The Coming Convergence, Renewables, Smart Grid and Storage

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A123 Systems (A123) is acting now to take advantage of complimentary advances in U.S. policy and commercial markets that are collectively enabling market entrance of beneficial technologies that will contribute to cleaner and more efficient electrical energy production, delivery and end-use. This paper provides an overview of the enabling policy, and a conceptual level overview of several near-term system applications of "smart" storage that take advantage of enabling policy and market structure advances. A brief illustration is also provided of the near-term opportunities to impart greater consistency across commercial tariffs and technical standards, to help the nascent energy storage industry offer our competitive options to the wider electric power industry and allow us to help meet national energy and environmental improvement goals.

KEY ENABLING U.S. POLICIES

Starting in 1978 with PURPA, there has been a deliberate and admirable progression of U.S. regulatory policy advances that have opened the provision of electrical services to 1) new resource technologies (including renewable resources, storage) and 2) new market participants (including independent power producers, load aggregators, and independent transmission owners). The sequence of policy progression and key market-evolutionary impact follows:

1) Federal Public Utility Regulatory Policies Act (PURPA) of 1978
2) Federal Energy Regulatory Commission's (FERC) Open Access Order 888 of 1996
3) Federal Energy Policy Act (EPACT) of 2005
4) FERC Open Access Tariff Revision Order 890 of 2007
5) Federal Energy Independence and Security Act (EISA) of 2007

Per the Department of Energy's (DoE) Energy Information Agency (EIA), "The single most important factor in the development of a commercial renewable energy market was the passage of the Public Utility Regulatory Policies Act (PURPA) in 1978. Among other things, PURPA encouraged the development of small-scale electric power plants, especially those fueled by renewable resources. The renewables industry responded to such incentives by growing rapidly, gaining experience, improving technologies and reliability, and lowering costs."[1]. Since PURPA, growth in renewable resource capacity has been significant in the U.S., going from essentially no grid-connected capacity to over 30,000 MW by end of 2007[2]. But, on a total resource basis, there is still significant room for growth. As a percentage of the over 1,000 GW of total generation capacity installed in the U.S., 30,000 MW represents less than 3% of total installed generation capacity.

In addition to providing the impetus for the commercial large scale renewable industry in the U.S., PURPA also contained key additional provisions that would later evolve to culminate in the aggressive end-user-interactive environment envisioned for the Smart Grid. Specifically, PURPA encouraged, and called for State regulators and non-regulated municipal utilities to consider "equitable" customer rates via pricing structures including Time of Use and Interruptible rates

FERC's Open Access order 888 provided the mechanism and frame work for new market participants to access wholesale electricity markets via the Pro Forma Open Access Transmission Tariff or OATT. With this market mechanism, non-traditional electrical market participants gained access to the shared electrical super-highway (the grid). This allowed transportation and delivery of competitively procured electrical energy products and related Ancillary Services (A/S) sold via open markets. The unbundling of A/S from provision of energy was a powerful evolutionary step to enabling today's participation of advanced storage devices to provide grid support. The unbundled A/S's originally listed in Order 888 are:

1) Frequency regulation
2) Operating reserves – spinning
3) Operating reserves - supplemental
4) Reactive supply and voltage control

[1] DoE EIA web article, "Renewable Resource Electricity in the Changing Regulatory Environment", Michael J. Zucchet, Sept. 6, 2002
[2] *"Renewable Energy Data Book", DoE EERE, Sept. 6, 2008*

5) Scheduling and dispatch services
6) Energy imbalance services

In general, most of the FERC jurisdictional Independent System Operators (ISO) and Regional Transmission Organizations (RTO) operate open bid day-ahead and real time markets for the first three listed A/S.

EPACT 2005 included provisions that have set key elements of the Smart Grid vision in motion. But first, what is the Smart Grid? According to the DoE Office of Electricity, functionally, it "offers valuable technologies that can be deployed within the very near future **or are already deployed today** (emphasis added)… In the short term, a smarter grid will function more efficiently, enabling it to deliver the level of service we've come to expect more affordably in an era of rising costs, while also offering considerable societal benefits – such as less impact on our environment."[3] EPACT 2005 set key foundational 'Smart Grid' elements by

1) Promoting consistency and defined functionality for interconnection of distributed resources,
2) Requiring time-based metering and two way communications between utilities and customers.

A key resulting action is the beginning of implementation of Advanced Metering Infrastructure projects by utilities across the U.S.

FERC Order 890 "Preventing Undue Discrimination and Preference in Transmission Service" gave direction to enable participation by non-generation resources in FERC-jurisdictional electric wholesale markets. This FERC action opens the door to the competitive participation of energy storage and demand response in FERC jurisdictional markets. While implementation of Order-890 and -890A are still on-going, several FERC jurisdictional markets, including the Midwest ISO, ISO-New England, PJM, and the California ISO are taking positive steps to include non-generation in their competitive A/S markets.

Finally, EISA 2007 gave definition to and direction on development of Smart Grid capabilities, and the oversight and reporting of industry implementation. EISA Title XIII Smart Grid section leads off with this statement of national policy. To quote Section 1301 of EISA '07 Title XIII, "It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid:

(1) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.
(2) Dynamic optimization of grid operations and resources, with full cyber-security.
(3) Deployment and integration of distributed resources and generation, including renewable resources.
(4) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.
(5) Deployment of ''smart'' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.
(6) Integration of ''smart'' appliances and consumer devices.
(7) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.
(8) Provision to consumers of timely information and control options.
(9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
(10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services."

In regards to reporting, EISA 2007 calls for formation of an advisory council that will report to Congress on status, and also make recommendations on additional action to remove barriers to implementation of the Smart Grid. To quote Section 1302 of EISA '07 Title XIII, "The Secretary, acting through the Assistant Secretary of the Office of Electricity Delivery and Energy Reliability (referred to in this section as the ''OEDER'') and through the Smart Grid Task Force established in section 1303, shall, after consulting with any interested individual or entity as appropriate, no later than 1 year after enactment, and every 2 years thereafter, report to Congress concerning the status of smart grid deployments nationwide and any regulatory or government barriers to continued deployment."

In addition to these market related policy advances, two policy advances with more of a technical flavor are worthy of note for their role in allowing new entrants to grid participation, including advanced energy storage devices, 1) FERC's Large Generator Interconnection Procedure (LGIP) and Small (20 MW or less) Generator Interconnection Procedure (SGIP) that provide consistent nation-wide interconnection rules for wholesale generators in FERC markets, and 2) IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems (IEEE 1547), which provides a framework and reference for

[3] "The Smart Grid: An Introduction, How a smarter grid works as an enabling engine for our economy, our environment and our future.", prepared for the U.S. Department of Energy by Litos Strategic Communication, 2008

consistency for smaller (10 MW and less) generator interconnection rules at the State & local municipal retail jurisdictional level.

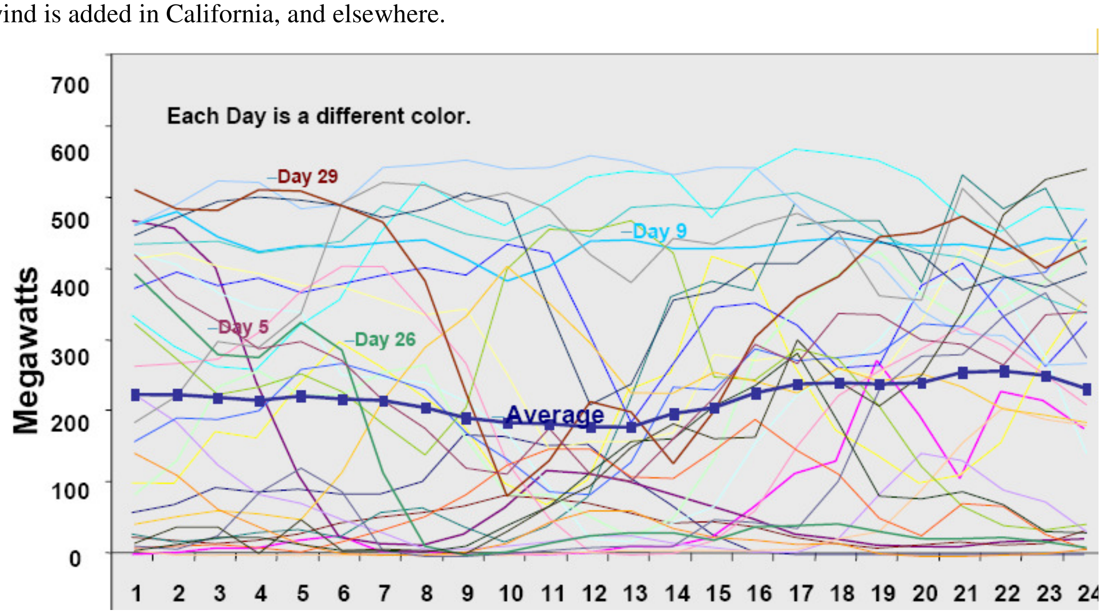
But for these policy advances, there would be not be commercial motivation, nor a pathway, for A123 to bring our advanced very fast acting (20 ms), and very-efficient (90%), storage technology to the "grid" to compete for provision of a cleaner, greener, more efficient, and more reliable, energy future.

EXISTING AND NEAR-TERM ENERGY STORAGE APPLICATIONS

With the clarity provided by existing U.S. Market and Interconnection rules, we are actively working with a developer that is deploying advanced energy storage systems using A123 batteries for the provision of wholesale market A/S, specifically, frequency regulation. Transparent and non-discriminatory FERC Interconnection rules and opening ISO markets allow pursuit of commercial (*not demonstration*) deployment of our 2 MW 500 kWh Hybrid-Ancillary Power Unit. Using our Nanophosphate™ Li-ion battery based storage systems, provision of A/S can be cheaper and cleaner compared to provision of A/S with conventional fossil-fired generation.

The technical capabilities that we have achieved with our H-APU to deliver A/S market services are extensible to additional wholesale market grid services, such as black start service, and future integration of intermittent renewable resources. Another appealing aspect of these targeted next-step capabilities/products is that existing U.S. wholesale markets and/or the participating stakeholders are the same as those engaged in existing A/S markets. So from a policy standpoint, the concept of extensibility from existing to future services may apply too.

Two aspects of the renewable energy related activity in the U.S. motivate A123 Systems to explore application of our storage solution in concert with renewable resources, 1) numerous State-level commitments to increasing renewable resources via Renewable Portfolio Standards (RPS), and 2) the intermittent nature of the number 1 developable renewable resource, wind. Numerous states have codified their commitment to adding renewable energy. The most aggressive RPS being California's legal requirement of using renewable energy to serve 20% of retail end-use energy by 2010. The intermittent opportunity for storage is best illustrated graphically. The following graph[4] contains overlapped traces of wind generation at California's Tehachapi wind area over numerous 24 hour periods within one month of recorded data. This will be an operational challenge as more wind is added in California, and elsewhere.



One of the identified means of mitigation for this intermittency is incremental addition operating reserves[5]. To the extent storage already participates in operating reserves markets, storage will have a role in positively supporting the future addition of more wind generation in California and other markets with similar operational challenges.

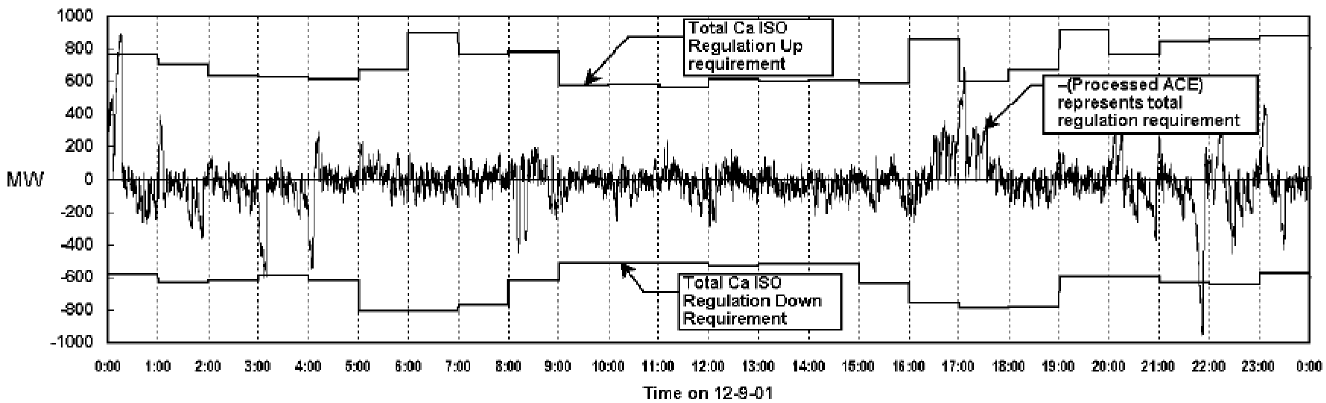
[4] "Renewables and Demand Response and their Impact on Operational Requirements", presentation, CAISO External Affairs, August, 27, 2007
[5] "Integration of Renewable Resources, Transmission and Operating Issues", CAISO Report, November 2007.

NEAR TERM OPPORTUNITY – INCREASE CONSISTENCY AMONG TARIFFS AND STANDARDS

Accessing and using desirable technology to help the wider industry reach various grid-of-the-future targets will be accelerated by removing unnecessary and/or unintentional barriers in existing market rules and technical standards. Two example cases are presented below to highlight the existence of inconsistencies that could hamper commercialization of technically credible emerging grid-supportive technologies. Each "case" concludes with suggested topics for consideration of further investigation.

CASE 1: DECOUPLING CAPACITY AND ENERGY for FREQUENCY REGULATION A/S

Currently there are inconsistencies across ISO markets operating under the same FERC 'Open Access' rules in the amount of energy that must be associated with capacity used for frequency regulation A/S. For example, the CAISO currently requires 1 hour duration, and the MISO has a proposed Tariff revision that has no minimum energy requirement/duration for storage-based providers of frequency regulation A/S. To illustrate the decoupling of capacity and energy in the actual provision of frequency regulation the following graphic is provided. As shown in the following graph[6], the actual expended energy over the sample day's worth of dispatched frequency regulation capacity oscillates around zero, numerous times, each hour.



If all FERC jurisdictional markets conformed to a minimally restrictive Tariff implementation as being developed by the MISO, it would be maximally inclusive to a wider range of non-traditional but beneficial resources such as flywheel energy storage systems and some advanced battery technologies. In fact, other capabilities not recognized by current markets, like very fast millisecond-scale ramp/response rates and high-cycle (thousands) capacity of flywheels and some advanced batteries, may be found to have greater relevance to providing frequency stability to the grid, versus the current typical Tariff focus on ability for extended energy output for provision of some A/S.

The evaluation and mapping of desirable expanded capabilities of new resource technologies against operational needs within grid markets is a recommended area for further investigation within industry-level forums such as the IEEE.

CASE 2: CONFORMING INTERCONNECTION STANDARDS FOR GRID-SUPPORTIVE FUNCTIONALITIES

Currently the interconnecting equipment for our stationary storage product is tested to UL 1741, and thus conforms to IEEE 1547. IEEE 1547 commendably established industry-accepted core functionalities that assure minimally acceptable safety to the grid and grid operators. With this assurance, a single consistent interconnection standard could be established, and is now widely referenced and used nation wide. Complying with one standard, referenced by numerous State and local jurisdictions, is very business friendly.

The safety-oriented core functionalities defined in IEEE 1547 include anti-islanding, which mean that a compliant device will disconnect within a specified time when the grid experiences defined levels of voltage or frequency excursions. But, there are requirements associated with wholesale interconnection that require ride through, i.e. staying online for a specified minimum duration through defined levels of voltage and frequency deviation. For example, the Western Electricity Coordination Councils' standard for generator ride through specifies continuous operation if system frequency is above 59.4 Hz. BUT, IEEE Std. 1547 calls for triggering of anti-islanding disconnection at 59.8 Hz. If a developer connects a relatively small project at distribution level, but wants to participate in provision of wholesale services, a conflict could arise. Currently, this may be a relatively rare interconnection scenario and could be dealt with on a case-by-case basis. But eventually, the Smart Grid envisions expanded participation of grid-interactive devices working in concert to improve reliability.

[6] "Vehicle-to-Grid Demonstration Project: Grid Regulation Ancillary Service with a Battery Electric Vehicle, Final Report", Figure 10, Alec Brooks, December 10,2002

We suggest that further technical investigation is warranted, now, at the industry-level/IEEE to determine how core safety functions are maintained, while also better realizing more grid-supportive capabilities such as ride through and voltage regulation from distributed resources.

AUTHOR'S BIO

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