundant capacity components • Basic site infrastructure guaranteeing 99.671% availability
2	• Fulfils all Tier 1 requirements • Redundant site infrastructure capacity components guaranteeing 99.741% availability
3	• Fulfils all Tier 1 & Tier 2 requirements • Multiple independent distribution paths serving the IT equipment • All IT equipments must be dual-powered and fully compatible with the topology of a site's architecture • Concurrently maintainable site infrastructure guaranteeing 99.982% availability
4	• Fulfils all Tier 1, Tier 2 and Tier 3 requirements • All cooling equipment is independently dual-powered, including chillers and Heating, Ventilating and Air Conditioning (HVAC) systems • Fault tolerant site infrastructure with electrical power storage and distribution facilities guaranteeing 99.995% availability

Optimization

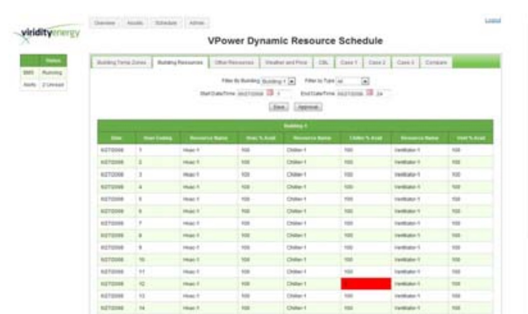
Optimization is where real separation and opportunity exists. With the ability to truly manage a power network, comes the ability to optimize not only the performance of the power network, but also the cost of the micro grid. The promise of the micro grid as envisioned in Viridity VPower™ is one that goes far beyond traditional demand response to true virtual power generation. By first modeling key energy consumers (such as HVAC) associated with the buildings and energy cost from a variety of generation sources, a "forecast" is possible that balances true energy cost and opportunity. With this as the starting point or baseline, it is now possible to envision or recommend various scenarios or cases.

Each case first considers a constantly changing market structure and environmental conditions to propose a solution. That solution is then analyzed (market forecast) with the model based Power Analytics™ from EDSA before any recommendation is presented to the micro grid operator.

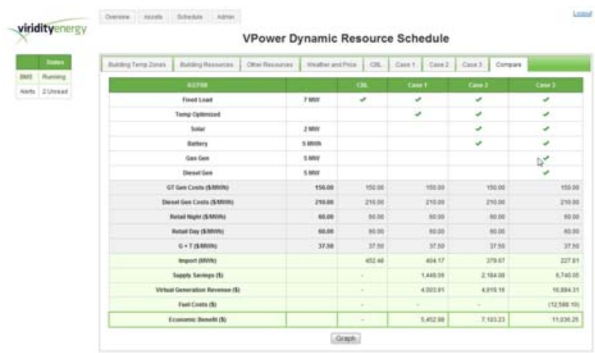
Potential constraints unique to a facility are identified and if necessary, re-optimized iteratively to arrive at a solution that is indeed a "no compromise" solution. This solution or recommendation is referred to by the Galvin Initiative (www.galvinpower.org) as "Perfect Power".



Resources are compiled, compared and forecasted that are optimized based on market, capability and power system constraints.



Once listed, compiled, resources are scheduled based on the forecast.



Once scheduled, resources are compared in multiples from the base case (or business as usual).

The result is a forecasted schedule that optimizes the power network, the available resources and the market prices.

Regardless of the micro grid opportunity, whether a campus, a building, or a data center; the primary mission of power is availability and if that need is not met, the “cost” of energy is irrelevant.

Putting it all together

In summary, data centers are more than symbols of the information age, they are the ideal environment for all that is envisioned by the micro grid. Data centers are large and growing consumers of power with strong financial and environmental incentives to increase energy efficiency. This is what epitomizes the technologically advanced managed power networks of the enterprise data center.

1. A power model is created as part of the overall design process. Goals are defined based on Tier Level, anticipated load and business requirements.

2. Once created, the model is integrated into the power management system so that actual data values are continuously compared to the model’s anticipated values, and any discrepancies elevated to operations and management.

3. This hyper-accurate model becomes the basis for planning and analysis. Changes are simulated and analyzed to determine viability, performance and cost as part of the planning process, not a reactive process.

4. A market optimization model suggests control settings based on fluctuating commodity prices, weather conditions and power demands.

5. The power and market optimization recommendations update on a regular time interval based on changing market, weather and power demands in an iterative process that recognizes the first requirement for power availability before ever recommending a course of action.

About the Author(s)

Kevin Meagher is responsible for a wide range of product direction, business development and strategic planning. As the creator of the Power Analytics concept and definition, Kevin leads the Company’s technology development and strategy as well as critical strategic relationships in emerging technologies. Recently named to the “100 People You Must Know in Smart Grid” list by GreenTech Media, Kevin is recognized as an industry expert in the areas of data acquisition, data analysis, expert systems and artificial intelligence.

Prior to joining EDSA, Kevin was president of a boutique business consulting company that worked closely in product planning, strategic planning and business valuation for public companies such as Eaton, Invensys General Electric, and Alpha Technology, as well as leading venture capital and private equity firms from Wall Street to Silicon Valley. Kevin has authored numerous technology works and has been a frequent speaker on power and energy management and related technologies.

Kevin has undergraduate degrees in Biochemistry and Business, and an Executive MBA from the University of Colorado as well as doctoral work in Knowledge Management. Kevin also holds a Master Captain's License from the USCG and has a current commission in the U.S. Merchant Marine.

About the Underwriter

EDSA is a privately held developer of software solutions for the design, simulation, deployment, and preventative maintenance of complex electrical power systems. Founded in 1983, the Company's Paladin® software products are used by thousands of commercial, industrial, governmental, and military customers worldwide, to protect more than $100 billion in customer assets.

The Paladin family of products helps organizations to ensure that their electrical power infrastructure is optimally designed (Paladin® DesignBase™), performs precisely as intended in terms of reliability and energy efficiency (Paladin® Live™), and operates flawlessly as organizations make real-time transitions between public and on-premise power sources (Paladin® SmartGrid™.)

By continually comparing operating conditions with the original, as-designed Computer Aided Design (CAD) model, the Paladin platform is the only real-time power analytics solution for diagnosing electrical power problems or energy inefficiencies at their earliest stages.

Headquartered in San Diego, Calif., the Company's worldwide operations include 30 sales, distribution, and support offices located throughout North America, South America, Europe, Asia, and Africa. For more information about EDSA and its products, visit www.edsa.com

References & Exhibits

Projected CO_2 Emissions Associated with the Electricity Use of U. S. Servers and Data Centers (MMT -CO_2/Year), All Scenarios, 2007 to 2011

Scenario	2007	2008	2009	2010	2011	2007-2011 Total	% of current efficiency trends scenario
Historical Trends	44.4	51.2	59.2	69.2	78.7	302.8	111%
Current Efficiency Trends	42.8	47.9	53.6	60.5	67.9	272.8	100%
Improved Operation	34.8	39	43.5	48.4	53.1	219	80%
Best Practice	30.2	30	29.8	29.7	30.1	149.8	55%
State-of-the-Art	28.1	25.7	23.5	21.4	21.2	119.9	44%

Emission Database for Global Atmospheric Research version 3.2, Fast Track 2000 Project.

Characteristics Of The California Test Buildings

Building Type	Floor Space (000m^2)	Electricity Peak Load (MW)	Annual Electricity Use (MWh)	Annual Natural Gas Use (GJ)	Fs Base	FS Peak
Nursing Home	32	0.96	5,762	20,542	0.5	0.1
High School	18	0.88	1,509	2,626	0.25	0
Data Center	0.06	1.8	11,421	9	1	1