Report-out Presentation
Session 6: Operational Optimization

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Notes from Day 1

Breakout Session 6: Operational Optimization

Research Topic A: Operational optimization of a single microgrid

"Mixed microgrids" – AC/DC and inverter/synchronous

Control definition suggestion:

- Primary control – fast, local control
- Secondary – controls shared with neighboring fast control loops
- Tertiary control - optimization

Research Topic B: Operational optimization of multiple microgrids

Framing of the Topic:
Operational Optimization of a Single Microgrid

- **What is covered**
  covers optimization of the microgrid in both islanded mode and grid-connected mode
- Determination of optimization objectives (reliability, economics, environmental, efficiency)
- What types of optimizations?: resource (dispatchable generation, energy storage)
- Discussion of optimization methods
- Optimization at a variety of time-scales
  - Real Time - time scale of the control loop (e.g. operations of a physical grid device)
  - near RT - within a factor of 10 of the control loop (e.g. next step in a state estimation – a few seconds to minutes – possible redispatch of resources)
  - Non-RT – hour to day ahead - including forecasting and anticipation of events in operations (e.g. weather, Demand Response actions, condition-based maintenance)
- Exchange of information for optimization decisions – how to get info to microgrid to improve optimization (collection of internal and external data)

- **What is not covered**
- Protection (Session 5, Topic B)
- Measurements
- Specific Protocols

Current Technology Status
Operational Optimization of a Single Microgrid

- **State of the Practice – what is in operations today**
  - Chevron Microgrid – week ahead forecast implemented in DERms
  - King Island (AUS) – optimized for reliability and economics
  - Kythnos – optimization of resources but not connected to larger grid
  - Burnstone Energy Center (Utica, NY) – optimization for reliability
  - CERTS- real-time operations of equipment for maintaining system stability, not optimization
- **State of the Art –**
  - Sendai – optimized for reliability
  - University Microgrids – IIT, Cornell
- **Current R&D activities – currently in the lab**
  - Universities – UCSD, FREEDM
  - DoD – Ft. Carson, HI-Power, 29 Palms
  - Utilities - Borrego Springs, Portland General Electric
  - National Labs – SNL (multi-objective optimization)

Needs and Challenges
Operational Optimization of a Single Microgrid

- **What is needed and why - to meet objectives**
- Objectives: Reliability, Economics, Environmental
- Multi-objective optimization techniques that can be implemented in near real-time (handle larger search space, less time, higher convergence)
- Non-linear stochastic optimal control - need to develop
- Push optimization toward real-time for controls
- Optimization of systems with both inverters and rotating machines
- Integration of systems with operational objectives
- Standard interface with external information/data for optimization

- **What are challenges**

  trade offs between computational time and certainty of optimal solutions
- Differential of the business case for microgrid and optimized microgrid
- Integration of microgrids that include inverter and rotating machines

R&D Scope
Operational Optimization of a Single Microgrid

- **Description of the R&D scope responding to the challenges and needs**
- New optimization techniques specific to microgrid operations (e.g. push toward RT control, address more complicated solution spaces,
  - Optimization of systems with both inverters and rotating machines
  - Multi-bus systems (e.g. AC/DC hybrids, multi frequency)
  - Characterize and validate with state and parameter estimation (check system health)
- New computation capabilities (e.g. IT horsepower, distributed computing, cloud computing, shared memory)
- Standard interface with external information/data for optimization – how to collect, store, clean, curate, analyze, and visualize data.
- Differential of the business case for microgrid vs. optimized microgrid
- Develop representative single microgrid case

R&D Metrics
Operational Optimization of a Single Microgrid

- ## Milestones

  ***Assuming FY13 start**

- Methodology for comparing fielded microgrids -baseline to optimized microgrid- operations to feed into a business case(for potential input into business case analysis). (FY14)
- Methodology validate on selected system (FY15)
- Demonstrate real-time and near-RT controls that incorporate optimization (FY15)
- Evaluation of a variety of optimization techniques as applied to microgrid operations – evaluated on a representative microgrid software test model (FY 17)

- ## Outcomes

- Demonstrate real-time and near-RT controls that incorporate optimization
- Evaluation of a variety of optimization techniques as applied to microgrid operations – evaluated on a representative microgrid software test model (session 4?)
- Methodology for comparing microgrid baseline to optimized microgrid operations to feed into a business case(for potential input into business case analysis).

Framing of the Topic:
Operational Optimization of Multiple Microgrids

- **What is covered**
  covers optimization of multiple microgrids in both islanded modes and grid-connected modes
- Everything that applies to single microgrids would apply here, but here are the additional topics for OOMMG
- Structure of optimization architectures around multiple microgrids (e.g. central, distributed, etc.) – control architecture may be covered elsewhere
- Scalability – is the optimization scalable

- **What is not covered**
- Protection (Session 5, Topic B)
- Measurements
- Specifications of Protocols
- Not covering microgrid architecture

Current Technology Status
Operational Optimization of Multiple Microgrids

- **State of the Practice**

  None

- **State of the Art**
- Denmark – Cell controllers
- Germany – Model City Mannheim (E-Energy)

- **Current R&D activities**
- SDG&E
- DoD - Global Energy Grid
- SNL – secure scalable microgrids
- NSF - FREEDM – Green Energy Hub – 1MVA - 5 SSTs

Needs and Challenges
Operational Optimization of Multiple Microgrids

- **What is needed and why**

  Method to negotiate objectives and optimizations between multiple microgrids (between different microgrid integrators)

- **What are challenges**
- Communications capabilities (interoperability concerns)
- Processing capabilities (too many nodes to do reasonable optimization – need to compartmentalize)
- Negotiating conflicting optimization goals (local vs. system wide)

R&D Scope
Operational Optimization of Multiple Microgrids

- **Description of the R&D scope responding to the challenges and needs**
  - Multiple microgrids with optimization
  - Communications between microgrids necessary to provide optimization (interoperabilty concerns)
  - Method to negotiate objectives and optimizations between multiple microgrids (between different microgrid integrators)
  - Processing capabilities (too many nodes to do reasonable optimization – need to compartmentalize)
  - Negotiating conflicting optimization goals (local vs. system wide)
  - Develop representative multiple microgrids case

R&D Metrics
Operational Optimization of Multiple Microgrids

- ## Milestones

  ***Assuming FY13 start**

- Methodology for comparing fielded multiple microgrids - baseline to optimized microgrid-operations to feed into a business case(for potential input into business case analysis). (FY15)
- Methodology validate on selected system (FY16)
- Demonstrate real-time and near-RT controls that incorporate optimization (FY16)
- Evaluation of a variety of optimization techniques as applied to multiple microgrid operations – evaluated on a representative microgrid software test model (FY 18)

- ## Outcomes

- Demonstrate real-time and near-RT controls that incorporate optimization between multiple microgrids
- Evaluation of a variety of optimization techniques as applied to multiple microgrid operations – evaluated on a representative microgrid software test model (session 4?)
- Methodology for comparing multiple microgrid baseline to optimized microgrid operations to feed into a business case(for potential input into business case analysis).
- Communications capabilities (interoperability concerns)
- Scalable processing capabilities (e.g. Outage Management System, data management)
- Ability to negotiate conflicting optimization goals between local and system wide