Executive Summary

High MW Electronics – Industry Roadmap Meeting

December 11th, 2009
8:30am – 3:00pm

Challenges to Growth of Grid Connected Electronics

Meeting Agenda

8:30 am	Al Hefner, NIST - Opening Remarks, High MW Roadmap Committee and NIST Host
9:00 am	David Prend, Rockport Capital - Barriers to Large Scale Grid Penetration
9:30 am	John Lushetsky, DOE Solar Program, Program Manger
10:00 am	Colin Schauder, Satcon, Satcon Fellow - Isochronous Grid through Electronics

10:30 – 10:50 am Break

10:50 am	Jeffrey B. Casady, SemiSouth – Recent Advancements in SiC Power Devices and the Impact of Normally Off SiC JFET's on PV and Wind Inverter Platforms
11:20 am	Jerry FitzPatrick, NIST - Smart Grid Interoperability
11:40 am	Al Hefner, NIST - Energy Storage and Priority Action Plans for Smart Grid Interoperability

Noon – 12:45 pm Lunh

12:45 pm	Charlie Vartanian, A123 - Storage, Smart Interfaces for Frequency Regulation and Beyond
1:15 pm	Madhav Manjrekar, Siemens – Green Energy and Power Systems
1:45 pm	Le Tang, ABB, - Smart Grids and Power Electronics
2:15 pm	Kevin Tomsovic, University of Tennessee – Power System Control Issues for Renewable Integration
2:45pm	Concluding Remarks
3:00 pm	Adjourn

Summary of Key Presentation Points

This summary highlights the key points made by each of the individual presenters. Readers are encouraged to view the individual presentations to obtain additional details. Attachment 1 contains a list of meeting attendees

Al Hefner, Opening Remarks, High MW Roadmap Committee and NIST Host

David Prend, Rockport Capital - Barriers to Large Scale Grid Penetration

- The technologies needed for the "smart grid" currently exist
- Based on the experience in other nations (i.e. Spain, Germany) significant increases in market penetration by renewable generation are possible
- The real problem is demand and financing
- Learning curve experience results in significant cost reduction – (i.e. - for every doubling of cumulative capacity, the cost of wind power decreases by 10%)
- Conclusions
    - Deal with demand side and supply will be there
    - Focus on institutional barriers rather than technical barriers

John Lushetsky, DOE Solar Program, Program Manger

- As cumulative installed capacity has increased, the cost of modules based on crystalline and amorphous Silicon and Cadmium Telluride cells have all decreased significantly
- In 2008, California alone installed 158 MW, exceeding the 150 MW growth achieved by entire U.S. in 2007. Outside California, annual installations grew 83% in 2007 over 2006.
- DOE's Office of Energy Efficiency and Renewable Energy accounts for almost 40% of early-stage Cleantech funding
- DOE is funding the development of SEGIS (Solar Electric Grid Integration System) which is focused on new requirements for interconnecting PV to the electrical grid, including intelligent hardware that strengthens the ties of smart grids, microgrids, PV, and other distributed generation.

Colin Schauder, Satcon, Satcon Fellow, - Isochronous Grid through Electronics

- Electronic generators began service in the 1990's as parts of other equipment types for VAR generation, voltage support, flicker reduction, transmission line power flow control, power oscillation damping, and underwater and underground power transmission by cable
- Connected to DC generators, these same designs could serve as very high performance AC generators for the grid
- The capability of an electronic generator could be used for grid control by

emulating a conventional synchronous machine generator in a conventional AC interconnection or establishing an isochronous AC interconnection area under electronic control
- Electronic generators can be used to maintain constant grid frequency, instantaneously absorb real and reactive load/generation differences, provide DC inter-ties for stable power exchange with other AC grid segments, and respond rapidly to control center commands through secure high-speed communications
- The challenges for proponents of utility-scale electronic generators are to achieve high reliability and availability and develop/incorporate suitable energy storage

Jeffrey B. Casady, SemiSouth – Recent Advancements in SiC Power Devices and the Impact of Normally Off SiC JFET's on PV and Wind Inverter Platforms
- SemiSouth SiC (Silicon Carbide) JFETs (Junction Gate Field Effect Transistors) can replace IGBTs (Insulated Gate Bipolar Transistors) and MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) for higher efficiency and higher frequency switching with power dissipation reduced by over 50%
- World record (> 99%) PV inverter efficiency has been demonstrated in the field
- SiC FET devices are suitable up to 3-4 kV, and are being released now

Jerry FitzPatrick, NIST- Smart Grid Interoperability
- Smart grid requirements - accommodate rapid growth in renewable energy sources such as wind and solar, empower consumers with tools to manage and reduce energy use, and enhance reliability and security of the electric system
- 20% of current grid capacity is needed to serve 5% of highest usage hours
- Combining electrical and information infrastructure to create a "smart grid" requires interoperability which requires reliable standards and validated performance
- The NIST role – n cooperation with the DoE, NEMA, IEEE, GWAC, and other stakeholders, NIST has "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems"
- Smart Grid Interoperability Panel, a public-private partnership formed in November 2009, is a permanent body which supports NIST in setting standards for U.S. smart grid, coordinates but does not develop standards, with over 360 founding member organizations

Al Hefner, NIST - Energy Storage Priority Action Plans for Smart Grid Interoperability
- The current US grid delivers 60 Hz uni-directional AC power produced in large central plants by rotating machines
- As the amount of intermittent, renewable (wind and solar), distributed power generation increases, and the demand side changes to include electric vehicles the character of the grid must change
- The new "smart grid" paradigm requires advanced, high megawatt, cost-effective power conditioning systems
- Meeting energy storage and cyber-security issues is a major challenge

- Development of standards is an enabling requirement
- NIST and the Smart Grid Interoperability Panel will guide and oversee progress on Priority Action Plans (fourteen are currently being developed)

Charlie Vartanian, A123 - Storage, Smart Interfaces for Frequency Regulation and Beyond

- PCS capabilities for full grid benefit include Steady State W power transfer plus:
  - Steady State VAR, *voltage reg.*
  - Transient W, *a/c stall barrier*
  - Transient VAR, *sag mitigation*
  - Dynamic W, *damping, inertia*
  - Dynamic VAR, *voltage stability* \Islanding, *reliability*
- Battery energy storage with frequency response capability is technically reliable today, but the barrier to wide-spread deployment is a viable investment recovery mechanism

Madhav Manjrekar Siemens – Green Energy and Power Systems

- Evolution to a Smart Grid:
  - From control generation and central control to distributed generation and distributed control
    - Penetration of renewables
    - Inclusion of energy storage
  - From load flow by Kirchoff's Law to load flow by power electronics
  - From manual switching, trouble response to automatic switching, anticipatory response with built-in intelligence
  - From periodic maintenance to prioritized, condition-based predictive maintenance

Le Tang, ABB, - Smart Grid and Power Electronics - Why Do We Need High MW Electronics

- A smart grid is the evolved system that manages the electricity demand in a sustainable, reliable, and economic manner built on advanced infrastructure and tuned to facilitate the integration of the behavior of all involved
- The major requirements of a visionary smart grid are
  - Capacity - Upgrade/install capacity economically and provide additional infrastructure (e-cars)
  - Reliability - Stabilize the system and avoid outages and provide high quality power all the time
  - Efficiency - Improve efficiency of power generation and reduce losses in transport and consumption
  - Sustainability - Connect renewable energy to the grid and manage intermittent generation
- Medium voltage variable speed drives are needed because
  - 60 - 65% of industrial electrical energy is consumed by electric motors
  - For each 1 USD spent to purchase a motor, 100 USD are spent for energy cost during its lifetime

    - Today, only 5% of these motors are controlled by variable speed drives
    - 30% of existing motors can be retrofitted with variable speed drives

- Smart Grid needs high MW electronics
    - Solid-state substation provides current switching, current interrupting current limiting, and transformer
    - Challenges include high reliability, low losses, thermal management/cooling, high switching frequency, high blocking voltage for direct MV connection, high power density/footprint, low cost

Kevin Tomsovic, University of Tennessee – Power System Control Research Issues

- Existing power control systems are:
    - Connected system built upon rotating machines with high inertia and relies on dependable patterns of consumption
    - Very little load is controllable, instead generation tracks daily load curve
    - System has been engineered to meet peak demands
    - Numerous central controls acting largely independently
    - Localized control schemes primarily for protection
- Needed system changes
    - A broader electric grid to include energy end use
    - Increased scheduling capability through local management for existing loads and the addition of new loads
    - New and reconfigurable transmission to improve source diversity
    - Provide effective storage through combination of fast-start units, PHEV's, low-level UPS, and utility-scale storage
    - A flattening of the control structure that replaces the traditional control strategies with simpler local controls operating within a more global context for the system
- Some potential topics for research in the area of control include speed of response, amount of response, need for new transmission and determining transmission limits in real time

Attachment 1

Registration List

High Megawatt Workshop
December 11, 2009
NIST Headquarters, Gaithersburg, MD

Name	Affiliation	E-mail Address
Abdallah, Tarek	US Army	t-abdallah@cecer.army.mil
Atcitty, Stan	Sandia National Laboratories	satcitt@sandia.gov
Bennett, Aaron	North American Electric Reliability Corp. (NERC)	Aaron.bennett@nerc.net
Biondo, Samuel J.	DOE-HQ (Retired)	sjbiondo@verizon.net
Biroschak, Ben	NEMA	Ben.biroschak@nema.org
Casady, Jeff	SemiSouth Labs	jeff.casady@semisouth.com
Casey, Leo	Satcon Technology	Leo.casey@satcon.com
Grider, David	Cree, Inc.	david_grider@cree.com
Johnson, Melanie	US Army CERL	m-johnson@cecer.army.mil
Kub, Fritz	Naval Research Laboratory	fritz.kub@nrl.navy.mil
Lesster, Laban E (Ted)	Satcon Technology Corporation	Ted.Lesster@Satcon.com
Litzinger, Kevin	Siemens	Kevin.litzinger@siemens.com
Lukas, Michael	FuelCell Energy, Inc.	mlukas@fce.com
Lushetsky, John	US Department of Energy Office of Solar, EE-2A	John.lushetsky@ee.doe.gov
Lynn, Kevin	Sentech, Inc.	Kevin.Lynn@ee.doe.gov
Manjrekar, Madhav D.	Siemens Corporate Research	madhav.manjrekar@siemens.com
Munro, James	Satcon technology Corporation	Jim.munro@satcon.com

Pierre, Joe	Siemens Energy, Inc. Stationary Fuel Cells	Joseph.pierre@siemens.com
Prend, David	RockPort Capital Partners	dprend@rockportcap.com
Price, Jack L.	ODDR&E, Research Directorate, Weapons Systems	jack.price@osd.mil
Reedy, Robert Martin	Florida Solar Energy Center at UCF	reedy@fsec.ucf.edu
Reidpath, Maria	US DOE / NETL National Energy Technology Laboratory	maria.reidpath@netl.doe.gov
Roettger, Thomas D.	Northrop Grumman	t.roettger@ieee.org or thomas.roettger@ngc.com
Schauder, Colin D	Satcon Technology Corporation	colin.schauder@satcon.com
Singh, Ranbir	GeneSiC Semiconductor Inc.	Ranbir.singh@genesicsemi.com
Soboroff, Mike	Department of Energy, Office of Electricity Delivery and Energy Reliability	mike.soboroff@hq.doe.gov
Stevanovic, Ljubisa	GE Global Research Center	stevanov@ge.com
Tang, Le	ABB Inc.	le.tang@us.abb.com
Tomsovic, Kevin	University of Tennessee - Knoxville	tomsovic@tennessee.edu
Vartanian, Charles	A123 Systems	cvartanian@a123systems.com
Wolk, Ron	Wolk Integrated Technical Services	ronwolk@aol.com
Wong, Joseph	DOE	Joseph.Wong@hq.doe.gov