NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Power Systems
Engineering Center

Evaluation of Microgrid Controller Performance

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Overview

- Introduction to the National Renewable Energy Lab (NREL) – advanced microgrid research
- MIT LL test sequence and raw results
- Key Performance Parameters (KPP) analysis
- Proposed metrics for NREL/MIT LL microgrid challenge
- Request for audience feedback regarding tests/KPPs/metrics

Energy Systems Integration Facility (ESIF)

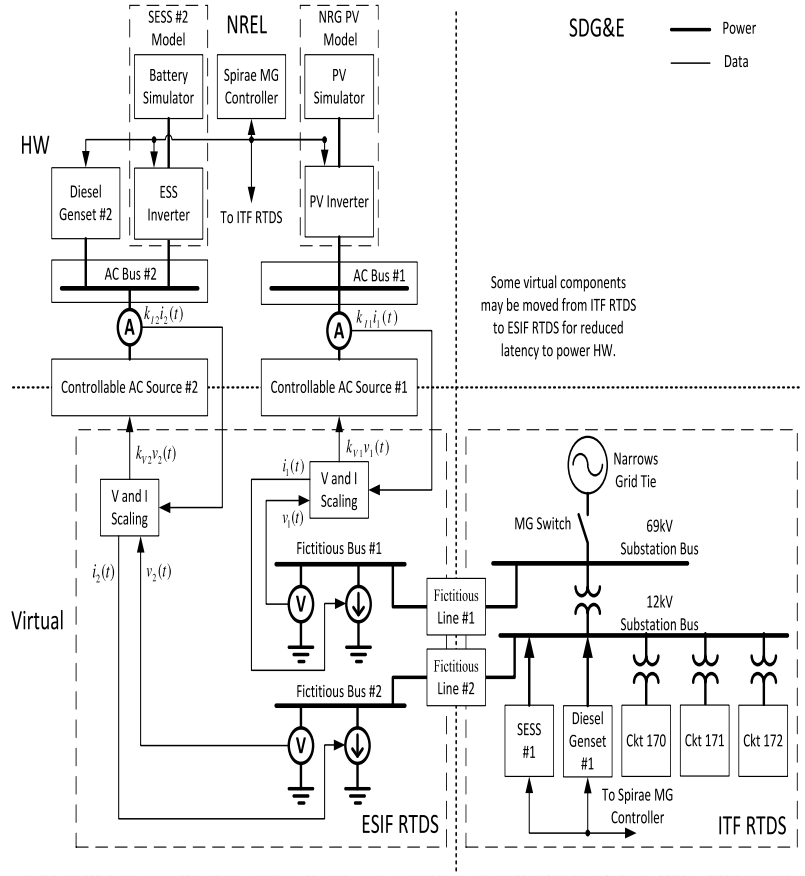
- NREL's largest R&D facility (182,500 ft^2 /20,000 m^2)
- Space for 200 NREL staff and research partners
- 15 state-of-the-art hardware laboratories
- Integrated megawatt-scale electrical, thermal and fuel infrastructure
- Peta-scale supercomputer and data analysis
- Interactive 3D advanced visualization

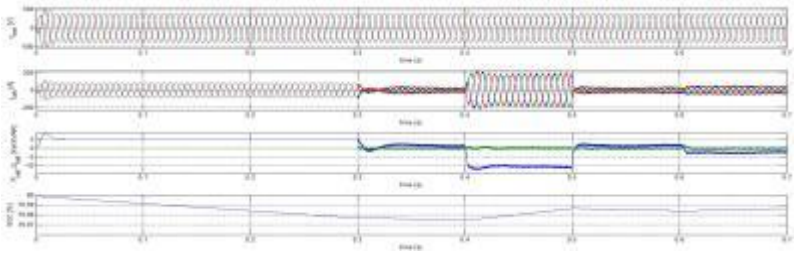
www.NREL.gov/ESIF

How Microgrids Can Improve Resiliency

- Help grid maintain balance
  - Can assist during instability events; help prevent collapse
- Self-heal distribution system
  - At user level, most outages are due to distribution faults
- Share area resources and prioritize critical loads
  - Combined inventory can better endure equipment failure(s)
- Integrate highly-variable sources as a STRENGTH
  - Manage intermittent PV, wind, etc to mitigate problems

Borrego Springs Microgrid Controller Evaluation



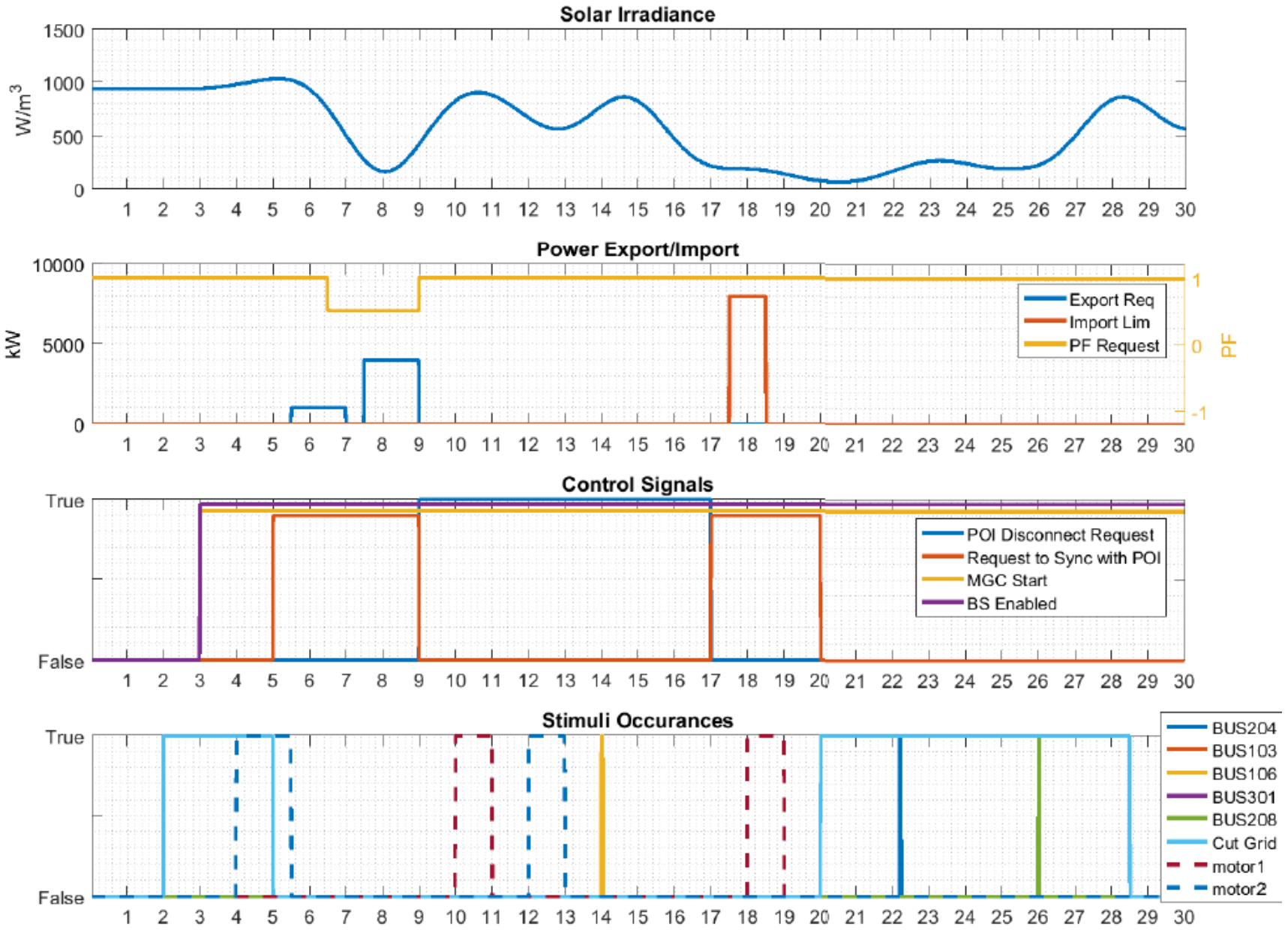


- Control hardware:
  - Microgrid controller
  - Genset controllers (2)
- Power hardware:
  - Battery inverter 550kW
  - PV inverter 550kW
- Remote hardware:
  - SDGE ITF

MIT LL Evaluation Test Sequence

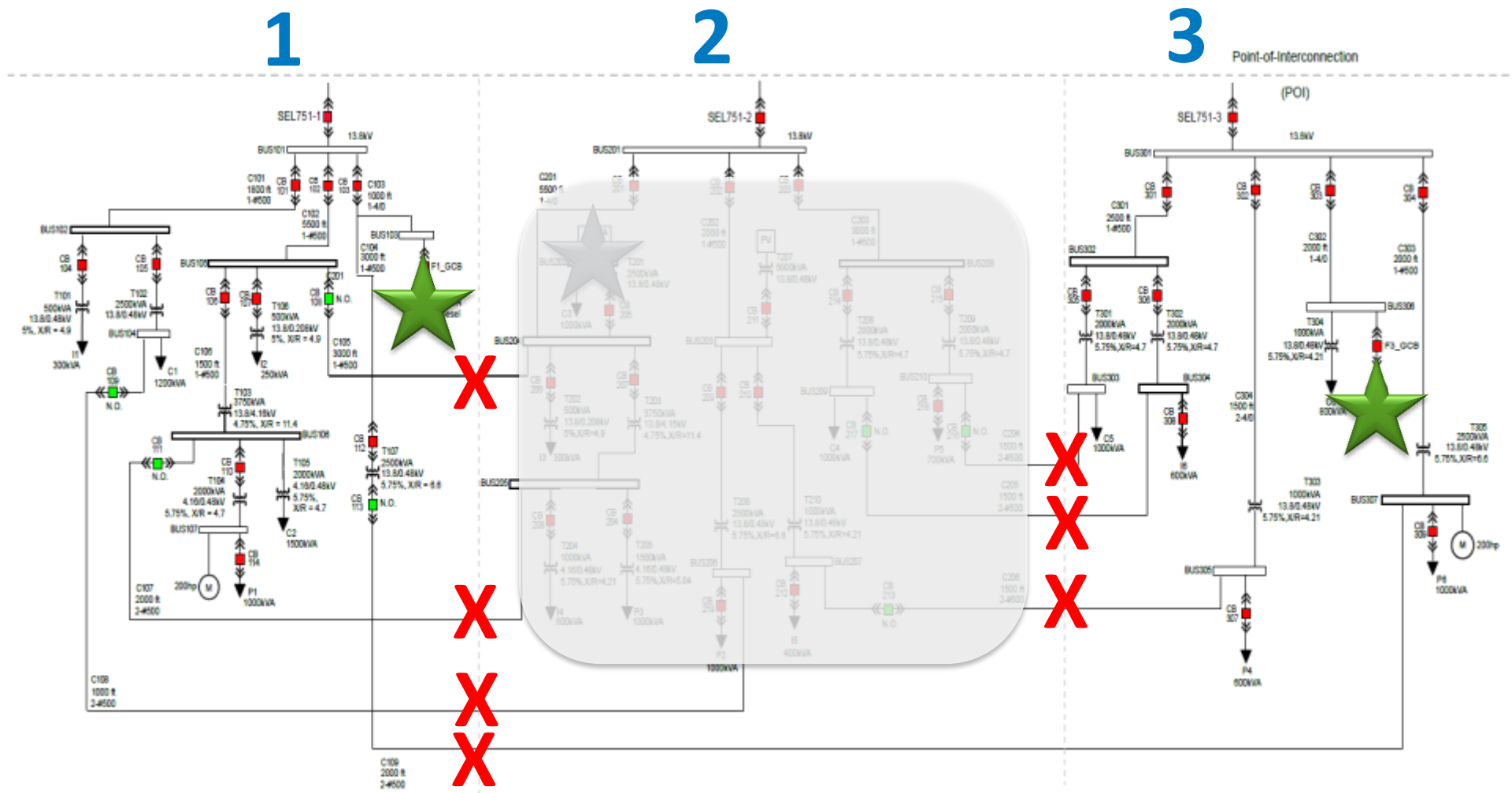
- Test sequence (depicted graphically on next slide) involves:
  - Large variations in load and PV; start/stop large motors
  - Faults on lines
  - Commands from DSO (disconnect, PF, DR, etc)
- Controller's objectives are defined in advance:
  - Serve critical loads and maximize renewables (always)
  - Minimize power losses (y, n)
  - Minimize fuel use (y, n) or emissions (y, n)
  - Minimize cost of electricity to end user (not yet part of test)

MIT LL Evaluation Test Sequence



Banshee Example

- How one case implemented the microgrid “island”



MIT LL Key Performance Parameters (KPP's)

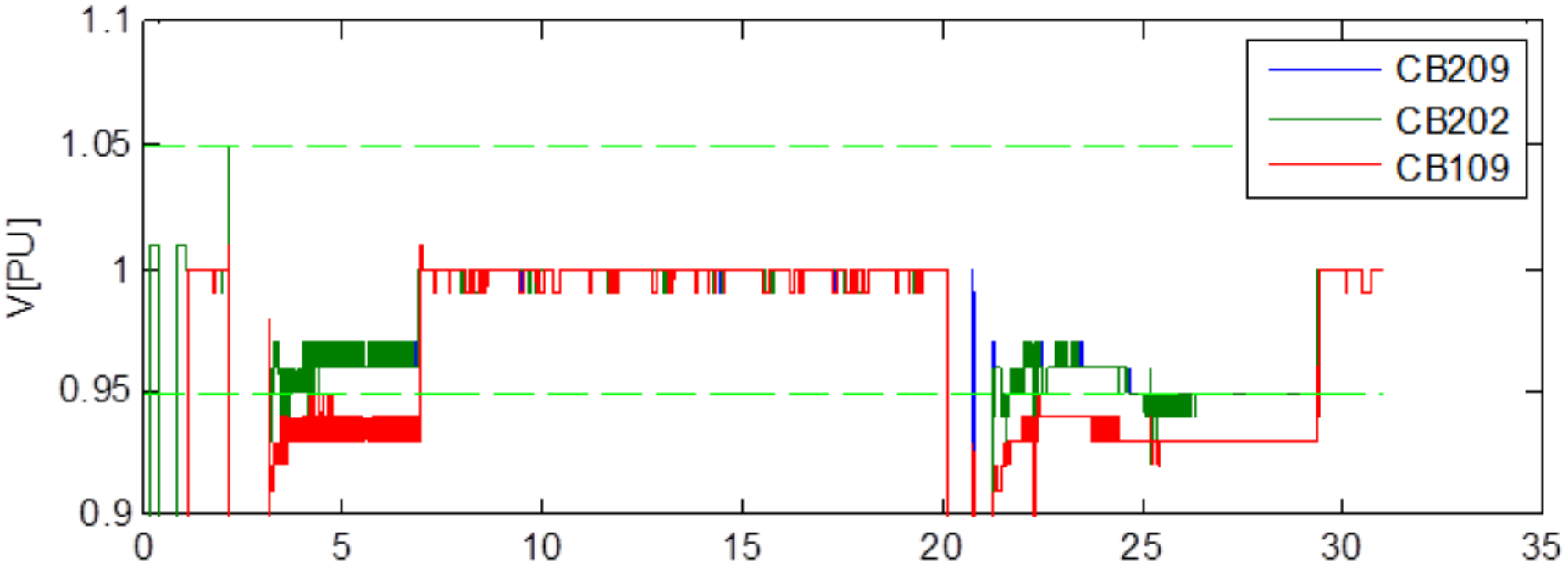
1. Load outage duration	User; operator; DSO
2. Fuel consumption	All
3. Survivability duration	User; operator
- Mutually exclusive w/ load served	
4. Interconnect compliance	DSO
5. DSO compliance	DSO; ISO; TSO
6. PV production	DSO; DER owner; IPP
7. Emissions	DER owner; IPP
8. Power quality	Society; policies

Results

	Case 1	Case 2	Case 3	Case 4
KPP1- outage duration:				
critical (% time)	18	38		
priority (% time)	76	56		
interruptable (% time)	70	73		
KPP3- survivability:				
genset (diesel gpm)	2.7	3.5		
CHP (NG m3/min)	9.3	12		
boiler (NG m3/min)	7.8	6.7		
KPP4- comply to DSO:				
exceeds contract (%)	0.097	0.098		
within contract (%)	3.2	3.3		
KPP6- PV production (%)	52	0		
KPP7- emissions (CO2 tons)	1.2	1.8		
KPP8- V not ± 5% (% time)	38	1.3		

Example of Voltage Sag

- Voltage sags occur when islanded
- VAR support (from PV inverter) was not used
  - Perhaps due to a status error or config error

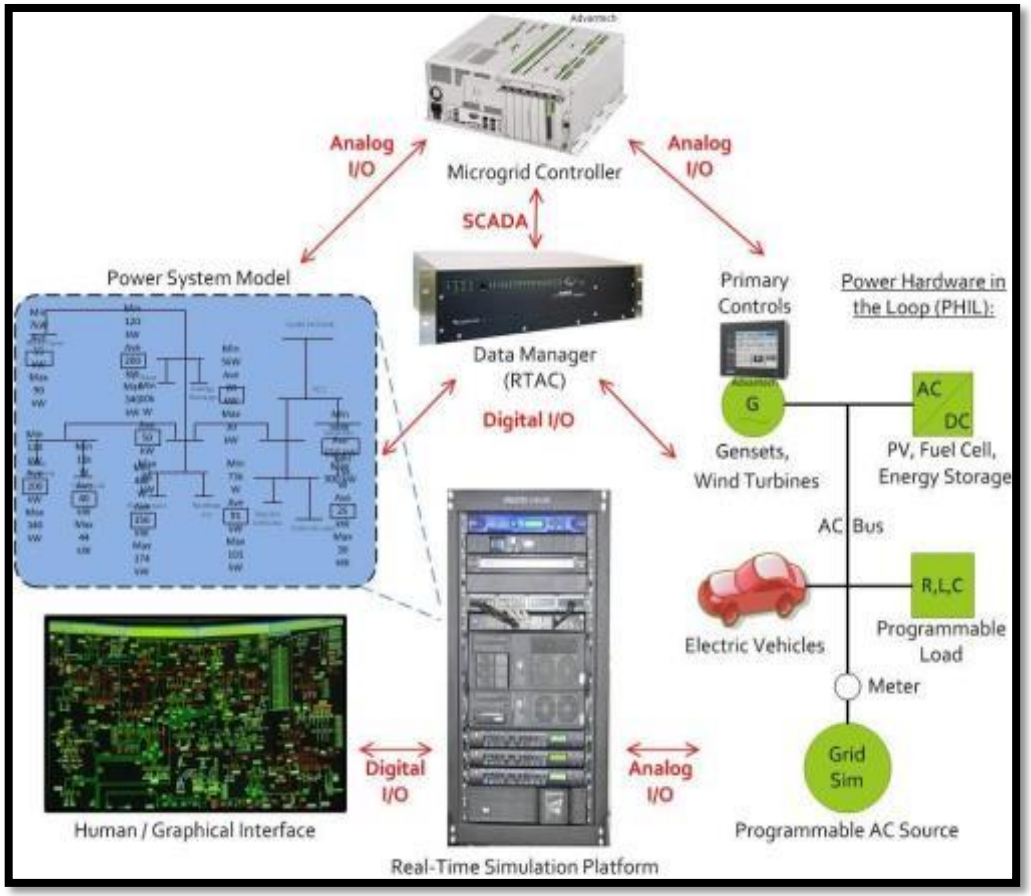


Microgrid Controller Innovation Challenge

Objectives: 1. Accelerate innovation in the microgrid controller market
2. Provide info to working group who will codify the 2030.8 standard

- Hosted by NREL with support from MIT LL
  - Incremental upgrades to testbed and EPHCC repository
  - Participant call in April

Challenges@NREL.gov



Proposed Scoring Metrics (More KPP's)

- Basic functionality (operate devices; comply with regs)
- Grid support (fast P or Q export)
- Resiliency (MW retained)
- Reliability (outage duration)
- Power quality (voltage and frequency accuracy)
- Cost-economic dispatch ($/MWh)
- Fossil fuel use (MMBtu/MWh)
- Renewable fraction (% by energy)

- Others? Fast load shed? Upward loading? Thermal storage?

Please email suggestions to Brian.Miller@NREL.gov

Thank you!

www.nrel.gov