Smart Microgrid Expanding Utility Infrastructure at MSU

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Smart Microgrid Expanding Utility Infrastructure at MSU

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MSU/DCO/SEL Objectives

1. Maximizing your investment and getting the most out of your energy dollar while building reliability and redundancy into your systems.
2. Understand the drivers for modernizing campus utility infrastructure in an expanding campus environment.
3. Define and understand the various features of a Micro grid and a Smart grid, highlighting the benefits and challenges.
4. Integration and testing of Microgrid into existing operating Campus without interrupting Campus Activities.

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"Problem 1"

- Aging Central Plant and Cogeneration System
- The entire steam distribution system was in such poor shape it had to be totally replaced.
- There was no chilled water distribution system, it had to be installed totally new.
- The Campus was expanding with new buildings and numerous renovations were being planned and underway, a comprehensive plan needed to be formulated.
- Temporary chillers where parked in multiple location around the Campus.
- Rocky terrain and numerous buried utilities needed to be considered, moved and maneuvered around.

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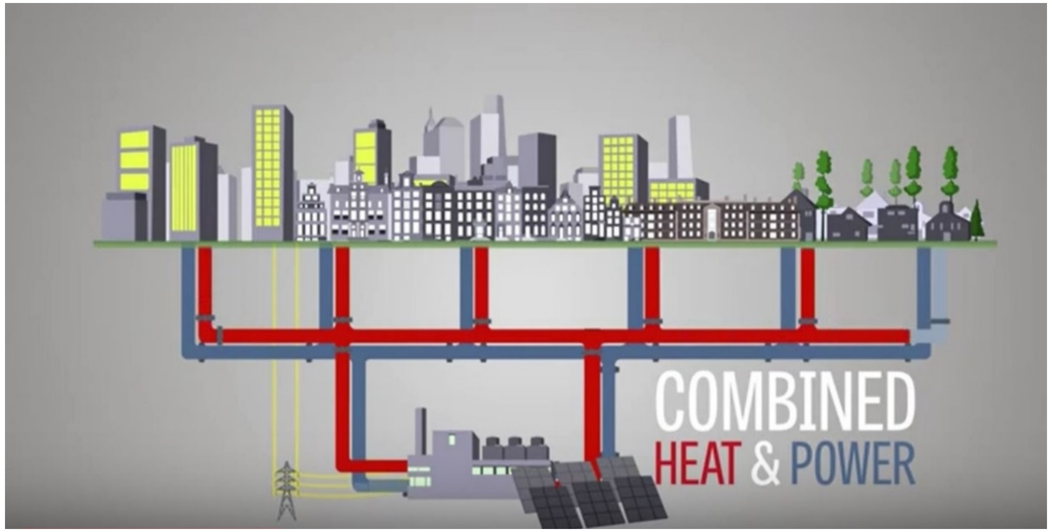
Step 1 - Solution District Energy System – New Combined Heat, Cooling & Power Plant

- Solar Taurus 60, 5.4 MW Gas Turbine, dual fuel, 29 MMBTU/hr heat recovery steam generator.
- Capable of satisfying 75% of campus electrical load and 100% of thermal load.
- 2 – 1200 HP NG Boilers, 42,000 lbs./Hr steam, each.
- 1 – York 2300 Ton/hr Steam Driven Chiller
- 1 – York 2000 Ton/hr Electric Chiller



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Step 1 Solution – New Piping Infrastructure

- 9,500 linear feet of trench
- 7.5 miles of Chilled Water, Steam and Condensate piping
- Supplying:
  - 100,000 LBM/hr Steam
  - 9,000 Tons/hr Chilled Water

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Step 1 Solution – New District Energy System

- 86% of electricity from Cogen
- Availability of 97.38%
  - .03% unscheduled
- Electricity Cost 40% lower than Utility rates

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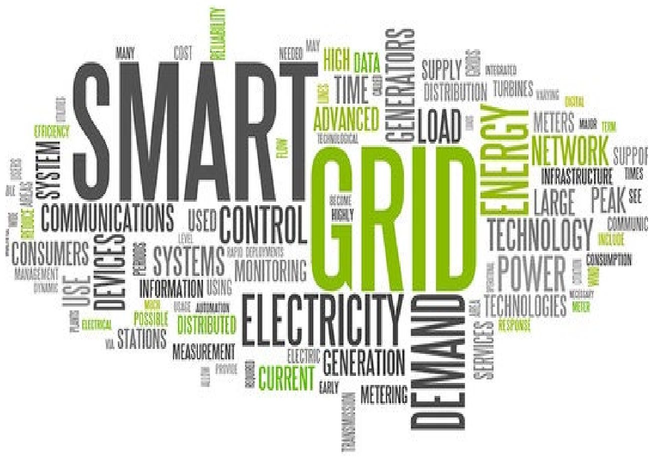
“Problem 2”

- Utility Communication link trips Campus (RFL).
- Load Shed Scheme not in place.
- Emergency Generation aging and in numerous locations.
- High Demand ratchet for supplemental power.
- Campus electric load growing.
- Reliability of Grid



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"Problem 2 " Economics Drivers

Supplemental Power Cost

- LMP Price $/kwh (Locational Marginal Price): Reviewed Energy Pricing an hourly $/kwh for summer and winter periods for MSU Zone
- Utility Peak Demand (PSEG): Reviewed 15 minute demand data to determines supplemental power peak loads; year by year adjustment
    - Summer Peak $/kw
    - Annual Peak $/kw
- PJM Generation and Transmission Obligation $/kw: Peak set based on highest 5 individual hours. This moves year to year and experience has shown that it occurs on the third weekday of + 90 degrees weather and high humidity. Year by year adjustment

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Step 2 Solution

- 2 X 2.6 MW GE Jenbacher JGS 616 natural gas fired reciprocating engine generators.
- A State of the Art Load Management System that provides the University with the ability to control every major end use breaker in the substation.
- Black Start Capability.
- Engine installation includes heat recovery.
- Total functionality with loss of Utility Grid.
- Permitted for approximately 2,000 hours of operation.
- System is export capable

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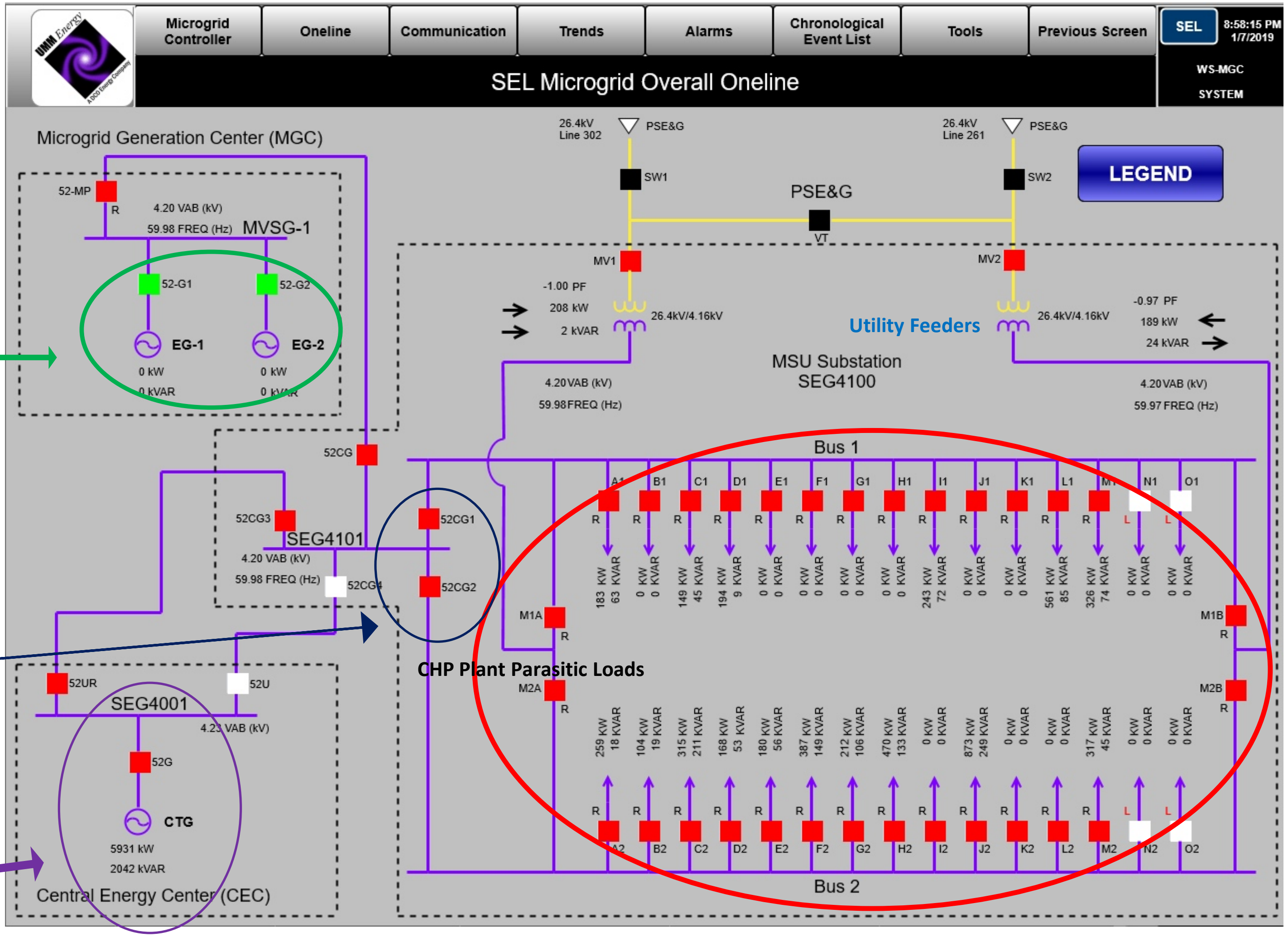
Step 2 Solution-MICROGRID LOAD MANAGEMENT SYSTEM

Peak Shaving Units

Redundant Feeders

CHP Generation



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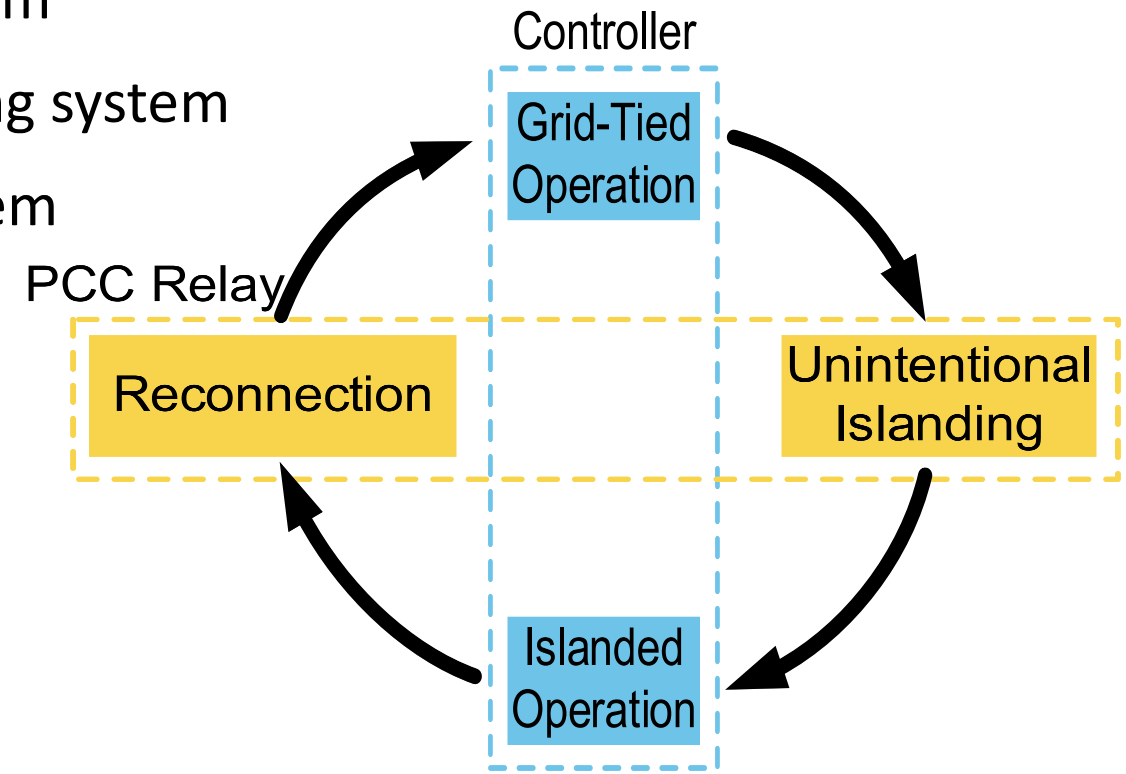
Step 2 Solution-MICROGRID LOAD MANAGEMENT SYSTEM

- Protection relay based fast decoupling system
- High speed contingency-based load shedding system
- Backup underfrequency load shedding system
- Generation control system
- Automatic synchronization
- Automatic Load restoration
- Human Machine Interface (HMI)
- Hardware in loop (HIL) testing



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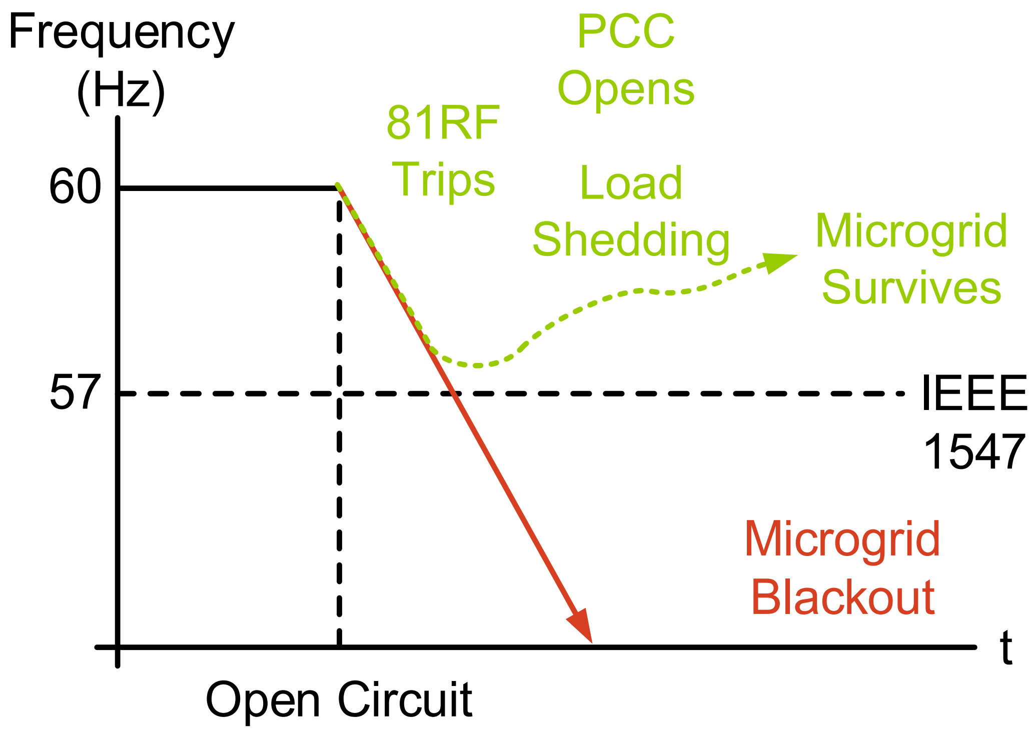
Step 2 Solution-MICROGRID LOAD MANAGEMENT SYSTEM

- Protective relays at PCC provides ~50% of Control Functionality
  - Automatic synchronization
  - Unintentional islanding
  - Protection
  - IEEE 1547 compliance
  - Metering
- High speed contingency-based load shedding
  - Round trip times of <30 ms
  - 14 pre-defined contingencies
  - Handle multiple back to back contingencies



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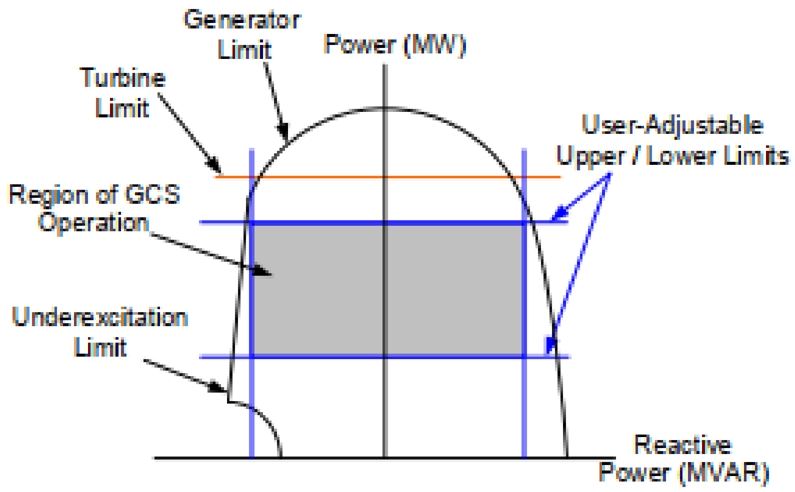
Step 2 Solution-MICROGRID LOAD MANAGEMENT SYSTEM

- Generation control system
  - Non-islanded (utility-connected)
    - Active and reactive power flow across tie and power factor (PF)
    - Maintain minimum import limit
  - Islanded
    - Voltage and frequency control for each island
    - Active and reactive power sharing
    - Assist in automatic synchronization



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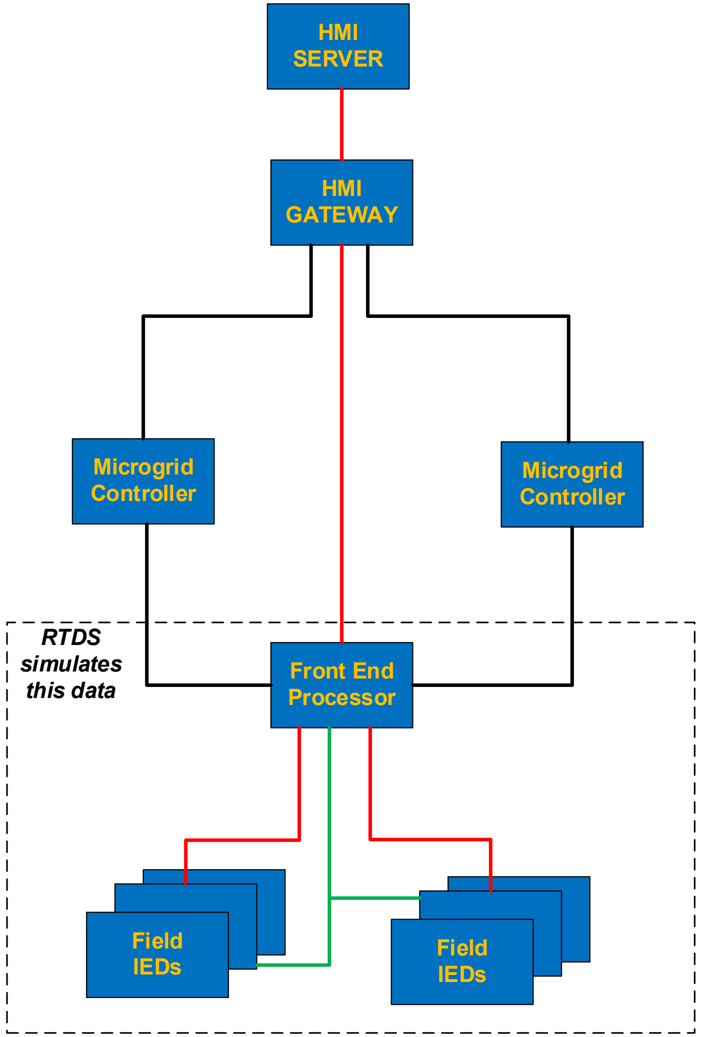
Step 2 Solution-MICROGRID LOAD MANAGEMENT SYSTEM

- Automatic load restoration
  - Restores shed load sequentially after the island is stable
  - Continuously monitoring available generation
- HIL Testing
  - Validate the system functionality
  - Hundreds of different scenarios were tested
  - Simplified commissioning and saved us a lot of time onsite



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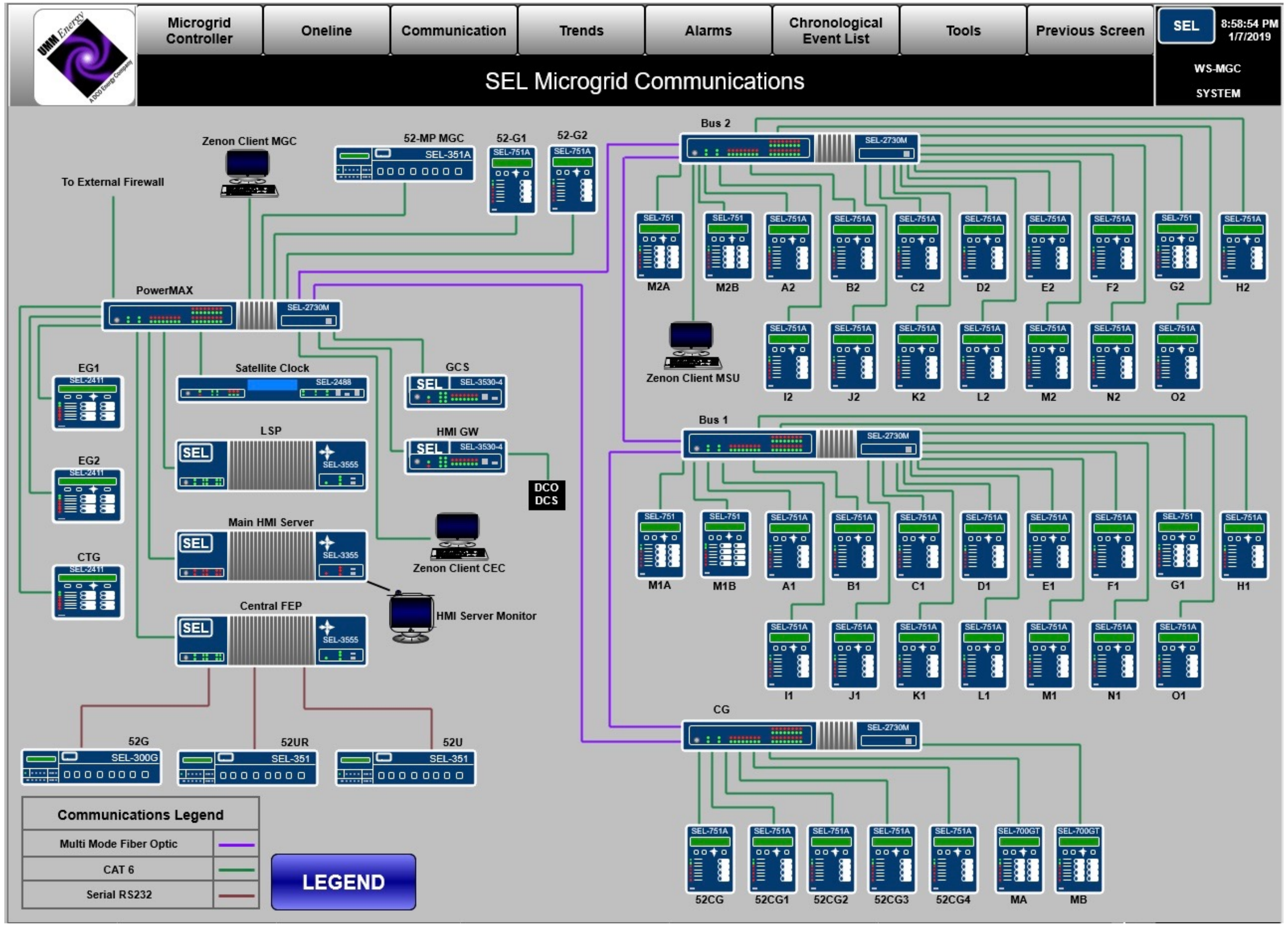
Step 2 Solution-MICROGRID LOAD MANAGEMENT SYSTEM



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Lessons Learned

- The MICROGRID provides the ability for the University to remain operating during periods when the Utility Grid is not in service.
- The MICROGRID provides a measurable economic benefit to the institution.
- The MICROGRID includes automatic functions.
- The MICROGRID supports the stability of the local utility network.
- The MICROGRID improves achieving sustainability
- The MICROGRID is expandable

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Lessons Learned -District Energy Cost Savings

Fiscal Yr	Purchased kWh	Purchased Cost ($)	Produced kWh	Produced Cost ($)	Total Cost Purchased and Produced
FY15	12,444,488.89	$1,970,014.50	41,304,239	$2,329,408.89	$4,299,423.39
FY16	12,794,247.91	$2,224,354.81	40,834,208	$2,239,373.06	$4,463,727.87
FY17	15,270,311.00	$2,231,545.36	41,323,812	$2,277,831.58	$4,509,376.94

Fiscal Yr	Total Cost if ALL Purchased from Local Utility	Savings on energy	Debt service	Savings with debt service
FY15	$11,789,105.39	$7,489,682.00	$5,288,592.00	$2,201,090.00
FY16	$12,956,865.20	$8,493,137.33	$5,288,592.00	$3,201,545.33
FY17	$11,547,787.58	$7,038,410.64	$5,288,592.00	$1,749,818.64

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Lessons Learned –Performance & Savings

Pre- Microgrid

Month	Supplemental Peak Demand (KW)
May	4,871
June	4,761
July	4,778
August	4,680
Sept	6,981

Post - Microgrid

Month	Supplemental Peak Demand (KW)
May	0
June	0
July	0
August	0
Sept	508

Average Summer Demand Reduction = 4,792 Kw → **90.4 % reduction**

Microgrid Performance	June	July	Aug
Total Microgrid Engines kWh Output (Net)	80,327	353,423	145631
Total Microgrid Engines kWh Output Utilized by MSU	35,196	162574	61165
Total Microgrid Engines kWh Output Exported to PSEG	44,929	190,849	84466
MicroGrid Acutal Mointhy Cost	$118,662.49	$138,374.00	$123,445.76
Savings	$123,669.00	$152,266.87	$131,023.42

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Questions And Then Goodbye & Thank You

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