

INTRODUCTIONS





MICROGRID TESTING

- Most Microgrids have two distinct operating modes which is a consideration for all testing protocols:
 - Grid Parallel (Normal Operation)
 - Grid Independent, aka: Microgrid, Island Mode, etc.
- Like all critical system, Microgrids need to be tested regularly to ensure proper operation during grid independent operation.
- Microgrids that receive utility, state or federal incentives often have mandated annual testing requirements. Be sure you understand those requirements.
- Through this presentation we will summarized our experience testing a variety of private sector Microgrids.









MICROGRID TEST PROCEDURE

- Critical Facilities often cannot afford to initiate site-wide outages necessary for Microgrid testing.
- Due to the complexity of Microgrids and the systems they serve the development of a detailed Test Plan is a necessity for success.
- Due to the cost and planning required for periodic testing a thorough plan is essential.
- Facilities that perform periodic testing must capture lessons learned for continuous improvement.
- At a minimum, the test plan shall cover:
 - Safety and LOTO Procedures
 - Team members contact info
 - Test Procedure:
 - Power loss simulation
 - Engagement of Microgrid Mode
 - Duration of the Test (4 8 hours typical)
 - Sensitive load emergency restoration plan
 - Restoration Procedures
 - Final "as left" Checklist

SAFETY

- Microgrid testing often requires manual switching operations and isolation of sources.
- Temporary Power for Critical Loads.
- Verification that UPS and Emergency Generator Systems are available.
- Coordination of Microgrid testing with other regulatory required testing to minimize facility impact.





THE TEAM

- In theory, Microgrids should activate at a moments' notice with minimal operator intervention.
- In practice, Microgrids remain an emerging technology that often require significant operator intervention.
- Due to the cost and consequences of an unsuccessful test, facilities often require a team of professionals to assist during the test:
 - Design Engineer
 - SCADA/BMS System Integrator
 - Electrical Contractor
 - Microgrid Controller Manufacturer

- Relay Testing Company
- Prime Mover O&M Provider
- Facility Department Staff

METERING & RECORDING

- The results of the test need to be recorded for verification purposes. Parameters include:
 - Primer mover output
 - System voltage and frequency
 - Critical load demand
 - Energy consumed
 - Breaker and switch operations
 - Faults and alarms
- State programs often require recorded data to be submitted as part of the test results and report.





ANNUAL TESTING **#** ANNUAL MAINTENANCE

- The Annual Test Plan should focus on verification that the Microgrid will operate in grid independent mode.
- The test must also validate that the sequence of operations is detailed and accurate.
- The day of the test is not the time to determine that individual components or systems require maintenance.
- Individual components need to be maintained and tested separately before the test, to the greatest extent possible.



INDIVIDUAL COMPONENTS TESTING

- Components that can be tested individually prior to the test, include:
 - Prime Movers
 - Signals and Position Contacts
 - Switch/Breaker Motor Operators
 - SCADA, controls and metering provisions





LOAD SENSITIVITY & TESTS

- Microgrid testing shall consider the sensitivity of loads and avoid disruptions to the extent possible.
- Loads sensitive to planned outages include:
 - Science Buildings with on-going experiments.
 - Morgues
 - Climate controlled environments
- If Testing Plan includes sensitive loads, always have a restoration plan in case testing does not go according to plans!



MICROGRID PROJECT OVERVIEW

Microgrid Projects			
Facility	Project Type	Prime Mover	Output
UMASS Medical	Microgrid	Steam Driven Turbine Generators & Gas Turbine Generator	10.0 MW & 6.6 MW
Backus Hospital	Microgrid	4x Cummins 2500 DQLC Diesel Generators	10.0 MW
Town of Woodbridge, CT	Amity Regional High School Microgrid / Fuel Cell Power Plant	FuelCell Energy DFC 3000 Fuel Cell	1.4 MW
University of Bridgeport	Microgrid & 13.8kV Upgrades	FuelCell Energy DFC 1400 Fuel Cell	1.4 MW
Berkshire Medical Center	CHP / Microgrid	Siemens/Jenebacher/PV	722 kW
Wesleyan University	CHP / Microgrid	Siemens Reciprocating Engine	680 kW

CASE STUDY HIGHLIGHTS

WESLEYAN UNIVERSITY

UNIVERSITY OF BRIDGEPORT



A CASE STUDY WESLEYAN UNIVERSITY

- Built in 2014
- Serves 3,000+ Students on Campus and Middletown, CT community
- Prime Movers are:
 - 670kW Siemens Reciprocating Engine
 - 2.5MW GE Jenbacher **Reciprocating Engine**

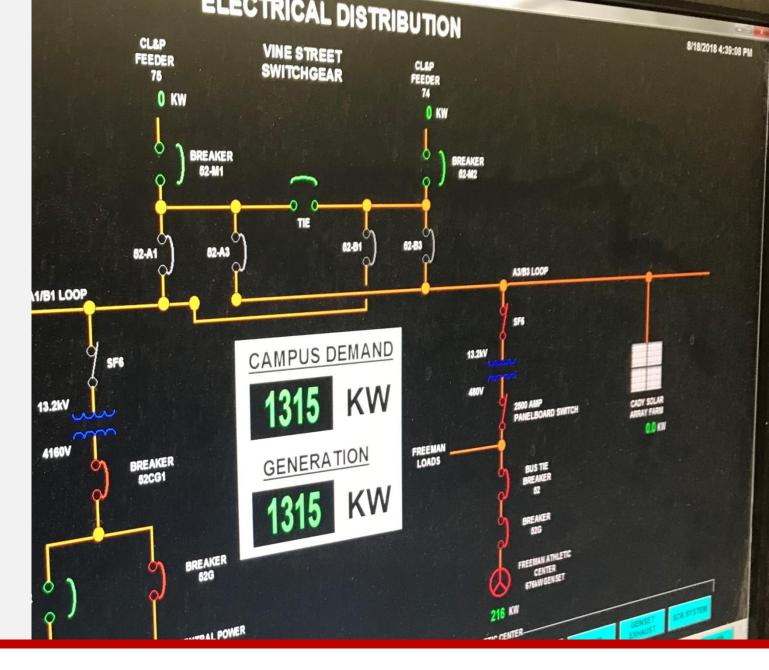


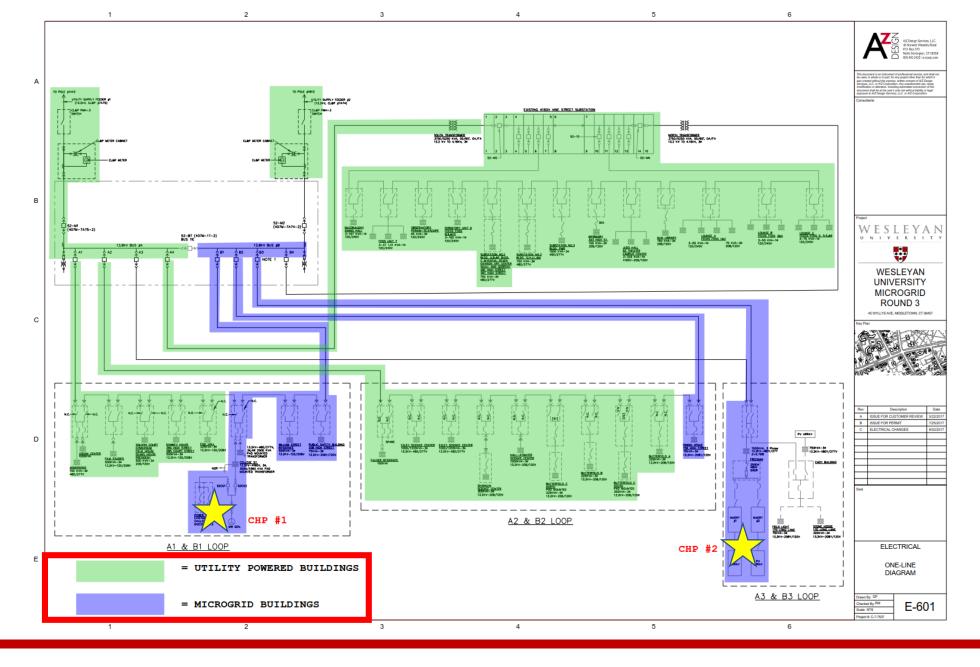
 An alternate distribution arrangement was developed for the test, where the campus MV loop was split into two:

• "A" Side : Utility Power

• "B" Side: Microgrid

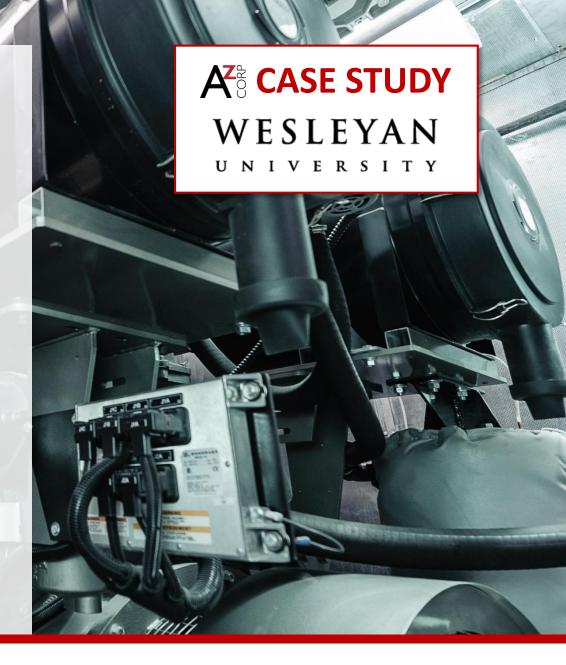
 This arrangement allowed the Microgrid components to be tested while sensitive loads remained on normal power.





TECHNICAL CHALLENGES

- Be aware of technical challenges and nuisances during testing:
 - Primer mover availability
 - Magnetizing large transformers
 - Block loading prime movers
 - Prime mover minimum turn-down ratios
 - Local weather events



PRIME MOVER **AVAILABILITY**

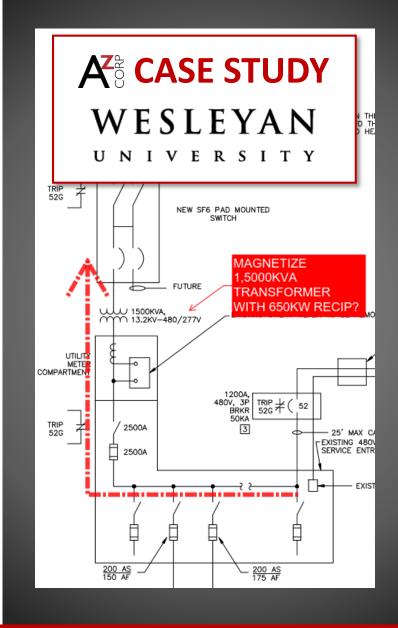
Ensure:

- Primer mover is available and up-to-date with maintenance schedules.
- Controls are programmed to support island operation.
- There are sufficient resources available for a meaningful test (i.e. sunny day if Microgrid includes Solar PV).



COMMON CHALLENGE MAGNETIZING TRANSFORMERS

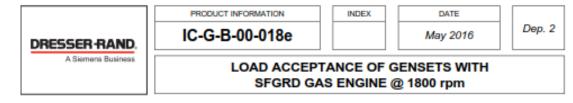
- Transformer inrush current may be too high for prime mover to pick up.
- Engine-based technologies can adjust excitation to achieve transformer magnetization.
- Design must consider implementing automated schemes to accomplish this sequence.



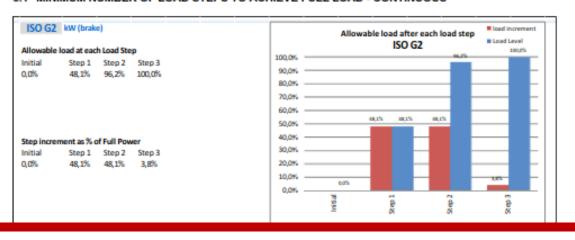
PRIME MOVER BLOCK LOADING

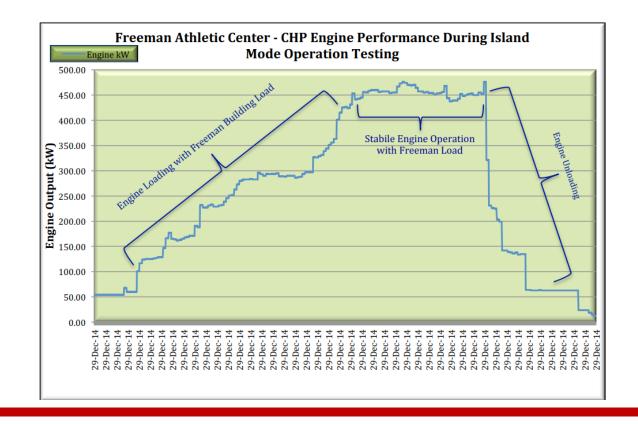
Consider prime mover load acceptance curves when block loading the generator.





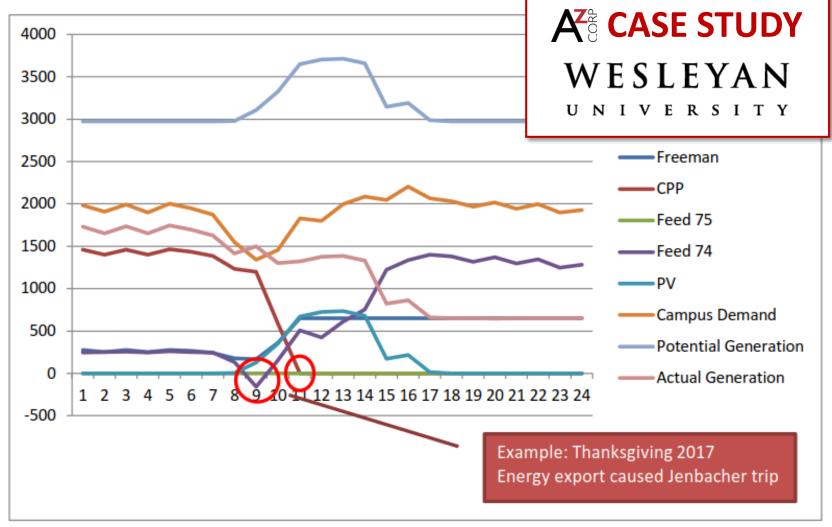
- 3. LOAD ACCEPTANCE OF SFGRD ENGINES CONTINUOUS GENERATION
- MINIMUM NUMBER OF LOAD STEPS TO ACHIEVE FULL LOAD CONTINUOUS







PRIME MOVER MINIMUM TURN DOWN



Reduced "Microgrid mode" load, coupled with intermittent resources could cause minimum turn down issues.

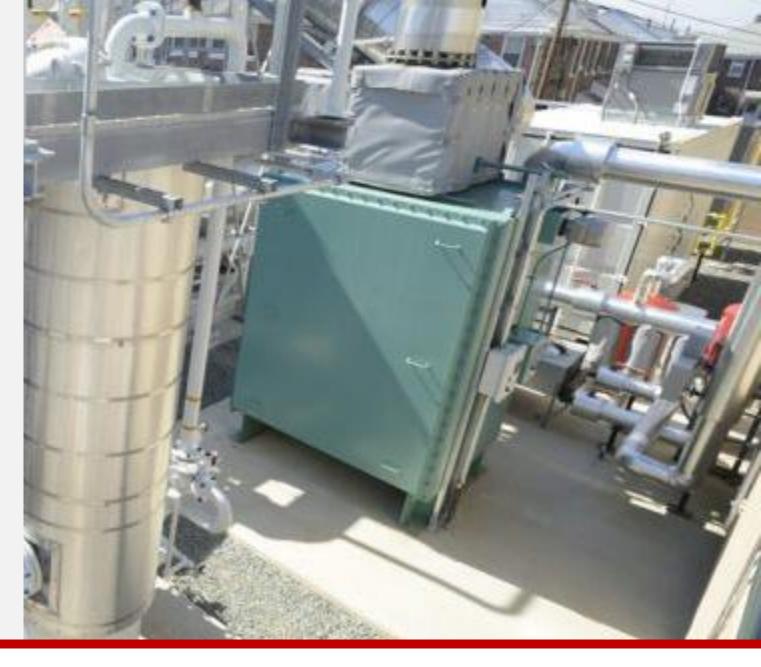


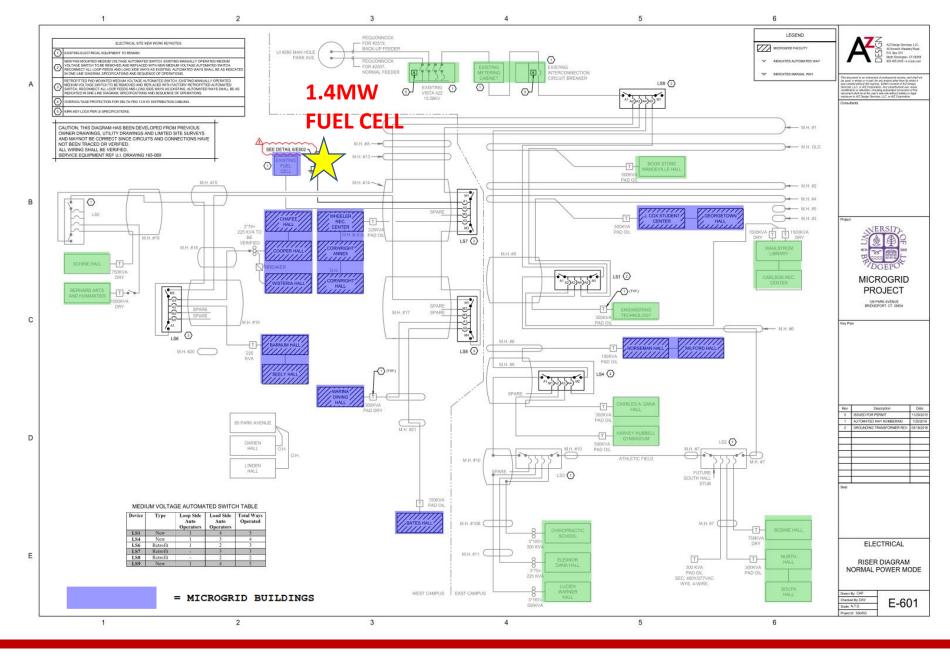
AZ CASE STUDY UNIVERSITY OF BRIDGEPORT

- Campus conversion to 15kV was the first enabling project.
- Installation of 1.4MW FuelCell Energy DFC1500 Fuel Cell next step.
- Installation of fiber optic control network, motor operated G&W switches and SEL Microgrid controller was final step.
- Project was funded through CT DEEP.

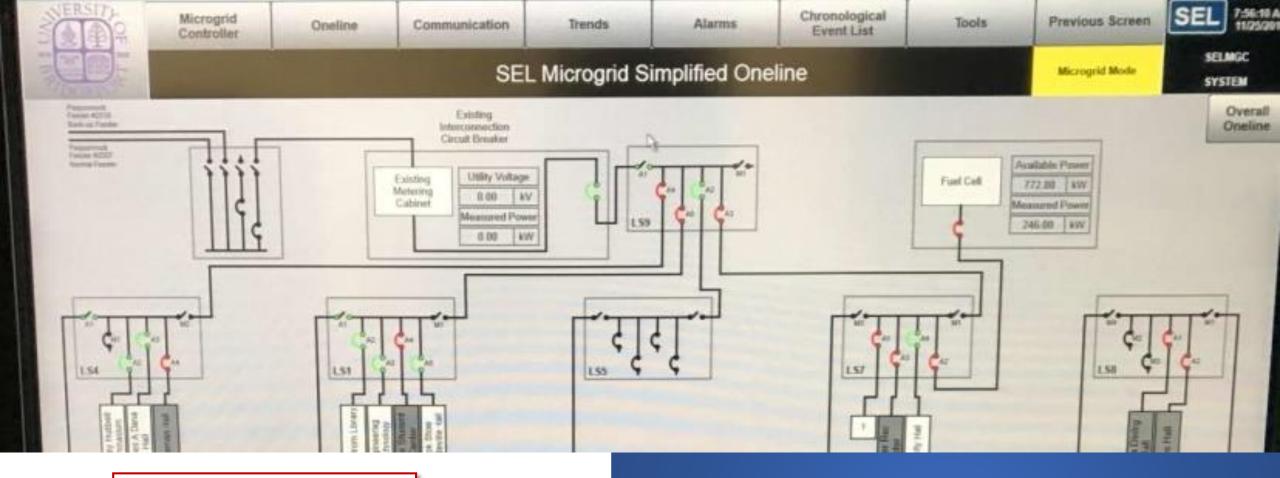
AZ CASE STUDY **UNIVERSITY OF BRIDGEPORT**

- Campus was completely isolated from the utility during test.
- SEL Microgrid Controller performs Microgrid switching operations automatically.
- Sensitive loads not part of the Microgrid were powered through roll-up generators.
- Be aware that Microgrid loads do not always include business critical loads. (Data Center)









AZ CASE STUDY UNIVERSITY OF BRIDGEPORT

Microgrid Controllers and automated switching simplify prime mover block loading and load shed controls.

CONCLUSIONS



For Commissioning:

- Microgrid Controllers make block loading and controls more efficient.
- Perform smaller pre-tests of different components before testing the system as a whole.
- Ensure prime movers can handle expected block loading and transformer inrush.
- Rental generators and load banks can enable the testing of additional operating scenarios.

For Annual Tests:

- Prepare a plan that minimizes disruption to sensitive loads outside of the Microgrid.
- Ensure individual components have been maintained properly and pre-tested.
- Confirm prime movers are available and ready to be dispatched in Microgrid Mode.
- Prepare a checklist for expected "as left" conditions to be verified after the test is complete.



WORK IN PROGRESS

Berkshire Medical Center

- 302 bed hospital in Pittsfield, MA
- DOER Microgrid Grant recipient
- 722kW Siemens Recip. Engine
- Will Operate Simultaneously with **Emergency Generators**
- Microgrid system will support patient care and common areas of the Hospital
- **Expected commissioning test:** February 2019





QUESTIONS & ANSWERS