Breakout Session 1
Report-out presentations

Technical Topic Session: Switchgear

Report-out Presentation

By: Dr. Robert Lasseter

University of Wisconsin

List of Non-Prioritized R&D Areas

1. Development of smart switch - Detect islanding condition; multiple DG inverters
2. Power electronic switch / DC or hybrid microgrid
3. Fast load shed requirements – one cycle
4. Coordination between inverter design and switch design. Dealing with high currents and speed of switch
5. Speed of switching to islanding – Aurora vulnerability
6. Neutral grounding? Architecture of protection systems
7. Detailed characterization of benefits of static switches versus simply using existing service entrance breakers
8. Trade studies on how to apply switches at different places

List of Non-Prioritized R&D Areas

9. Design guide for the selection of active vs. passive synchronization and impact on power quality
10. How does presence of battery storage affect switch technology?
11. Demonstrate benefits of microgrid without a circuit breaker/switches
12. Integration of generation – synchronization, harmonics issues
13. Protection – standard breaker curve protection is not adequate; short circuits never trip
14. Current limiting capability
15. Equipment for prioritized load shedding
16. Legacy grid-connection technologies – connect/disconnect from grid. How to drive cost out of this area? No communication with microgrid; does it communicate with DER/utility. Operational - fault current contributions; resources integration; timeline of life cycle for switch.

Research Areas that DOE Can Impact

- Legacy grid-connection technologies – connect/disconnect from grid
  - How to drive cost out of this area? No communication with microgrid; does it communicate with DER/utility?
  - Integration of functions
  - Achieve functionality without designating technologies
  - Operational - fault current contributions; resources integration; timeline of life cycle for switch
  - Long-term maintainability; reliability. Needs to work 20 years??
  - Converter interface in lieu of a switch may be a research area
- Information for end-users on needs; myriad of applications
- Define different topologies; Define requirements based on customer and utility needs
- DC microgrid/switch?

Legacy grid-connection technologies: Baseline vs. R&D Performance Targets

Baseline	R&D Target
Transition – time depends on customer requirements	• Not limited by visual disconnect • Must meet utility requirements at the switch (instead of generators) • Power quality • Protection issues • Seamless: ¼ cycle • Interoperability

Caveat: switchgear technology is mature

R&D focus should be on functionality & Cost

Specification & Requirements

Determine Functions

- Seamless Transition
  - ¼ cycle; ½ cycle to 3 cycles
  - Don’t collapse the microgrid
  - Depends on requirements of customer; based on loads
  - Undesirable transients; power quality – standards exist.
- Re-syncing
  - Voltage angle to sustain
  - Non-synchronous/DC
  - “Transient-free connection”

Doe Action Plan: R&D Activities

- DOE collect information on technical challenges
- Provide guidelines
- Share best practices
- Customer requirements

Technical Topic Session: Protection & Controls

Report-out Presentation

By: Mark Zeller

Schweitzer Engineering Laboratories

List of Non-Prioritized R&D Areas

Controls
1. Black-start controls for microgrid 2. Microgrid control architecture 3. Communication: technology, latencies, bandwidth - layered level with different response times; optimization at different levels. - predictive maintenance 4. Operation modes and transition: on-grid, islanding mode, islanding to on-grid 5. Cross micro-grid control – combination of many smart grids; points of common coupling 6. Use cases associated with microgrid information model – what info needs to be exchanged.
Protection
1. How to turn existing radial time current coordinated schemes into fast selective and sensitive transmission system 2. Depth of protection awareness 3. Achieve reliable, fast, cheap communications – latency issue 4. Back-up protection schemes 5. Define central-level protection functions 6. Dealing with faults – HIF, series

Research Areas that DOE Can Impact

- **Define best practices and specifications for protection and controls; information models**
  - Use case model. Pilots with DOE/DoD to develop use cases
  - Provide guidelines for multiple approaches
  - Leverage what works at transmission-level to distribution-level
  - Phased approach – "pre-standard research best practices"
  - Basic classification of protection approaches
  - How do we mitigate "re-engineering" microgrid protection
- **Develop reliable, low-cost protection**
  - Layered approach: 1st Level - fast, local decision; 2nd Level: Controls – how much load can we reduce, define minimal set needed, reconfigure load; 3rd Level: optimization
  - Data and latency based on the level
  - Re-think entire architecture
- Switches to handle full fault
  - Fault current limiting systems at point of coupling – truly transformational; may have significant benefits
  - How to design around the fault
- Make components that can handle fault current flow or detection systems; then system level control
  - Issue: Fault currents approaching load currents – high impedance fault
- Protection with new technologies

No baselines available

Technical Topic Session: Converters

Report-out Presentation

By: Shalom Flank

Pareto Energy

List of Non-Prioritized R&D Areas

1. Operational converter improvements: Harsh environments; Robust operation during fault conditions; Remote reprogramming; Parameterization; More rugged, reliable, improved overload; Remote diagnostics, prognostics (wear-out)
2. Next-generation inverter: Volume, weight, cost, efficiency (WBG, improved thermals) improvements
3. Advanced inverters as system elements
4. System yields; Ultra efficient DC/DC converters
5. Advanced concepts - Direct medium voltage inverter - transformerless - Integrated storage inverter - DC microgrid subsystems – should DOE focus on this? Data centers; renewable integration with offshore wind; energy storage; EV charging and EV fleet charging - Integration of transformer isolation function - Inverter control: synchronization, islanding

List of Non-Prioritized R&D Areas

6. Inverters as current sources are used today; they should also be able to run as voltage sources.
7. Dealing with coordination across multiple inverters.
8. Optimized operation of synchronous generators with multiple inverters.
9. Modularize standard inverter – use same inverter for EV, solar, etc. – AC/DC and DC/DC converters
10. Short term – develop an inverter that will last longer; ARPA-E ADEPT, SEGIS, PMMEP, CERDEC, ARPA-E hybrid energy module storage program; NAVSEA Long-term – sustainability – mitigate supply chain issues.
11. Build redundancy into inverters to increase life-time
12. Inverter topology to reduce number of components and passives.
13. Fault tolerance – control degradation of microgrid inverter - instrumentation of inverter - monitoring inverter health: determine failure signature (thermal)
14. Prevent capacitor failures; eliminate or reduce capacitors

Research Areas that DOE Can Impact (Multi-MW Systems)

- (19 votes) **Topologies & control algorithms for multiple inverters to run a microgrid**
  - Define functionality that is needed, avoid specifying approach
  - Combine multiple power sources – rotating machinery, inverter based, multiple (balanced) utility feeds
  - Control of multiple, smaller distributed inverters
  - Switching between voltage sources, master/slave (unique to microgrids?)
  - Operating mode – autonomous vs. grid connect vs. islanding
- (17 votes) **Advanced power electronic technologies**
  - Topologies for reduction of passive components (volume, cost, weight)
    - Switch and magnetic technologies
  - Multi-functional power conditioning systems including transformer function; DC circuits; multiple types of generators (including integration of small modular reactors)
- (8 votes) Develop systems and microgrid component model. Validate dynamic models; converter interface at the electrical connection and controller connection.
- (8 votes) Can we advance lifetime of converter technology for microgrids?
  - Understand failure modes
  - Determine and control degradation to improve life of converter

Topologies & control algorithms: Baseline vs. R&D Performance Targets

Baseline	R&D Target
• IEEE 1547 • Limited capability for multiple sources; custom designed systems	• IEEE1547.8 – ride through, volt-var, frequency, no user disturbance whether or not drawing from grid. • Integrate and control multiple co-located sources, multiple remote sources, multiple (balanced) utility feeds • Open architecture • Standardized control environment/ Uniform baseline package solutions; Easy-building block; best practices and standards for multiple systems integration

Advanced power electronics: Baseline vs. R&D Performance Targets

Baseline	R&D Target
• Every device has dedicated power converter; alternative approaches are developing • Switch & magnetic technologies: 1700V, 5-10Khz	• Integrate components so there are less of them • Enable new single power conditioning system with multiple functions (unique to microgrid applications) • Switch: 10-15kV; same frequency and higher efficiency (w/ 0.1% loss per switching level) Or 1700V; >50KHz

Caveats: Are other organizations doing this work?
Proof-of-concept vs. commercial?