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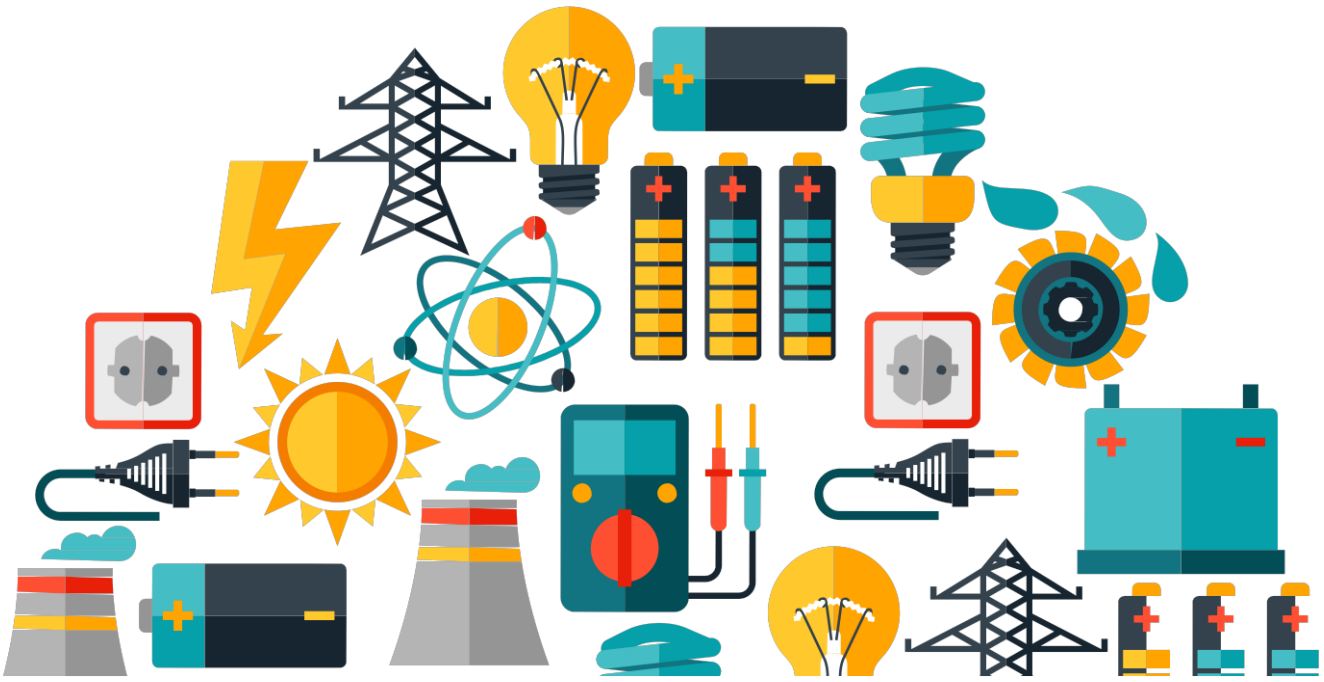
Microgrid Power Management System™

Power Flow Optimization with

Power Analytics Paladin®



POWER ANALYTICS™

Microgrid Basics:
Power Flow Optimization with the Power Analytics Paladin Microgrid Power Management System (MPMS)

The goal of any system operator—whether at a microgrid, utility, balancing authority, or RTO/ISO[i] level—is to optimize the power flow provided by the available generation assets. In the case of a microgrid, this function is particularly critical because of the disparate nature of the resources, the intermittency of the renewables, and the potential positive (or negative) impact the microgrid could have upon the macro electric grid. The spectrum of microgrid components can include, but is not limited to: diesel or natural gas microturbines, combined heat and power (CHP), wind generators, solar PV arrays, small hydro, fuel cells, battery storage, and load-provided demand response and energy efficiency. The optimal use of each of these assets, alone and in combination, requires real-time situational awareness that only a top-down, all-encompassing perspective can provide. It is the purpose of this paper to compare and contrast the typical hardware-driven solution for power flow optimization, provided by most vendors, with the overarching, real-time software-driven solution provided by the Power Analytics Paladin Microgrid Power Management System (MPMS).

Today, the most common method for optimizing the power flow of a microgrid in both stand-alone "island[ii]" mode and grid-interconnected mode is a hardware solution. Although different vendors may offer variations of this methodology, their approaches are similar. In general, each element of the microgrid is monitored and controlled by its own unique hardware controller, with hard programming (sometimes called firmware[1]) resident within the device. While the hardware controller controls the physical aspects of turning the microgrid element on and off, the firmware checks the element's "vital statistics" (e.g., voltage, frequency, circuitry health, etc.) and reports that information to similar control devices on all the other microgrid elements.

[1] Firmware is a software program or set of instructions programmed on a hardware device.

Under this hardware-driven mesh methodology, each microgrid element communicates with every other microgrid element and to the system operator's SCADA[2] system. The Ethernet communications backbone that connects the microgrid element controllers in this peer-to-peer mesh network theoretically creates "a unified power system." This system has no centralized control. Instead, status messages are passed from node-to-node and each element makes an autonomous decision to start, stop, or adjust its own operations, depending on what it hears from the other elements. This activity is driven by a pre-established set of algorithms (equations) or rules within each controller's firmware which communicate the critical aspects of the system and tell each microgrid element to act in a certain way. For example, if X occurs, do activity Y. *Does this methodology work?* Yes. *Does it optimize the power control?* Yes, at least under normal operating conditions.

Is there a better methodology? Yes. A better methodology would provide a real-time, top-down perspective of all potential variables, limitations, and contingencies which could impact system performance, such as—unexpected maintenance, bad weather, fuel shortages, and emergency conditions on the macro electric grid. This overarching perspective would permit the system to monitor conditions in real time, instantly respond to unexpected variables, and control microgrid element activity accordingly. **This real-time, situational awareness approach surpasses the use of pre-programmed logic, embedded in individual microgrid elements, which can never fully anticipate, react to, and support real-world situations.**

The Power Analytics Paladin MPMS is a real-time, model-based, optimization software solution that takes an eagle's eye view of the microgrid system, and the point of common coupling with the local utility, encompassing all of the current system capabilities,

[2] SCADA means Supervisory Control and Data Acquisition System.

constraints, limitations, problems, demands, market pricing, and any other random variable that might enhance, limit, or impact system performance. This software includes the Power Analytics Power System Optimization capability, which is an advanced Security Constrained Optimal Power Flow (OPF or SCOPF). Rather than relying upon pre-established algorithms to control the microgrid elements, the Paladin MPMS takes a real-time view of the entire system and directs the microgrid elements to respond appropriately.

How does it work? The Paladin MPMS considers all possible configurations of the microgrid elements and, with the juxtaposed goals of maximizing reliability and minimizing cost, determines the optimal microgrid configuration appropriate for the current moment. The Paladin MPMS derives this optimal configuration in seconds (real-time) by gathering current system status and running virtual iterations of optional system configurations, in comparison to the system's ideal "model" and in conjunction with any temporary constraints the system is currently experiencing. Within an instant, the optimal configuration is determined and deployed, and then the process starts all over again. **No other microgrid methodology on the market can do this.**

As an example of what the Paladin Microgrid MPMS can do, consider a day when the utility's transmission line to a microgrid community has an unexpected outage due to severe weather. The Paladin Microgrid MPMS immediately senses the outage and signals the microgrid's largest generating unit, a natural gas microturbine, to start operations. Since the price of natural gas is unexpectedly high, due to pipeline damage further upstream, the MPMS intends to start, and appropriately tilt, seven of the fourteen solar PV panels, which are not currently under maintenance, as soon as the clouds clear. Later in the day, as load on the system peaks, the MPMS knows to enable the commercial and residential demand response controls within the microgrid footprint, and to disable these

controls once the peak need diminishes. Because the list of hourly/daily contingent variables that can impact microgrid power flow optimization is infinite—the inherent inadequacy of the algorithm-based hardware controller solution is self-evident. ***The hardware controller solution simply cannot adequately or efficiently respond to real-time contingencies that impact power system optimization.***

We at Power Analytics are excited to bring you our superior, software-driven Paladin Microgrid Power Management System and are ready to demonstrate its extraordinary capabilities at our real-world microgrid deployments. Please call us to arrange a demonstration and to discuss how this product can dramatically improve the power flow optimization, economic dispatch, and long-term profitability of your microgrid.

[i] Independent System Operators (ISO) grew out of Orders Nos. 888/889 where the Federal Energy Regulatory Commission (FERC) suggested the concept of an ISO as one way for existing tight power pools to satisfy the requirement of providing non-discriminatory access to transmission. Subsequently, in Order No. 2000, the Commission encouraged the voluntary formation of Regional Transmission Organizations (RTO) to administer the transmission grid on a regional basis throughout North America (including Canada). It should be noted that not all regions of North America have RTO/ISOs.
[ii] Islanding refers to the condition in which a distributed generator (DG) continues to power a location even though power from the electric utility is no longer present.