MICROGRID for

MONTCLAIR STATE UNIVERSITY

DCO ENERGY LLC

IDEA – MARCH 2018

MICROGRID FOR MSU

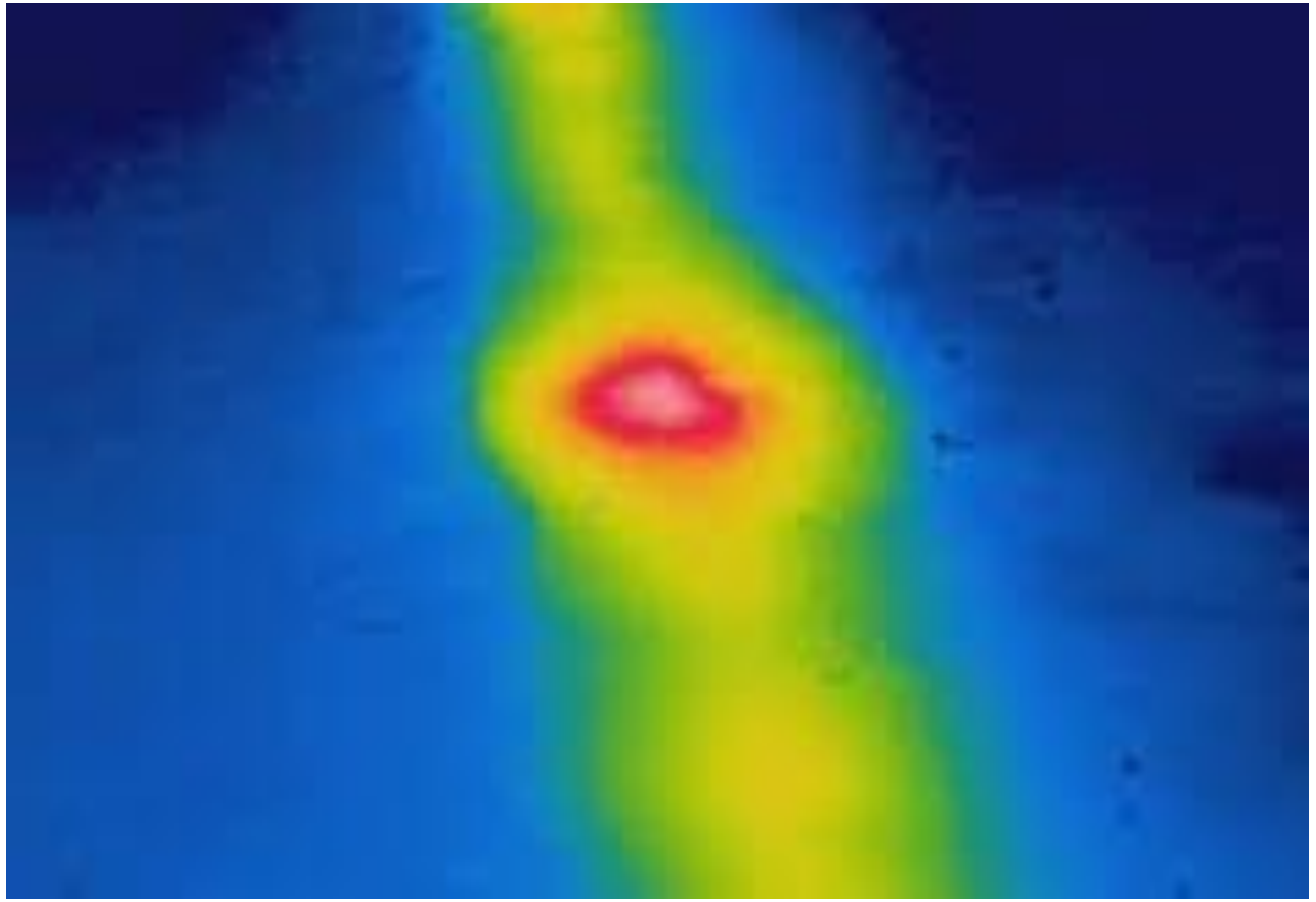
PART I -The path to a MICROGRID

MICROGRID FOR MSU – Where it began

- In 1993 MSU built its first Cogen in what was an existing Boiler House.
- 4.3 MW natural gas fired turbine with 23 MMBTU/Hr of heat recovery.
- It was connected to the Campus's existing steam and condensate system from the 50's.
- No Chilled Water distribution
- Several small boilers and gas fired smaller units providing heat around the Campus.

MICROGRID FOR MSU – Action Required

- The picture is a thermographic image of the typical steam line previously buried on the MSU Campus
- The Central Plant was operating at an efficiency rating of less than 50%.
- Returning condensate was less than 20%, thermal losses were significant.
- In 2009, as part of an Energy Master Plan, the University performed an analysis of potential upgrades to the Utility Systems



MICRODGRID FOR MSU – Partnership Formed

- In 2009 the NJ Economic Stimulus Act provided for the use of Public Private Partnerships (PPP) for Colleges and Universities.
- The Montclair District Energy System was the first PPP utilized for Energy.
- Project Financing Utilized
  - Taxable Bonds
  - Tax-exempt Bonds
- UMM Energy Partners and MSU signed an Agreement that included Design, Construction, Financing and Operations and Maintenance for 30 years. A long term partnership was born.

MICROGRID FOR MSU – Issues to be Addressed

- 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.
- Distributed emergency generation was past it's life expectancy.
- Temporary chillers where parked in multiple location around the Campus.
- Rocky terrain and numerous buried utilities needed to be considered, moved and maneuvered around.

MICROGRID FOR MSU – First the District Energy System

- 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

MICROGRID FOR MSU – and the new distribution system

- 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

MICROGRID FOR MSU – District System Performance

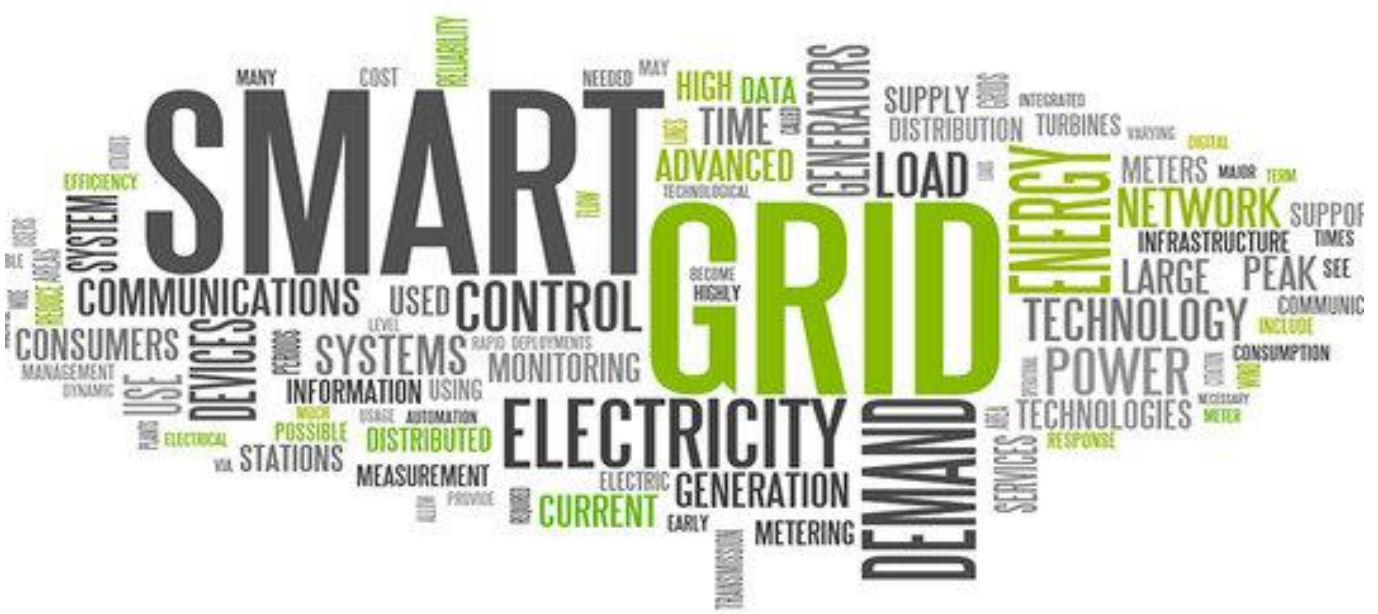
- Commercial September 2013
- 86% of electricity from Cogen
- Availability of 97.38%
  - .03% unscheduled
- Electricity 40% lower than Utility rates
- Saving on average $2.2 million annually on energy and taking into account debt service
- Estimated savings over the course of the contract (30 years) is expected to be approximately $66 million

MICROGRID FOR MSU

PART II - The MICROGRID Arrives

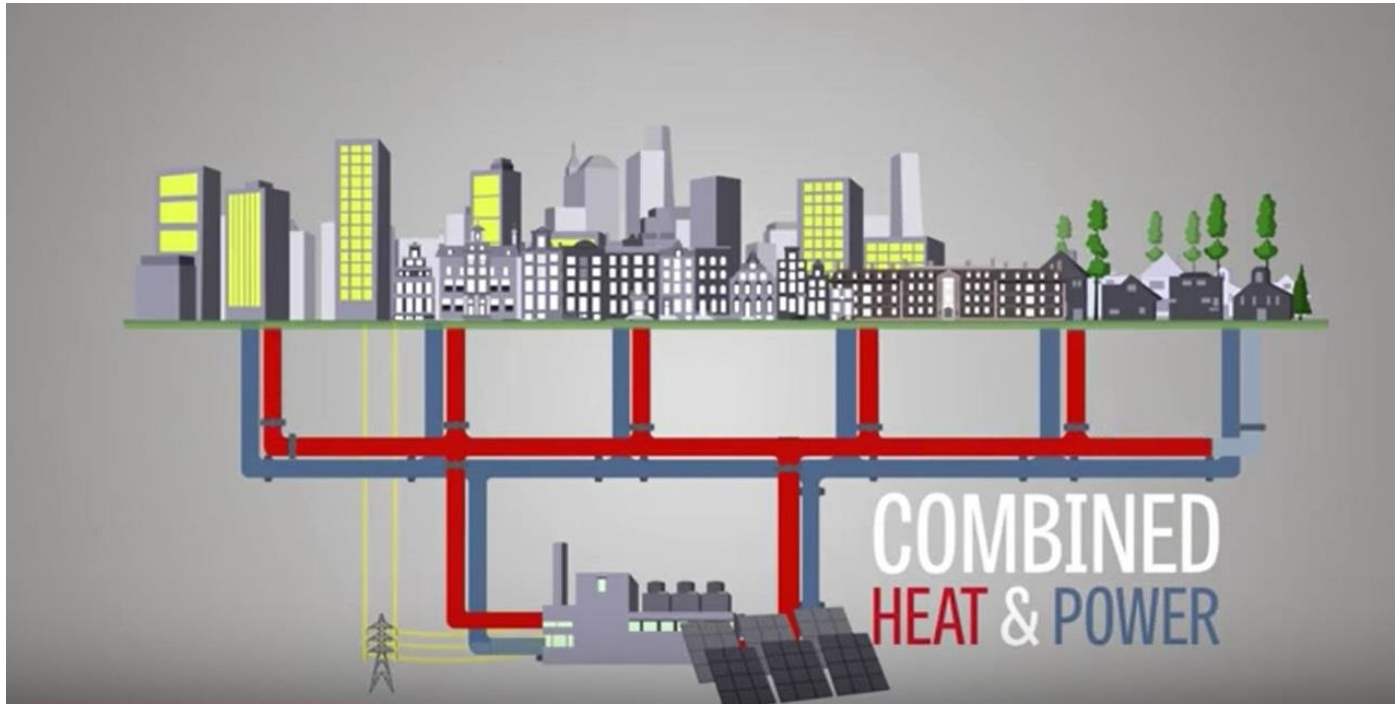
MICROGRID FOR MSU – System Challenges Why MICROGRID

- Utility Communication link trips Cogen (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



MICROGRID FOR MSU – What is a MICROGRID

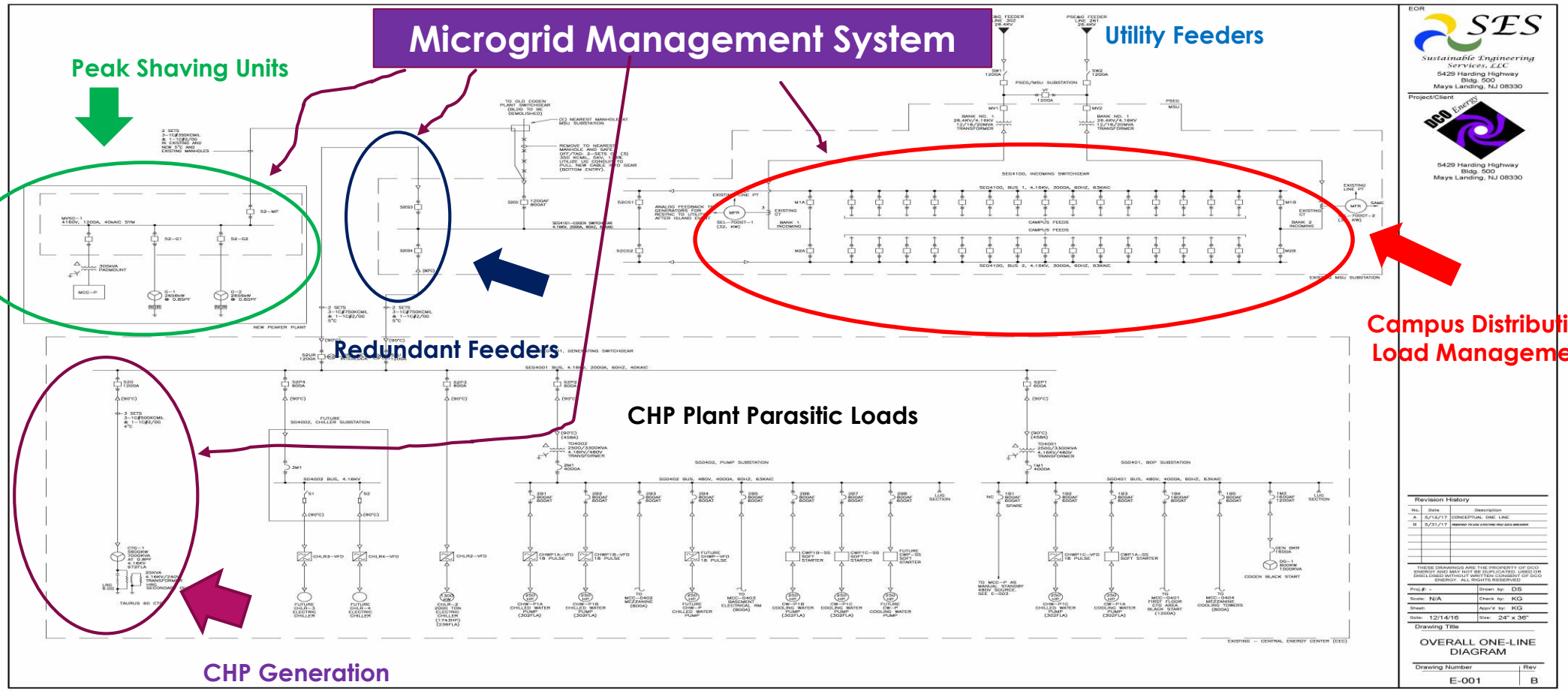
- "A small-scale power grid that can operate independently or in conjunction with the area's main electrical grid. Any small-scale localized station with it's own power resources, generation and loads and definable boundaries" qualifies.
- Pairing a MICROGRID with Combined Heat and Power improves the efficiency and economic benefits of the MICROGRID system.



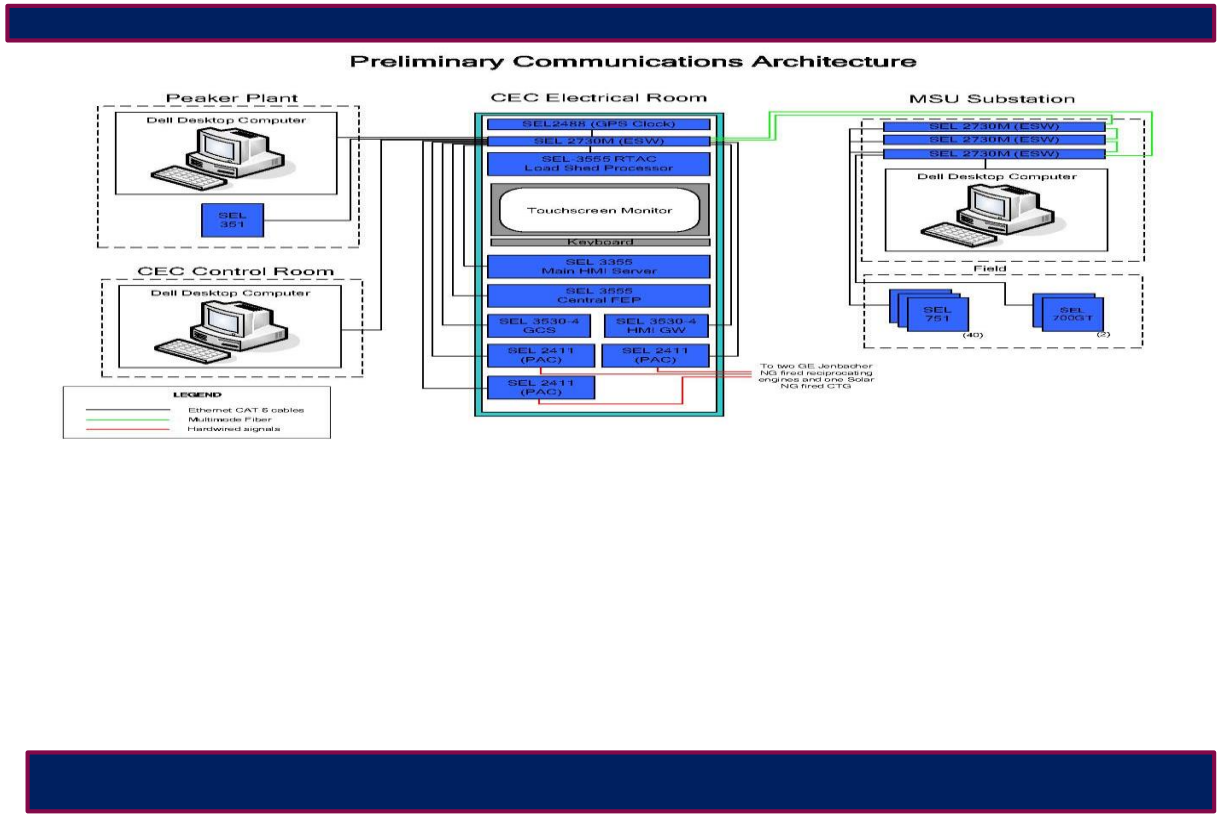
MICROGRID FOR MSU – What does the MICROGRID include?

- 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

MICROGRID FOR MSU – LOAD SHEDDING

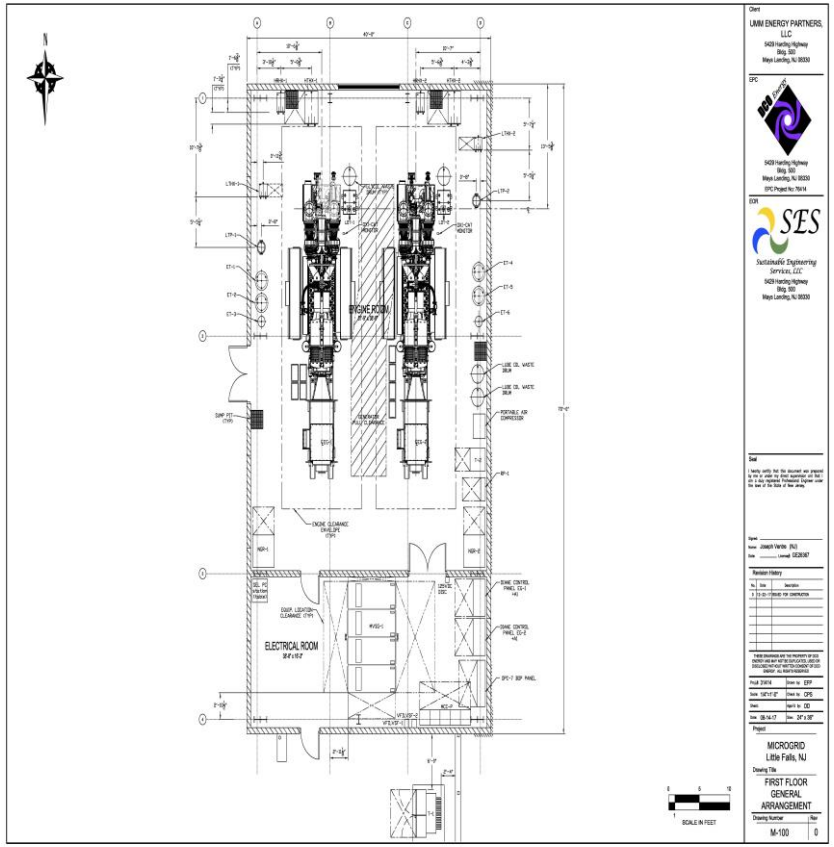


MICROGRID FOR MSU – Load Shedding Control

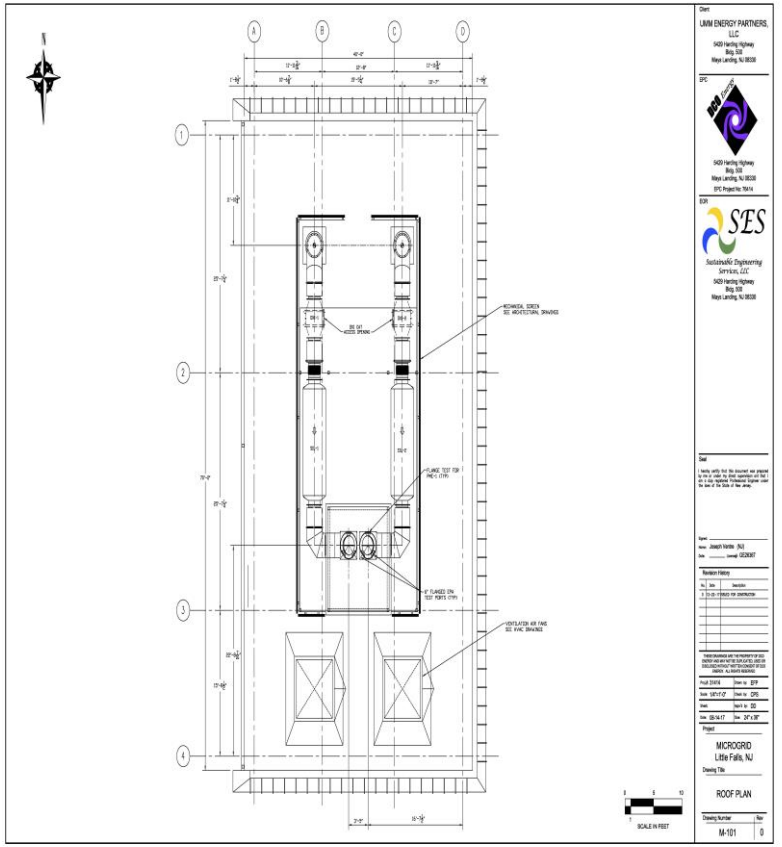


MICROGRID FOR MSU – Plant Layout

Main Operating Floor



Roof Plan



MICROGRID FOR MSU – Progess

MICROGRID FOR MSU – System Costs and Savings

- System estimated cost approximately $9.4 million – Engines, controls, building and communications interface.
- Provides two sources of major electric generation.
- Controls system to seamlessly interface the multiple generating sources.
- Initially provides approximately $298,491 (increases going forward) of additional savings.
- Resolves outstanding challenges with Utility Grid interface.
- Provides:
  - **LMP savings ($/kwh)**
  - **Utility Demand savings ($/kw)**
  - **PJM Capacity & Transmission savings ($/kw)**

MICROGRID FOR MSU – The Supplemental Power Demand – The Economic Driver for the MICROGRID

- Economic Drivers
  - **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

MICROGRID FOR MSU –
The Supplemental Power Demand – The Economic Driver for the MICROGRID

MSU Supplemental Power Demand

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 FOR MSU – The Supplemental Power Demand – The Economic Driver for the MICROGRID

MSU Supplemental Energy Usage

Pre- Microgrid

Month	Supplemental Peak Usage (Kwh)
May	2,056,023
June	1,351,052
July	1,710,979
August	1,661,817
Sept	2,086,676

Post - Microgrid

Month	Supplemental Peak Usage (Kwh)
May	1,267,159
June	1,035,127
July	1,295,311
August	1,288,798
Sept	1,436,876

Usage Savings (KWH) = 2,543, 276 → **28.68 % reduction**

MICROGRID FOR MSU – Savings Comparison

- PPP/DCO - Bond Financing Case
  - Cost $9.4 M
  - Term 25 years
  - WCOC 8.5%
  - Natural Gas Bypass Rate
  - Annual Savings: $298,491
  - Payback = ∞ (no capital required)
- Self Financing Case
  - Cost $9.4 M
  - Term 25 years
  - WCOC – 4%
  - Natural Gas Bypass Rate
  - Annual Savings: $615,753
  - Payback = 15.27 years

MICROGRID FOR MSU – MICROGRID Challenges

- Communications and controls are at the heart of the MICROGRID function. Installing those networks on the urban Campus is a challenge.
- Providing the best possible fuel cost to power the MICROGRID is important to the economics, so opting for a utility bypass rate can be profitable.
- Having a back up fuel source like LNG provides more reliability to the MICROGRID System.

MICROGRID FOR MSU - Conclusions

- The MICROGRID provides the ability for the University to remain operating during periods when the Utility Grid is not in service. **A safe haven for Faculty & Students during environmental events**
- The MICROGRID provides a measurable economic benefit to the institution as installed and in conjunction with the District Energy System and Combined Heat, Chilling and Power System.
    - **All forms of Energy provided during upset conditions – Both Electric & Thermal**
- The MICROGRID includes automatic functions; connect and disconnect from the grid, conducts load shedding and interconnectivity that allows for the interface with other systems when necessary. Two way communications is a basic requirement that supports full functionality.
- The MICROGRID supports the stability of the local utility network.
- Improves achieving sustainability goals by displacing the use of grid supplied power (coal and oil generation) during Peak Periods
- The MICROGRID is expandable in order to service Campus growth and can accommodate additional sources of generation including renewable sources.

MICROGRID FOR MSU

- Thank You for your attention!
- Please contact DCO Energy, LLC for additional information about the MSU MICROGRID.
- We can be reached at 609-837-8025 or,
- At www.dcoenergy.com