Oak Ridge National Laboratory (ORNL)
Distributed Energy - Communication and Controls (DECC)
Meeting at ORNL on October 11, 2007
Summary of Discussion Items

October 23, 2007

The following are major topics of discussion at the recent DECC Meeting at ORNL and are under consideration by ORNL for enhancing the DECC R&D roadmap.

1. Input to Distributed Energy (DE) Standards Formulation

The DECC is laying the groundwork for the ancillary services including dynamic regulation of local voltage using reactive-power-producing distributed energy resources. The current standards, such as IEEE 1547, are not consistent with this approach because they prohibit local voltage regulation from DE. In actual practice, however, local voltage regulation could be a cost effective ancillary service for DE which provides the following benefits:

- Reduction in distribution system losses.
- Increase in margin to local voltage collapse.
- Improved power quality.
- Increased distribution and feeder capacity
- Reduced congestion on the transmission system and thus lower prices.
- Increase voltage stability for the distribution and transmission system
- Overall increased power system reliability

At present, individual utilities can allow local voltage regulation at the point of common coupling (PCC) although the IEEE standard does not. One of the key issues is the response time of the DE's control system which can be much faster than conventional voltage regulation devices. DECC can address the issue of regulating voltage on the DE side of the PCC and the impact on utility voltage. Distribution voltage regulation response is often in the range of 30 to 40 seconds so the fast response from DE is what concerns distribution system engineers. There should be an optimal response time which ensures no interaction with utility devices and also provides control stability. Simulation and testing is needed to ensure optimal control settings that will provide rapid voltage regulation, damp out rapidly and not cause oscillation of other power equipment.

DECC could provide analysis and test results to guide a revision of 1547 to allow for local voltage regulation under the direction of the local utility, such as through the use of a voltage schedule. ORNL could (1) attend and present at IEEE committee meetings on relevant DECC analysis and testing results, (2) conduct tests at DECC to assess the interaction of dynamic voltage regulation with conventional voltage regulation systems (3) investigate appropriate

response times for the DE controls to ensure rapid response while provide adequate damping, (4) develop reports and papers that can be presented and provided to the IEEE for incorporation and modification of existing standards and (5) conduct specific tests and analyses to respond to IEEE comments and feedback.

2. Development of Field Deployable DE Controls System

The integrated instrumentation and controls system of the DECC sets the stage for a field-deployable automation system for voltage regulating distributed energy devices. Currently, the DECC inverter control is unique in that the ORNL has developed an integrated platform for data acquisition and analysis, controls development and testing, and real-time control of the DE. The platform is extremely flexible using the dSpace software and hardware platform interfaced with Matlab/Simulink and its Real-Time Workshop. Currently, the control system is a mixture of manual and computer-activated controls and needs to be configured into an integrated control system design. ORNL could develop a field-deployable system with automated controls tied to the data acquisition and instrumentation system that can be implemented in field demonstrations on a utility system and ultimately be transitioned into in a production system. ORNL could (1) automate the DECC so that all voltage regulation controls can be activated from a computer or web via a layout or recipe file , (2) develop interfaces to integrate all of the hardware into the computer control, (3) develop software techniques for scheduling control and (4) document requirements of the field deployable system.

3. Power Electronic Equipment Ratings & Requirements for DE Reactive Sources

There are a number of rating issues associated with inverter operation for power system level applications. First, the inverter operating temperature can have a drastic impact on the rating of the inverter which is a function of the materials used and the heat sink design. Unlike power system equipment, such as motors, that have a rating that matches closely with how it can be operated, inverters normally have to be de-rated to ensure that the operating temperature of the components such as silicon-based IGBTs will not be overheated and fail. Furthermore, the rating of the inverters can drop drastically with the switching frequency. ORNL has first hand knowledge of an inverter failure –a 75A rated inverter failed at DECC while operating at 67% of its level. The inverter's over-temperature protection failed to protect it. Also the need to operate the inverter at 10 or higher kHz for controls stability drives up the operating temperature since the temperature increases exponentially with current and has a steeper slope with higher switching frequencies. In order to achieve anywhere close to rating, the air cooling of inverters has to be boosted to ensure against component failure. On another front, ORNL is exploring inverter packaging and materials for automotive inverters so that they can operate at higher temperatures and reach higher current ratings. However, the future for inverters for the automotive industry is to cool with fluids initially and eventually use under the hood air. Thus, manufacturers need to revise their inverter power ratings to come in line with the rest of the

industry. Furthermore, manufacturers need to provide adequate heat sinks for inverter cooling. These design and rating problems are typical for power electronic components. Another issue concerns the sensitivity of inverters to the power quality of the source signal. In outside testing, it has been noted that an inverter has problems operating when the timing of a nearby diesel-generator piston firing is slightly off. In the DECC testing, ORNL has noted that on some days, the inverter trips when AC interfacing is attempted with the ORNL distribution system. On those days, data measured at DECC shows there to be a high content of harmonics in the voltage when this happens. Relative to this issue, large fuel cell manufacturers are concerned about what happens when the fuel cell is islanded with local load due to a system problem and has to operate when it supplies power to potentially poor power quality loads. A standard should be developed for power electronic equipment that clearly describes the capability of the equipment for carrying rated levels of voltage and current and its sensitivity to power quality or capability to correct power quality. ORNL could (1) conduct testing at DECC to explore the sensitivity of conventional inverters to varying power quality, (2) characterize high temperature operating regions to provide information to packaging development and (3) prepare results and documentation on the issue of inverter rating for an IEEE Project Approval Request for an inverter standard.

4. Using Dynamic Reactive Sources for Correcting System Voltage Problems

Modern high efficiency air conditioners (A/C) use a small, low inertia motor. This motor has much lower starting torque than conventional A/C and is more susceptible to stall. The stall is when the motor continues to draw a high reactive current (6 to 10 times rated current) without running when the voltage is too low, such as below 0.6 per unit. There is a need to characterize and understand the following associated with these stall events: (1) air conditioner response to low voltage to characterize when a stall occurs, (2) the duration time of the stall event, (2) the effect of stalling other distribution system loads and motors, (3) the effect of compact fluorescent bulbs at low voltage, especially, since they can produce high harmonic content and poor power factor, and (4) the potential of the voltage collapse spreading from a local to a more system wide problem. Providing dynamic reactive support at the load rather than at the system (feeder, substation or primary) level can be a more effective and lower cost solution. Estimates are that a system level solution can cost 10 times the load-side solution. Also, the use of multiple distributed load-side reactive power support devices may offer greater flexibility than a single system-wide device solution. A further concern is the effect of very short and low voltage dips on modern loads. Southern California Edison has customers with motor controllers in industries that experience trips for very shallow dips of 4 to 5% of only a few cycles that are take their systems offline. When this happens during a process, it can have a significant economic impact on the industry in terms of cleanup and restart. The new compact fluorescent light bulbs use lower energy but have poor power factor and harmonic distortion which has to be compensated by the power system. There needs to be evaluation of what happen as they comprise a larger percentage of the load. Using distributed reactive supply and improving our understanding

allows us to look at a system-side solution. ORNL can (1) perform studies and tests to better understand the voltage effect on distribution system load and the load's effect on reactive power flow.

5. Communications for Dynamic Voltage Regulation

ORNL's strategy for DECC has been to develop autonomous, local voltage regulation control using dynamic reactive power producing DE. However, the proliferation of communications into the distribution system for automated metering is expected for the next few years and its later use for other automated distribution system functions. This expected growth in communications in the distribution system makes a case for ORNL to evaluate the benefits of less versus more communication between the DE and utility and between the DE and other DEs. It is recognized that at a minimum the DECC controls will achieve the goal of providing support to the system with absorbing/producing reactive power to lower/raise voltages per a voltage schedule. We want to avoid the type of proprietary and localized communication system available right now like the Encorp Goldbox which requires an Ethernet connection between all the DEs. Another associated aspect is the need for rapid fault detection so that the DEs don't feed a fault and interfere with system protection to interrupt and isolate the fault. Communications is going to be key for future distribution system operation and we need to guide our work towards flexibility and openness as more communications and sensor capabilities become available. ORNL could (1) assess the benefits of using less versus more sophisticated communication for implementing dynamic voltage regulation in the distribution system, (2) identify the roles for fast versus slow communication for the DE control actions, (3) coordinate opportunities between DEs and other advanced and smart sensors becoming available and (4) put some limited communication into the DECC facility starting with wireless communication to the 3000 substation to have the substation power factor available for voltage regulation and power factor correction controls.