Hi-MW Electronics – One key to a Future Grid which is Smarter, Greener, more Robust and more Reliable

It is hardly controversial to assert that the fundamental Generation, Transmission and Distribution technology of the US Grid has been relatively unchanged over the last century. As we enter an era of increased renewables, metering, instrumentation, communication and computation applied to the Grid there are some intriguing choices in front of us that can lead to a wide range of outcomes. If these new technologies, particularly renewables, are introduced on the path that has been followed to date they will likely lead to a significantly less reliable grid than we have today, and while large quantities of clean energy may be generated, as non-dispatchable resources they will not save any capital spending on conventional generation technology and will not significantly impact the use of inefficiently operated fossil fuel plants as spinning reserves. Conversely, a different path to grid integration of renewables and the use of these resources to control real and reactive power flows on the Grid, could lead instead to an enhanced Grid in terms of reliability, dynamic stability and efficiency. The key is the utilization of the potential of the Hi-MW electronics that will interconnect the renewable resources to the Grid.

A group of Market Development and Technical leaders have been meeting as the "Hi-MW Working Group" for the past several years, with focus on developing a Roadmap to achieve high penetration of high power electronics into the US Grid. This work grew originally from the realization that any coal gasification efforts, in the Clean Coal initiative, would lead to large quantities of hydrogen, possibly 20% of the power plant rating, that could in turn power large fuel cells which would need to be interconnected through appropriate electronics at the Transmission level, whether ac or dc. As wind and particularly solar PV generation has ramped up, this original thrust towards power electronics has only become more relevant. The subsequent NIST hosted workshops and road-mapping effort has focused on:

- Advancing Power Electronics for large scale grid integration of Alternative Energy Generation sources, particularly Fuel Cells, Wind and Solar PV, focusing on cost, performance and Controllability (by Utilities)
- Power Systems Architectures and Control for hi-penetration of Intermittent Renewables, with hi-MW electronics as the key mitigation mechanism for system disturbances
- Modification of regulations and standards to avoid the difficulties encountered with hi-penetration of renewables in Europe, where tripping of Inverters under moderate Grid transients caused major problems

The road mapping effort has brought together representative of the key Utility and Industry stake holders in addressing the fundamental barriers to successful application of MW scale Grid-connected electronics and the future acceptance and adoption of the same. One particular focus has been to lobby for changes of the IEEE-1547 voltage and frequency trip specifications to avoid the cascading blackouts that Europe experienced in the summer of 2004. At this time these trip points for Grid power electronics are too tight, are orders of magnitude tighter than for conventional thermal power plants, and have the effect that the Inverters trip off at exactly the time they are needed which is when a disturbance has been caused by either a fault or a Power Plant tripping off. This is a fundamental barrier to a high level of penetration of Renewables, and wherever a high penetration has been achieved the Utility concerned has waived compliance with the standard. Post event review of the U.S. Northeast blackout of 2003 also identified lack of dynamic VAR resources as a contributing factor to that major outage. While the frequency-instability on the Eastern Interconnect that led up to the final blackout does not completely support this view, Hi-MW electroncs can play an important ancilliary role as dynamic VAR machines. Another activity has been to work on the effects of intermittency by achieving acceptable ramp-rates under the control of the local Utility, through their SCADA system, to avoid destabilizing the local grid.

Inconsistencies across technical standards also mutes uptake of new technologies and their associated benefits. An example is the inconsistency between anti-islanding requirements of IEEE 1547 and the ride-through requirements of wholesale interconnection standards (FERC Large Generator Interconnection Procedures, LGIP). Large wind projects have been the first to exceed the FERC LGIP threshold (>20MW) and have had to incorporate ride-through capabilities. Other renewable projects that are inverter-interconnected will also be increasingly deployed at these larger magnitudes. Building Hi-MW inverters for multiple and sometimes conflicting technical criteria is not efficient. “Harmonization” of these and similar inconsistent standards will foster smoother transition of renewable technologies that will be evolving to deployment at much larger magnitude, connected to the grid as large wholesale generation projects.

With the excitement around the imminent investment into the “Smart Grid” with attention extending beyond demand-response and metering programs and now also been paid to high-penetration of renewables, and of advanced Power Systems architectures such as Micro-Grids, the Hi-MW activity seems to offer some pointed solutions. The Grid is almost purely an electro-mechanical device with the electronics distributed on the edge of the grid, and largely the consumption edge at that, in the form of meters and instrumentation. Power Electronics connected to the grid in large amounts, as the gateways for alternative energy sources, offer the ability to switch and control power at speeds that are many orders of magnitude faster than today’s grid connected switching and protection devices.

Our vision is of a Future Grid that incorporates renewables as Dispatchable resources, often in Distributed Generation environments where they can form vital components of grid-interactive microgrids. This Future Grid is demonstrably more rugged, reliable and robust than today's Grid with significantly higher 9's of availability, is significantly greener, also significantly more efficient and more secure. One key element of this future is the physical layer of the grid, long taken for granted, which must move to be more electronic and so higher speed and more flexibly controlled than the synchronous generators and exciters of today. But, without proactive steps by industry during this major transition period, implementation and delivery of these demonstrable benefits are not assured.

As we examine the major outages of the recent past we find a common negative theme, excessively slow response time. Instabilities with frequencies significantly longer than 1 sec, lead eventually to complete system collapse because there is nothing on the Grid capable of responding. A moderate amount of grid connected power electronics can and will change this dynamic and we believe that the hi-MW group can join with others in bringing this capability forward in a timely manner.

Hi-MW Working Group
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