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Power Analytics: A Model-Based Approach to Availability, Energy, and Resource Management

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Power Analytics is a new and proven way to ensure data centers operate precisely as they were intended to in the design process while maximizing energy efficiency

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Introduction

Mission critical power systems are, by definition, complex and only continue to increase in complexity. Changes in instrumentation and data acquisition have also progressed significantly with true industry-standard communications protocols and intelligent devices.

The overall increase in available data hasn't significantly increased the ability to manage a complex power system; rather the opposite is the norm. Achieving computing uptime availability goals must now also include energy management. Using analogous techniques from *business analytics*, the creation and use of specific metrics are providing powerful new analytical insights into the management of these complex power systems.

We call these metrics the *Power Analytics.* Two core concepts form the foundation of Power Analytics:

- managing based on key performance indicators
- use or reuse of a sophisticated power systems model

Power Analytics is the applied science of power management for operations personnel and executive management (both power and non-power professionals).

Power Analytics includes the creation of a model-based power system and the application of that model in a real-time environment. The unique model-based approach allows for extensive *what-if* simulations based on actual conditions for availability, conditional alarm management, commissioning, energy management (including power usage effectiveness, or PUE), arc flash and overall power, cooling, and space management.

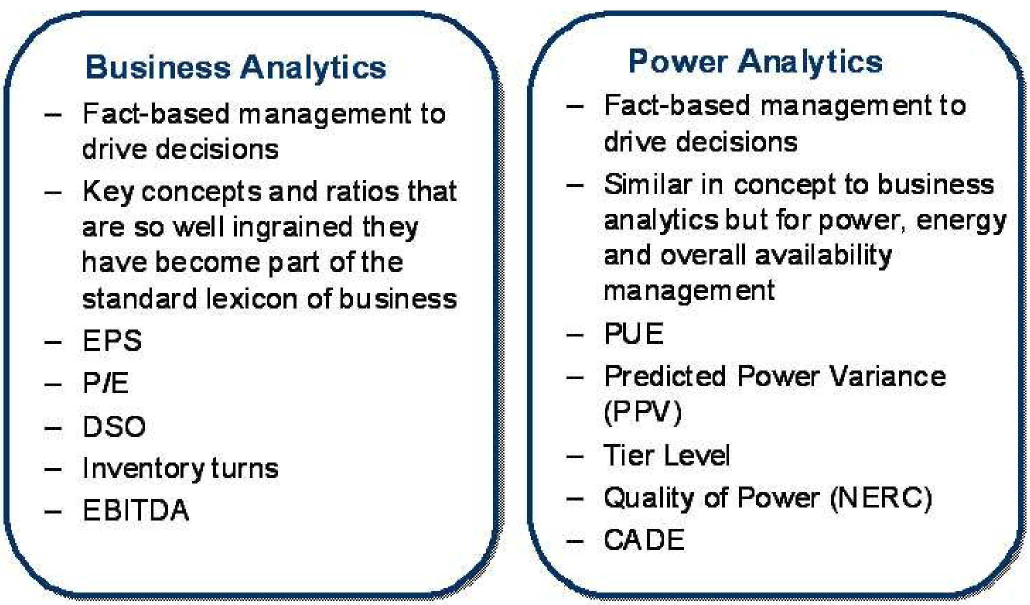


Figure 1. Business Analytics compared with Power Analytics
EPS – Earnings per share
P/E Ratio – Price to earnings
DSO – Days sales outstanding
Inventory Turns - the number of times invested in goods to be sold or used over in a year
EBITDA – Earnings before interest, tax, depreciation and amortization
PUE - Power Usage Effectiveness
DCiE - Data center infrastructure efficiency
PPV – Predicted Power Variance
Tier Levels - data center performance in tiers or criticality levels
Quality of Power - summarizing power in terms of the probability that the quality standard is attained
CADE - Corporate Average Data Efficiency

The Power Modeling Process

Many benefits accrue to a metrics-modeling approach to managing a complex process. Within the discipline of *operations research*, for example, models are frequently created and referenced to explain both actual and predicted behavior that is often based on massive amounts of data for everything from manufacturing to network management. Perhaps the most frequent disincentive to modeling a complex process is the time and effort required to create the model.

A common approach to reduce time and effort to create a model for many applications is to observe current conditions and relationships to approximate or "model" future performance. This approach is valuable but has two flaws.

The first flaw relates directly to the complexity of the system. The more complex the system, the more likely that the observed conditions for the model represent a snapshot in time and frequently don't reflect the overall complexity and synergistic nature of the data. This is in fact the inherent limitation of most neural network designs that require constant retraining.

A second limitation is that the projections frequently are linear in nature and more representative of an index and not specific critical components. In other words, the value of the projection is to see what will happen to a specific rack or critical breaker or load.

Power Analytics uses tools and methods that have withstood the rigors of peer review, agency approval and related system design. The approach then uses real-time data to repeat the analysis as the power network changes to compare and contrast real-time values versus predicted values.

Typically beginning with the creation of a single line (or one line), the system is designed using all the elements of the eventual system. The details and specifics are very important and included in the libraries of thousands of devices and manufacturers of equipment. From cables to breakers, to switch gear to motors, each element inherits the critical information from the other elements of the design using a "plugs and sockets" approach to build a power system.

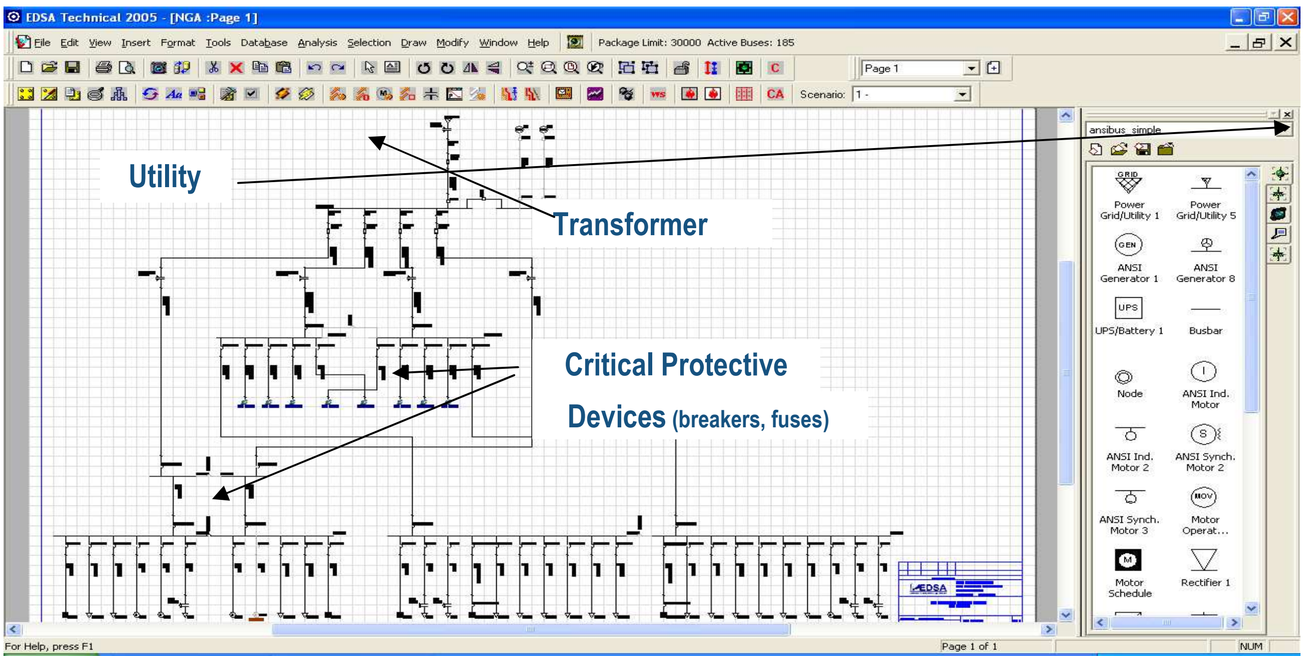


Figure 2. The Power Systems One Line Design

Whether using standard libraries from major manufacturers or generic devices for custom equipment, the entire model or system is created.

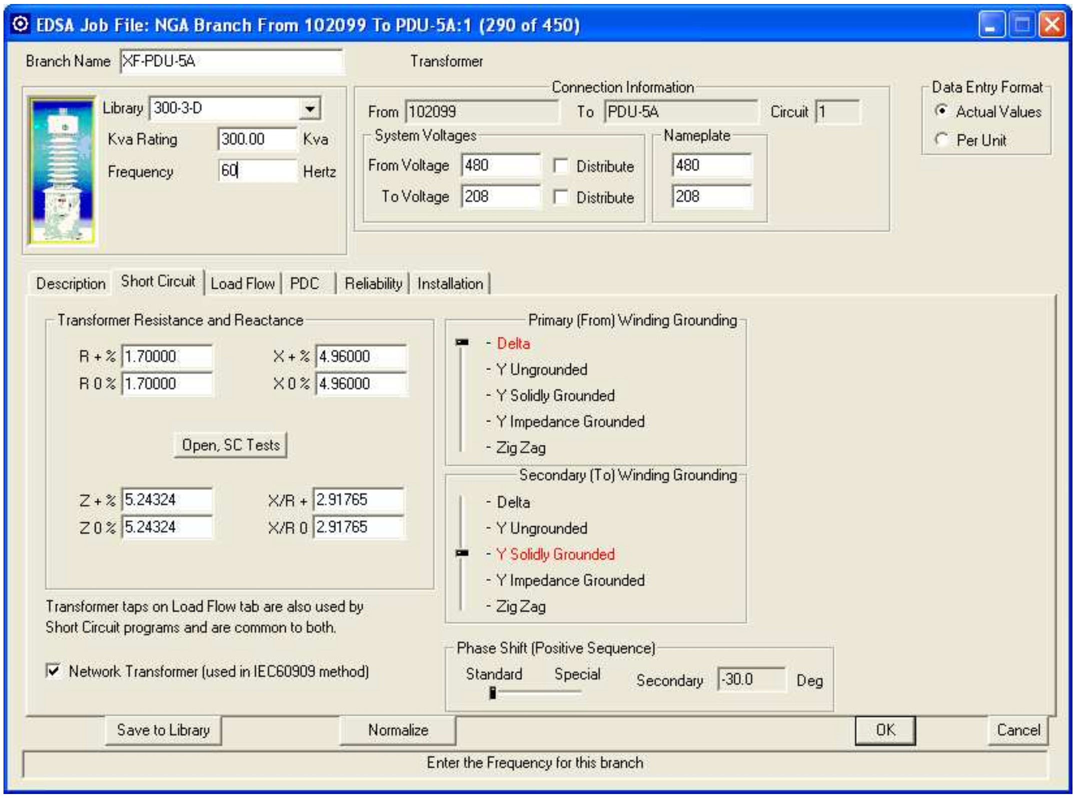


Figure 3. Library example of a transformer

Detailed information shown in this example includes short circuit, load flow and reliability.

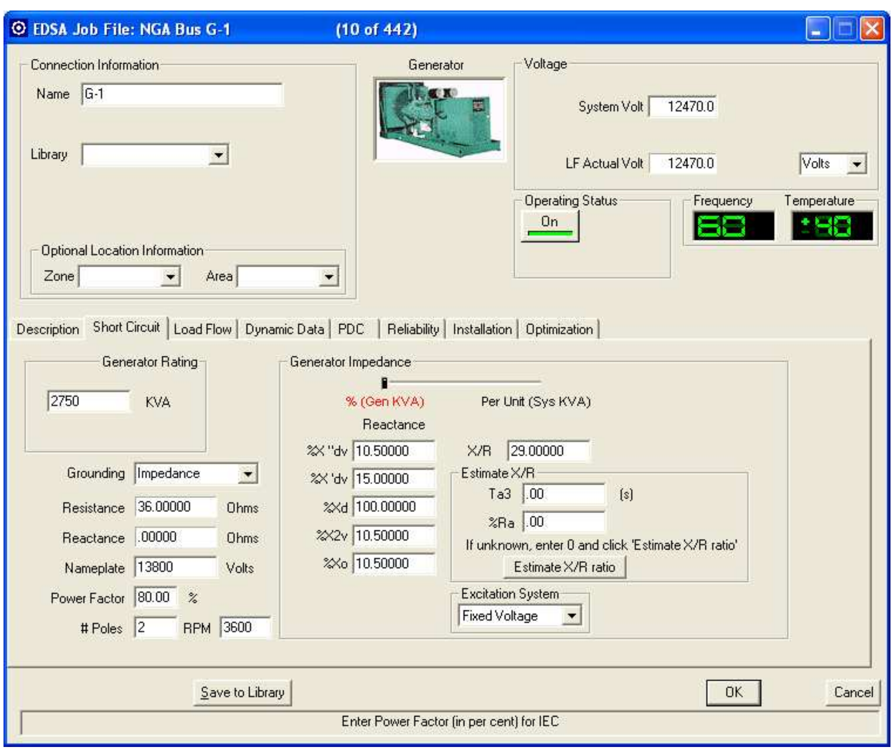


Figure 4. Library example of a generator

Once designed, a series of analytical steps are performed to evaluate key assumptions. These analytics have a long history of use in utility grid design, nuclear power plants and combat naval designs. All have examples of close tolerance and regulatory requirements that have been used for many years to refine and develop power systems. The extreme critical nature of these systems, and requirements for audited quality standards and methods, are essential to a successful design and the safety of the communities these systems serve.

The design can and should be evaluated and tested before a single piece of cable is purchased, or any construction begins.

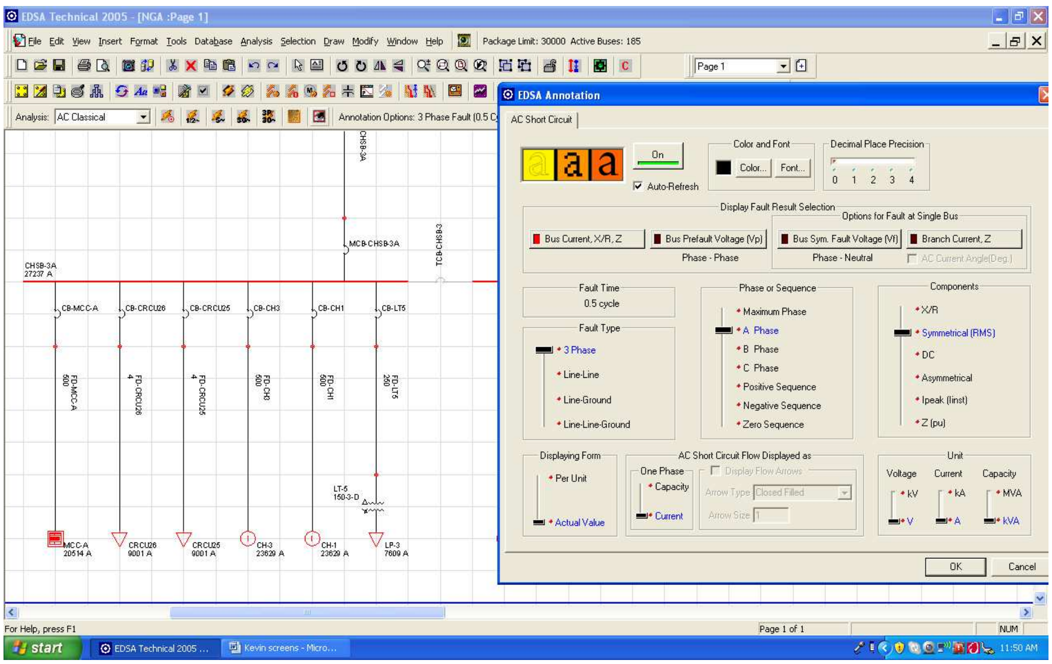


Figure 5. A common basic analytic shown here is "short circuit"

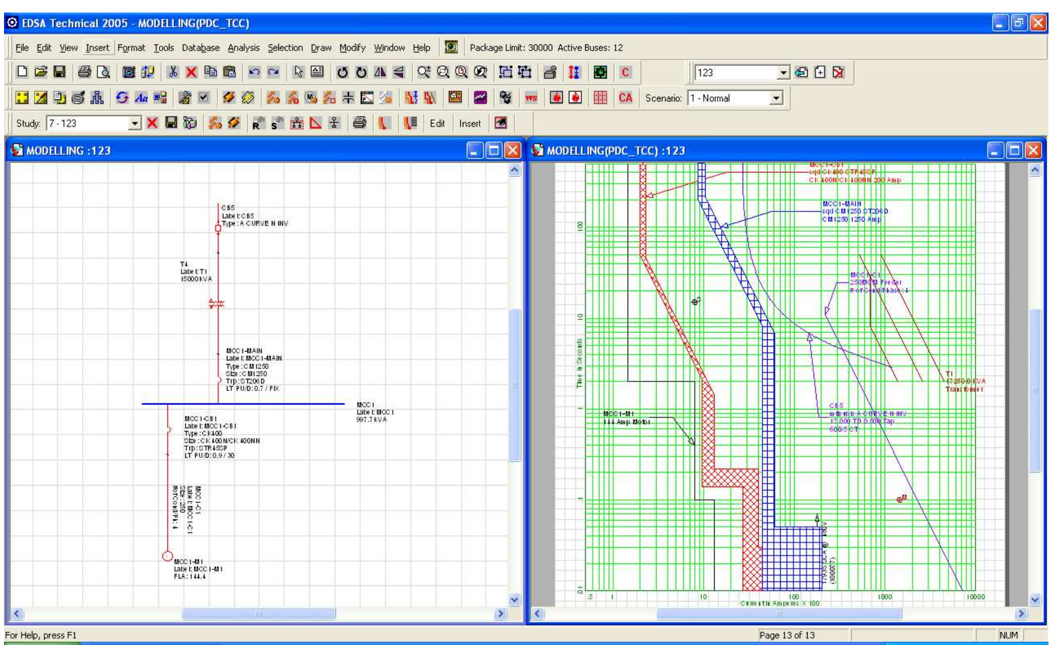


Figure 6. A protective device coordination (PDC)

The evaluation of a design serves many purposes. The most essential is to determine if the selected power network components will achieve or support the intended mission of the design. Keep in mind that this design is typically done by the real power systems expert. The designing engineer has specific objectives and goals, so the process of evaluating the design is more than academic. In many ways, this initial design is the best the system will ever be, or "perfect on paper".

The process of designing, simulating, and evaluating performance and components in the design all form the basis for the "model".The model becomes the sum of all the critical parts of the system and most importantly, the interaction of these parts with the whole system.

Once the design is ready for submission to various end users (general contractors, electricians, facilities engineering management), the design begins to change in implementation as a part of the normal course of events. A value-engineered substitution might change certain components, and this can and will affect the overall performance of the system.

In a very real sense, it is not just the *as-built* drawings that frequently deviate from the original design, but the actual performance and capability can diverge from the *expert* design, sometimes to an alarming degree.

In general, the ability to evaluate the actual system is limited to a post-operational power audit or analysis to determine the capability of the system. All too often, the power audit is the result of an unforeseen or catastrophic event.

Introducing Power Analytics

What if you could take the expert design and, in real time, feed critical performance data to the design model, then re-analyze the system? This simple concept can provide a powerful capability and forms the fundamental paradigm of Power Analytics. Remember, the critical power system is a power network, not a collection of discrete devices. The model-based approach allows for evaluating the overall performance based on the very specific design, every second.

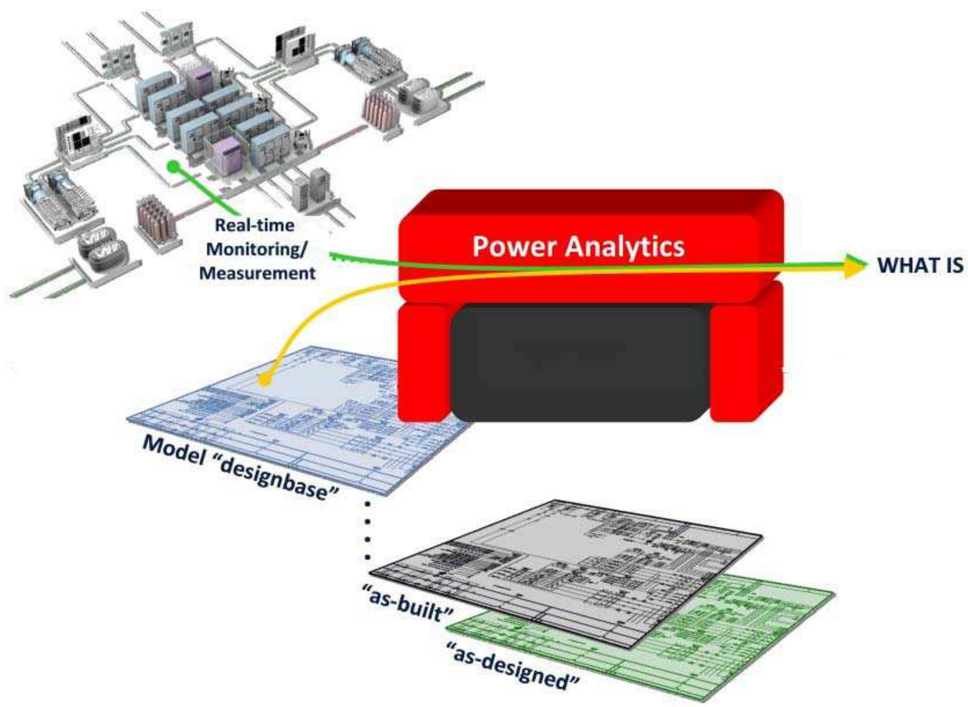


Figure 7. Power Analytics

Comparing expected performance with actual data is also the foundation for extremely accurate metrics. These metrics facilitate deep knowledge and understanding of a power system without being a power engineer. The use of metrics are directly analogous to business analytics without which management and financial decisions would be nearly impossible.

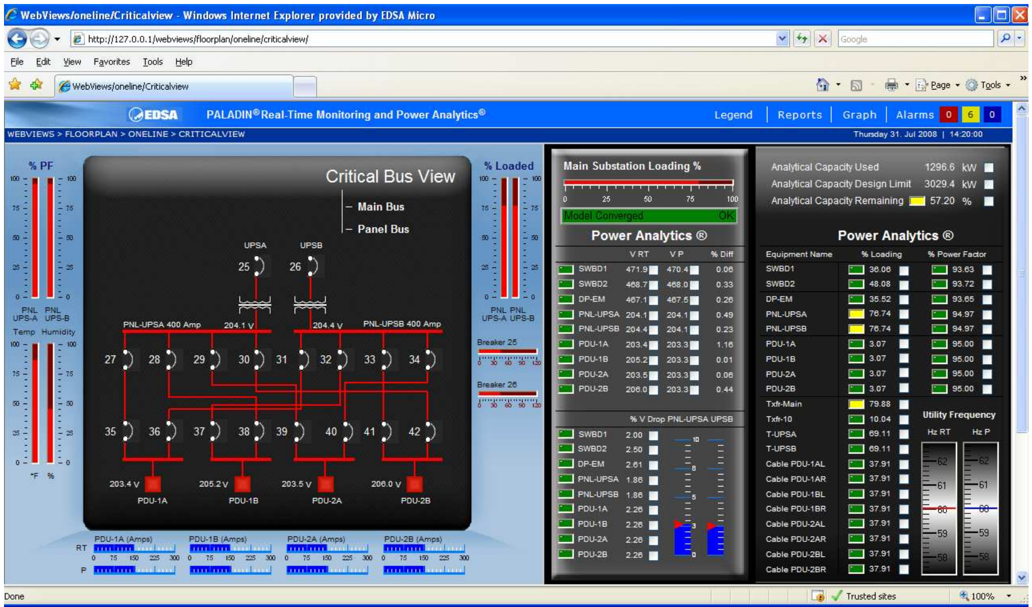


Figure 8. The “Live” one line showing any variance with the expected performance

Figure 9. Power Analytics present an “executive dashboard” of critical metrics.

With the expert model as the cornerstone of the overall power and energy management of mission critical systems, extraordinary insight is now possible for such things as:

Actual capacity of the system and capacity remaining—The overall capacity of a system is a function of the weakest link of the system. This is determined by the protective devices, which is at least partly why the “protective device coordination” study exists. But capacity is a function of network loading at an instant in time, so capacity can and does fluctuate based on how well balanced and loaded the power network is. Using algorithms similar to those used by utility companies to determine the stability of grid, the power network is continuously evaluated and reported in real time based on actual conditions.

Health of the system—The complexity of the system is translated into a simple Power Analytic: the system is good, marginal or bad. Simple.

Predicted Power Variance—Data acquisition systems have the ability to acquire vast amounts of data with resolution as low as 1ms, but of what value is the data? In and of itself, it has limited value, because it merely represents a number; it's up to the observer to determine the value.

However, these specific values do have meaning to the expert design. A voltage drop or value at a location is extremely important if you know what it should be. And what it should be was determined in the original design. This variance is the basis for predicted power variance (PPV) in Power Analytics.

Intelligent Alarm Management—Elaborate and complex alarming schemes and alarm masking rules are often futile attempts to manage the system and minimize false or inconsequential alarms. The model represents a contextually accurate expectation for these values based on the design capability of the system. When on generator power (for example), values are different but they are not in the alarm mode. This simple example of Power Analytics automatically creates intelligent alarming or contextually accurate (conditional alarming) instantly. Perhaps more important is that the "expert" behind the process is the same power engineering group who designed the system originally.

The whole process is now integrated from design, to deployment to operation—the full life cycle of the power system.

Figure 10. The Power Analytics Live Cycle

The Power to Ask, "What If?"

This extremely accurate approach to modeling a complex system or mission critical power has immediate extensions that dramatically increase the value of the approach. The most powerful by far is the ability to ask a range of questions such as:

- How will a planned maintenance procedure impact the overall system?
- What impact will our planned technical refresh have on the system's perform-ance and capability?
- How will our anticipated changes affect our PUE or data center infrastructure efficiency (DCiE)?
- How robust and reliable is our system should certain key components fail?
- How capable are our standard operational procedures and should they be modified?
- How will a change affect critical safety requirements such as protective gear for a potential arc flash hazard?

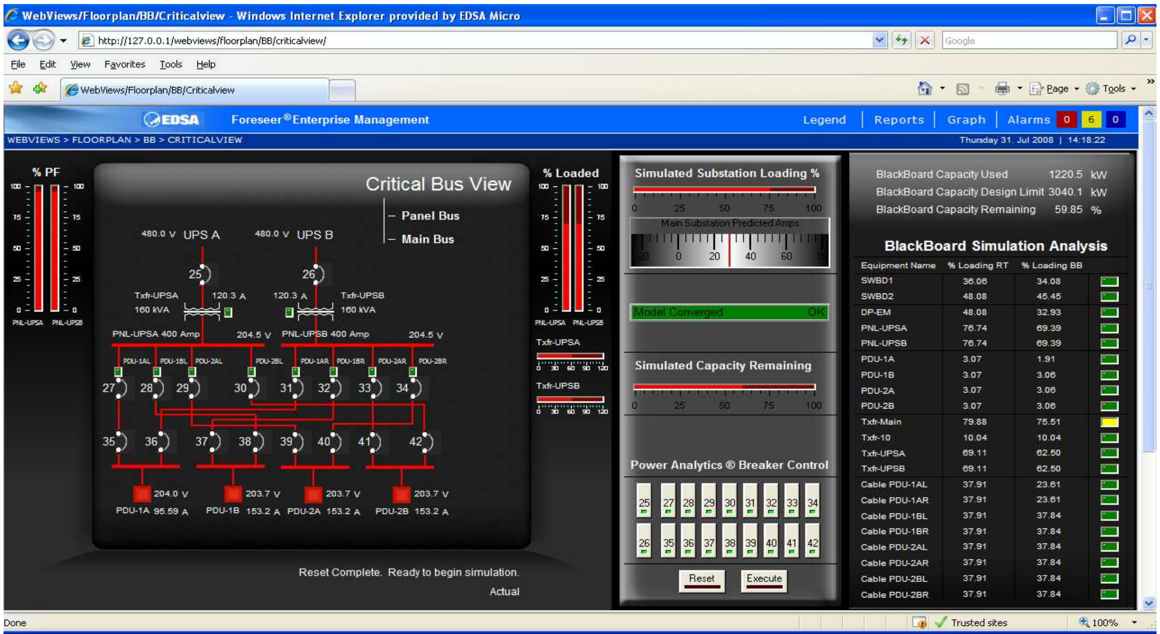


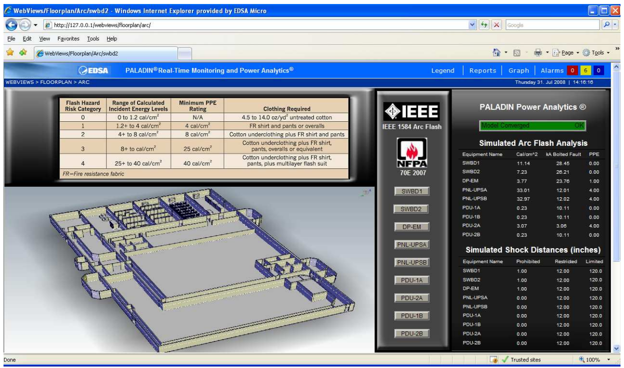
Figure 11. The modeled system provides the ability to "blackboard" live operations

From Energy Management to Arc Flash

The impact of the model-based approach to *what if* goes beyond availability management. The same questions asked earlier also apply to energy management. How would the proposed changes for capacity or equipment changes effect energy efficiency or even energy cost?

The other critical power analysis facing mission critical sites is arc flash. Driven by safety requirements and increasingly critical to operations, not only is the arc flash possible now to model in real time, but changes to the site can be modeled to reflect how these changes might affect the National Fire Protection Association–Institute of Electrical and Electronics Engineers (NFPA-IEEE) safety requirements.

Figure 12. PUE or DCiE in real time and reflect what if changes



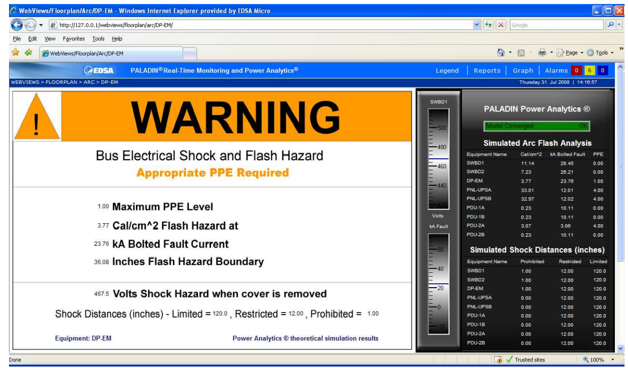


Figure 13. Arc Flash standards in real time because of the model based Power Analytics

Summary

Model-based analysis of complex systems has long been the preferred method of scientists, engineers, and managers. The ability to combine the expertise and work product from the initial design of a power system into daily operations creates a compelling and powerful systems approach to mission critical systems. If it makes sense to model an aircraft carrier or nuclear power plant to understand how it will perform in the real world, why not other mission critical systems? Now that possibility is a reality.

The combination of model-based management of a complex system and the model that originates from the original design objectives provides a powerful link to the overall value chain of design, build, operate. The accuracy facilitated by the model is the perfect platform for complex decisions necessary for energy management, availability management and forensics.

The practical impact of this is demonstrated in design accuracy and design time, commissioning, operations and maintenance, and overall customer satisfaction.

About the Author

As EDSA's CTO, Kevin Meagher is responsible for a wide range of product direction, business development and strategic planning. Prior to joining EDSA, Kevin was president of a boutique business consultancy 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 undergraduate degrees in biochemistry and business, an Executive MBA from the University of Colorado, and has completed doctoral work in Knowledge Management. Kevin also holds a Master Captain's License from the US Coast Guard and has a current commission in the US Merchant Marine.

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About EDSA

EDSA develops software solutions for the design, analysis, diagnosis, and preventative maintenance of complex electrical power systems. The Company's Paladin software platform has been used in thousands of commercial, industrial, governmental, and military applications worldwide, to protect more than $100 billion in customer assets. EDSA's two core products, Paladin DesignBase and Paladin Live ensure not only a *perfect-on-paper* up-front facility design, but also that—once constructed—the finished facility operates precisely as it was intended to, by constantly calibrating actual and as-designed specifications. As a result, users not only enjoy extraordinary facility reliability, but unprecedented energy efficiency as well. Headquartered in San Diego, the company maintains sales, distribution, and support offices around the world.

About the Uptime Institute

Uptime Institute is a leading global authority on data centers. Since 1993, it has provided education, consulting, knowledge networks, and expert advisory for data center Facilities and IT organizations interested in maximizing site infrastructure uptime availability. It has pioneered numerous industry innovations, including the Tier Classification System for data center availability, which serves as a de facto industry standard. Site Uptime Network is a private knowledge network with 100 global corporate and government members, mostly at the scale of Fortune 100-sized organizations in North America and EMEA. In 2008, the Institute launched an individual Institute membership program. For the industry as a whole, the Institute certifies data center Tier level and site resiliency, provides site sustainability assessments, and assists data center owners in planning and justifying data center projects. It publishes papers and reports, offers seminars, and produces an annual Green Enterprise IT Symposium, the premier event in the field focused primarily on improving enterprise IT and data center computing energy efficiency. It also sponsors the annual Green Enterprise IT Awards and the Global Green 100 programs. The Institute conducts custom surveys, research and product certifications for industry manufacturers.

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