ENABLING TECHNOLOGIES FOR STUDYING MICROGRIDS

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Presentation at the NREL-CSU workshop on:
Increasing the Value of Microgrids through Focused RD&D
What Dan Zimmerle asked me to talk about

- Introduce the latest control and market approaches (e.g. multi-agent, AHP, etc.)
- Discuss enabling base technologies for μGrids and how microgrid application requirements differ from distribution or transmission requirements (e.g. protection systems, standards, etc.)
- Thoughts on coordination between generation and load
- Thoughts on how to reduce design costs up front and make μGrids robust to changes in loads and topology.
- Path forward
What is a microgrid?

- “A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources, which as an integrated system, can operate in parallel with the grid or in an intentional island mode.

- What it is NOT: One form of technology or a group of individual generation sources that are not coordinated.”

  Source: Taken directly from [2].
The **smart grid**

- Use of digital information and controls
- Dynamic optimization and cyber security of the grid
- Widespread deployment of distributed energy resources including renewable sources
- Use of demand response and peak-shaving technologies
- Deployment of smart appliances and technologies
- Providing customers with timely information and control options
Dichotomy? Similarity?

- Often, ‘μgrid’ and ‘Smart Grid’ are wrongly used interchangeably.

- View the μgrid as an enabling technology for realizing some of the mandates of the Smart Grid Initiative.

- “Think beyond the Smart Grid”
  - Again, wrongly Smart Grid is being portrayed as ‘smart meter’ installations!
  - The name Smart Grid may be gone but μgrid technologies will stay.
  - What will it be 20 years from now?
But, µgrid itself needs some enabling technologies

- Regulation (Not just $|V|$, $f$)
- Controls & Smart appliances
- Sustained funding
- Cheap power electronics
- Storage (energy & data)
- Pervasive DR programs
- Standards Policies
- Emerging studying techniques
- LMP and Retail market
- Risk-takers
- Comm networks

**µgrid enabling technologies**
Some thoughts on latest approaches

- Customer-driven microgrid
- Use of subjective controls in tandem with traditional approach
  - Analytic Hierarchy Process (AHP)
- Linking massively deployed DR to ISO
  - Multi-agent technology
- Delayed gratification (temporal information) of DR participation
- Hybrid systems
  - Navy’s all-electric ship
What are multi-agent systems?

- A group of agents (actuators, sensors, software) interacting with each other and their environment to attain a global goal while maintaining some purview over local objectives.
- Help define interactions between the individual elements of a system.
- Enabled by communication infrastructure.
- Must be robust!
MAS in Building EMS

Figure from [4].

Increasing the Value of Microgrids through Focused RD&D
Customer-driven μgrids

Increasing the Value of Microgrids through Focused RD&D

Inputs:
- 24 hr weather forecasting
- 24 hr local load profile
- 24 hr dynamic pricing for real and reactive power

Market and economics based control
- Analytic Hierarchy Process
- Markov Decision Processes
- Heuristic optimization
μgrids interacting with the transmission grid

Agents with markets and technical roles

Agents with sensors and actuators

Dashed lines indicate connections with more agents of same kind.

Figure from [6]
Navy’s all-electric IPS is a floating μgrid

Source: Center for Advanced Power Systems, Florida State University
Real-time hardware-in-the-loop (RT-HIL)

Figure from [7]
Simulation test beds are essential

Figure from [6]
...economics

Electricity demand growth

- Critical congestion area where near-term action is essential
- Congestion area of concern where additional analysis and information is required
- Conditional congestion areas where additional generation will introduce major problems
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The interconnected grid is NOT in ruins!

- But, microgrids have a value proposition
- We need to identify this clearly and then move forward
# References


