Report-out Presentation

Breakout Session # 5: Transient State Control and Protection

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Total Participants ~ 10. Good mix of industry, academia and national labs.

Framing of the Topic

- **What is covered:**

Before, during, and after a system reconfiguration or a large source/load change. For example:

1. Disconnection from main grid
2. Resynchronization with main grid
3. Fault protection (includes fault detection, internal and external, microgrid helping asset protection as well as feeding back requirements to inverter manufacturers)
4. Source/load/microgrid-network connect/disconnect/change – planned
5. Source/load/microgrid-network connect/disconnect/change – unplanned (includes large changes in renewable sources)

Handled Transient Control and Protection together.

- **What is not covered**

1. Microgrid architecture
2. Microgrid communication architecture and protocol
3. Steady state controls
4. Chicago weather

Needs

- **What is needed and why**
  1. Autonomous smooth and reliable transition strategies
     - To ensure microgrid transition to the desired steady-state and maintain stability
       - Maintain voltage and frequency within acceptable limits (and trade-off between these and other such limits)
     - To provide uninterrupted power supply to sensitive loads and reduce SAIDI, MAIFI
       - Minimize load interruptions.
  2. Policy-driven needs, for example:
     - To best utilize distributed energy resources in transient response
  3. Microgrid protection to cover all conditions
     - To ensure safety of both equipment and personnel, under all microgrid operational conditions

Challenges

- **What are the challenges**
  1. Large change, low inertia, fast response
  2. Multiple DGs, including inverter based ones
  3. Variation of system configuration
  4. Variation of fault current directions and magnitudes
  5. Coordination of main grid, microgrid, DER and protection devices

Current Technology Status

- **State of the Practice**
  1. Microgrid technologies implemented in isolated cases
  2. Unidirectional overcurrent protection designed for on-grid operation

- **State of the Art**
  1. Fundamental functions fulfilled with distributed architecture, and some coordination of components and microgrid level control
  2. Microgrid system level control and protection functions being developed
  3. Conventional distribution system protection schemes – some are modified to work in islanding operation mode

1. Current Technology Status

- **Current Major R&D activities**
  1. DOE:
     - CERTS microgrid
     - SNL energy surety microgrid
     - ORNL microgrid on control, protection, and communication
     - Renewable and Distributed Systems Integration projects
  2. DOD:
     - GE microgrid demo at CA 29 Palms Marine Base
     - Microgrid enabled distributed energy solutions (Lockheed Martin)
  3. DOD and DOE co-funded:
     - Smart power infrastructure demonstration for energy reliability and security (SPIDERS)
  4. Outside US, pilots in Japan, Europe and few remote communities

R&D Scope

- **Description of the R&D scope responding to the challenges and needs**

1. Transient Control:
   - Modification of V and/or f control of DERs (including loads) during transients to include damping, and trade-off of stability limits
   - Improve dynamics of existing control and protection by using additional local and system- wide control and communication
   - Dynamic load control (including demand response uncertainties) beyond current UVLS and UFLS schemes and optimization/adaptive controls around it
2. Protection:
   - Develop new protection schemes/modification of existing schemes especially to handle system with high penetration of inverter-based assets (low fault capacity)
   - Develop ride-through capabilities and coordinate ride-through of all components in microgrid during events to achieve overall system level ride-through.
   - Adaptive protection with communication
3. Define impact of types of communication to support measurement, transient control and protection. Identify requirements like Interoperability, Latency, Bandwidth, Redundancy, Cyber-security and Survivability/reliability
4. Develop 3ph unbalanced dynamic stability analysis models for microgrids. Use it to develop a Reference Study for Transient Stability Analysis of Microgrids.
5. Validation of Standard Microgrid Component Models for Protection and Transient Studies

R&D Metrics - Milestones

- Define impact of types of communication and Identify requirements:

  1 year Study

- Dynamic stability analysis models and Reference Study:

  2-3 years Development. Validation could be planned with the items below.

- Transient Control:

  Lab Demo – 2 years, Field demo - 3 years

- Protection:

  Lab Demo – 2 years, Field demo - 3 years

- Demos should cover validation of Standard Microgrid Component Models for Protection and Transient Studies
- Integrated Demo of Transient Control and Protection Concepts in 5-7 years

R&D Metrics - Outcomes

1. Short term (3-5 years)
   - Technically mature, commercially available autonomous transition control and protection concept and products with the following capabilities
     - Establishment of system restoration criteria with defined voltage and frequency variation and duration
     - Uninterrupted power supply for critical loads
     - Improvement in reliability indices
     - Protection for internal and external faults and under all microgrid operation conditions
2. Long term (>5 years)
   - Drive down the cost of microgrid installation to clear $/watt target (excluding generation, energy storage, and their interfaces)
   - Compatible, scalable, modular, and plug-and-play products to make microgrid technology economically competitive for high penetration deployment
   - Commercial products that can effectively integrate and utilize large scale and amount of DER, energy storage, electric vehicles, responsive loads in distribution systems