Packaged CHP Accelerator

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Customer Engagement Partner Webinar

August 15, 2019

Agenda

- CHP for Enhanced Resilience
  - Results, tools and resources from DOE's recently completed CHP for Resilience Accelerator
  - Nick Posawatz, ICF
- CHP in Microgrids
  - CHP as the base for resilient clean energy microgrids
  - David Jones, ICF
- Case Study
  - Resilient microgrid at Montclair State University anchored by a 5.4 MW CHP system
  - Kurt Koenig, DCO Energy
- Packaged CHP Accelerator Update and Next Steps
  - Bruce Hedman

This Webinar Is Being Recorded

CHP for Enhanced Resilience

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The CHP for Resiliency Accelerator

Purpose & Goals

- Incorporate consideration of CHP into resiliency planning efforts at the city, state, and utility levels
- Collaborate with Partners to:
  - Assess opportunities for CHP to maintain critical operations
  - Document Partner process for replicability

Key Materials Developed

1. DG for Resiliency Planning Guide
2. CHP for Resiliency Screening Tool
3. DER Matrix – Issue Brief
4. Partner Profiles

https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency

The Distributed Generation (DG) for Resilience Planning Guide

Web-based guide that provides information and resources on how distributed generation (w/a focus on CHP), can help communities meet resilience goals and ensure critical infrastructure remains operational regardless of external events

Stakeholder Take Action Pages

- Information and resources for resiliency planners to actively use to incorporate CHP/DERs in their planning process
  - Decision Makers
  - Utilities
  - Take Action
  - Resource Library

101 Background Information Pages

- Background information on critical infrastructure, DERs, and how to apply in end-use sectors
  - Critical Infrastructure
  - Combined Heat and Power
  - Solar + Energy Storage
  - Microgrids
  - Applying CHP in Critical Infrastructure
  - Case Studies

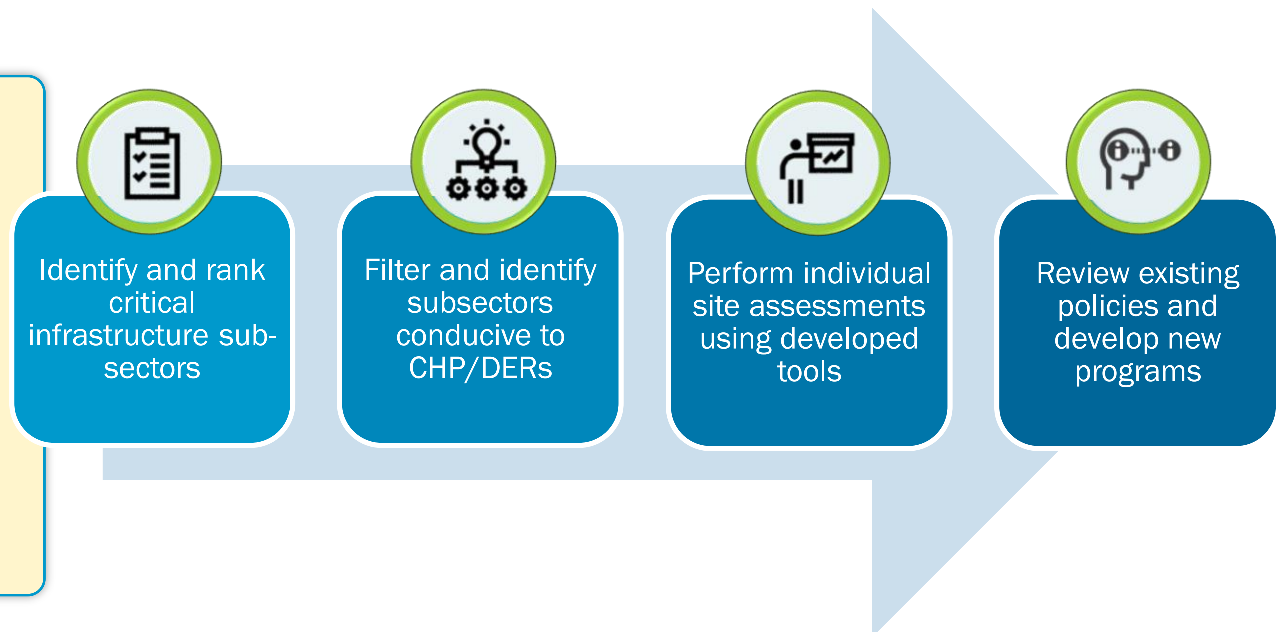
Access the DG for Resilience Planning Guide here:
htthttps://resilienceguide.dg.industrialenergytools.com/takeAction

The DG for Resilience Planning Guide – Take Action

HOME | DECISION MAKERS | UTILITIES | TAKE ACTION | RESOURCE LIBRARY

101 BASICS: CRITICAL INFRASTRUCTURE (CI) | COMBINED HEAT & POWER (CHP) | SOLAR + ENERGY STORAGE | MICROGRIDS | APPLYING CHP IN CI | CASE STUDIES

- Provides users with an efficient approach to quickly assess a critical infrastructure portfolio for potential DG deployment
- Provides a framework for reviewing existing resiliency strategies and policies, and developing new programs



Access the Take Action section of the DG for Resilience Planning Guide here: htthttps://resilienceguide.dg.industrialenergytools.com/takeAction

The CHP for Resilience Screening Tool

Allows users to screen and rank individual sites or portfolios of buildings based on a variety of resilience metrics and their suitability for CHP

Resiliency Screening

- **Inputs:** User-defined critical infrastructure ranking criteria, as well as microgrid and load factor ranking assessments
- **Results:** Users receive a resiliency score, microgrid score, load factor score, historical CHP uptake, and combined total resilience score

CHP Screening

- **Inputs:** Resiliency score (from resiliency screening), site location, energy consumption data, and energy price data
- **Results:** Estimated CHP size and stoplight screening assessment (taking into account resiliency screening)

Stoplight Screening Assessment

This site has a high potential for CHP, contact your CHP TAP for more information

This site has medium potential for CHP, contact your CHP TAP for more information

Limited CHP Potential

Resiliency Screening Factors: Government Continuity, Locational Ranking, Leverage/Scalability, Life Safety, Economic Impact, Microgrid, and Load Factor

Access the tool at the accelerator website under "Featured Resources": https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency

The CHP for Resilience Screening Tool: Valuing Resilience

Provides a framework for users to assign a value of resilience to individual sites, and understand the affects on overall potential

One-time Resilience Payment ($)

- Estimates the impact of placing a simple monetary value on resilience
- Not based on capacity or energy use of the system
- Ex. Avoided cost of installing backup diesel generators

Energy Resilience Value ($/kWh)

- Potential cost of downtime to the facility
- Extra portion of electricity prices they would be willing to pay for assured resilience

Capacity Resilience Value ($/kW)

- Similar to capacity incentives for CHP/DER systems, this determines the value of resilience based on system size
- Useful for site-by-site comparisons, or end-users familiar with capacity incentives for CHP/DERs

Access the tool at the accelerator website under "Featured Resources":
https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency

Issue Brief – Examining the Performance of Different DERs in Disaster Events

- Explores how different DERs are impacted by various types of natural disasters (flooding, high winds, extreme temperature, etc.)
- Goal: To assist stakeholders in evaluating the technology options best able to meet their resilience priorities
- DER Disaster Matrix & Design Considerations to Increase Resilience of DERs

Natural Disaster or Storm Events	Flooding	High Winds	Earthquakes	Wildfires	Snow/Ice	Extreme Temperature
Battery Storage	◒	○	◒	●	○	◒
Biomass/Biogas CHP	◒	◒	◒	●	○	○
Distributed Solar	○	◒	◒	●	◒	◒
Distributed Wind	○	◒	◒	◒	◒	◒
Natural Gas CHP	○	○	◒	◒	○	○
Standby Generators	◒	○	◒	●	◒	○

Natural Disaster or Storm Event / Resource	Flooding	High Winds	Earthquakes	Wildfires	Snow/Ice	Extreme Temperature
Battery Storage	• Elevate equipment above flood and storm surge levels • Use NEMA-rated enclosures that protect against water damage • Factor equipment repair or replacement in O&M plans	• Use NEMA-rated enclosures to minimize exposure to debris • Design EMS or protection systems to shut down at harmful wind speeds or conditions	• Utilize shock-mount system enclosures to maintain integrity of individual system components	• Use built-in fire suppression system	• Design enclosures to withstand snow/ice loads • Design with sealings and venting to address moisture • Use NEMA-rated enclosures to minimize exposure to moisture	• Design protection or EMS to withstand extreme temperatures • Design system to shut down to protect component integrity
Biogas/Biomass CHP	• Elevate equipment and biomass stockpiles above flood levels • For biogas, coordinate with the facility supplying the fuel on potential planned shutdowns	• For digesters, use rigid covers to protect tanks • For biomass, cover or protect onsite fuel supply stockpiles	• Maintain industry standards for facilities sited near seismic activity	• For biomass, use enclosures, fire protection, or containment strategies for fuel supply	• Design with proper freeze protection • Protect biomass stockpiles from excess snow and ice	• Use heating jackets designed for optimal temperatures and adequate thermal management systems • Ensure systems are designed for regional temperature ranges
Distributed Solar	• Design systems and framing for easy runoff and drainage, especially for commercial rooftop systems with flat roofs • For ground mount, avoid siting in flood zones	• Use secure, flush-mounted systems for rooftop solar • Use flexible racking and anchoring systems • Maintain ASCE standards for rooftop systems based on expected wind loads	• Ensure roof mount design meets ASCE building code for seismic areas	• If ground-mount, site in open areas away from flammable material (trees, shrubs, etc.)	• Manually remove snow/ice to clear panels • Automonous mechanical cleaning (tiled removal) • Install bifacial systems capable of absorbing irradiance on the back or front of panels	• Site systems in applicable weather conditions • Enhance design to maximize cooling and airflow in order to ensure optimal temperature conditions for modules and electrical components (inverters)
Distributed Wind	• Design foundation for conditions in high water table • Elevate controls and electronics above flood and storm surge levels • Use site drainage strategy	• Include design features and braking procedures to withstand hurricane force winds (feather blades, lock rotors, change orientation, etc.)	• Design systems for ground acceleration rating based on typical seismic activity	• Extend gravel apron around base of turbine	• Install electro-thermal ice protection systems • Use ice-resistant coating on blades	• Design uninterruptible power supply to operate within adequate temperature range • Add on "cold weather packages"
Natural Gas CHP	• Elevate equipment above flood and storm surge levels	• Locate systems indoors or protect with containers designed to withstand high wind and debris	• Shock-mount system enclosures • Maintain industry standards for pipelines sited near seismic activity	• Use fire protection systems for above-ground facilities associated with gas delivery networks	• No additional design consideration needed	• To ensure fuel availability, purchase "firm supply" to avoid curtailment
Standby Generators	• Elevate equipment above flood and storm surge levels • Store enough fuel onsite to avoid delivery issues	• Locate systems indoors or protect with containers designed to withstand high wind and debris	• Purchase an earthquake-resistant model (IBC certified, subject to shake table testing)	• Avoid siting in areas prone to wildfire • Store enough fuel onsite to avoid delivery issues	• Store enough fuel onsite to avoid delivery issues	• Check generator batteries during cold weather • Enclose the system to protect from temperatures • Store "winter diesel" fuel in cold climates with additives to prevent gelling

Access the DER Disaster Matrix Issue Brief here: https://betterbuildingsinitiative.energy.gov/sites/default/files/attachments/DER_Disaster_Impacts_Issue%20Brief.pdf

Partner Profiles

- Summary of individual partner achievements throughout the accelerator and future plans
- Short profiles containing:
  1. Partners' approach to resiliency planning
  2. Program or project implementation related to CHP/DG
  3. Lessons learned and future plans
  4. Additional resources and information

CHP FOR RESILIENCY ACCELERATOR PARTNER PROFILES

The partner summary table highlights key partner accomplishments, initiatives, and strategies related to resilience planning, and implementing CHP or DG programs or projects. Please click on an individual partner to see more information in their individual partner profile. Partner profiles were completed through multiple interviews with each partner listed below and focus on 4 aspects: 1.) Resilience Planning, 2.) Program or Project Implementation, 3.) Lessons Learned, and 4.) Additional Information.

Partner Name	Partner Type	Key Accomplishments
City of Boston	City	Coordinated a pilot project for a multi-user CHP district energy microgrid and Community Energy Study
Healthcare Without Harm	Non-Profit Organization	Helped develop toolkits and initiatives focused on resilient healthcare facilities for the US Department of Health and Human Services' (HHS)
Hoboken, NJ	City	Completing a feasibility study for the development of a city-wide microgrid to connect and power critical and community facilities
International District Energy Association (IDEA)	Non-Profit Organization	Organizes stakeholder engagement events that highlight the importance of CHP, microgrids, and district energy in increasing energy resilience
Maryland Energy Administration	State Agency	Administers a CHP grant program designed to encourage the growth of CHP to improve end-user resilience throughout the state
Massachusetts Department of Energy Resources	State Agency	Provided project implementation support to add resiliency capabilities to clean energy technologies at hospitals
Miami-Dade Water and Sewer Department	City	Increasing the capacity of cogeneration units at two wastewater facilities studying of individual facilities to evaluate CHP and DER options
Missouri Department of Economic Development, Division of Energy	State Agency	Collaborated with Spire on several initiatives, such as co-hosting CHP summits focused on energy resiliency for critical facilities
Montgomery County, MD	County	Leading implementation of two pilot projects to enhance resiliency of individual facilities and the electric system with CHP
National Grid	Utility	Facilitated the interconnection of 900 MW of DERs for customers, and examining the feasibility of community microgrids in New York

Access the individual Partner Profiles here: https://betterbuildingssolutioncenter.energy.gov/accelerators/combined-heat-and-power-resiliency/chpr-partner-profiles

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CHP in Microgrids

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Microgrids

- A microgrid is a **group of interconnected loads and distributed energy resources** within clearly defined electrical boundaries that acts as a **single controllable entity** with respect to the grid.

- A microgrid can **connect and disconnect** from the larger utility grid to enable it to operate in both **grid-connected** or **island-mode.**

- Microgrids can use any combination of distributed energy resource (DER) technologies
  - Can be a single technology, such as combined heat and power (CHP), serving multiple buildings
  - Can be a group of connected DER technologies serving a single facility

- Microgrids are designed to improve resiliency of the delivery of electricity to connected facilities in order to perform critical functions when the larger utility grid is down

Source: U.S. DOE Microgrid Exchange Group

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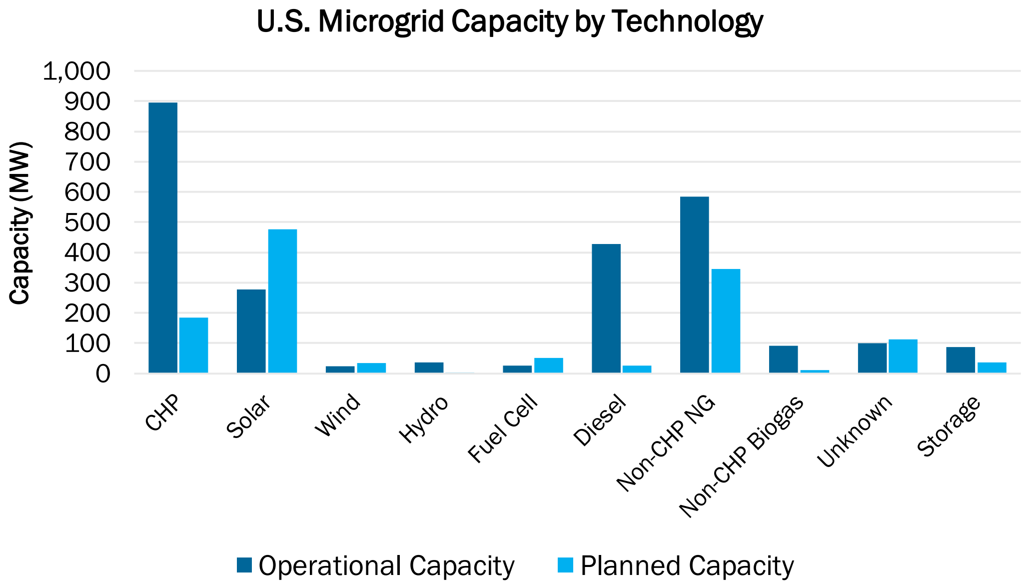
The Current Microgrid Market

- As of May 2019, there are 363 total microgrid projects in U.S.
  - 225 operational microgrids identified, with 3.85 GW of total capacity
  - 122 planned microgrid projects with 1.55 GW of expected capacity
  - 16 microgrids that have been stalled, or whose status is unknown
- CHP serves as resilient baseload anchor for many microgrids – most operational capacity by technology
- Microgrid market is growing fast, with solar PV increasing compared to current operational capacity



Currently 47 operational or planned microgrids have an installed CHP capacity of 5 MW or less – many are packaged CHP systems

Source: ICF Microgrid Database

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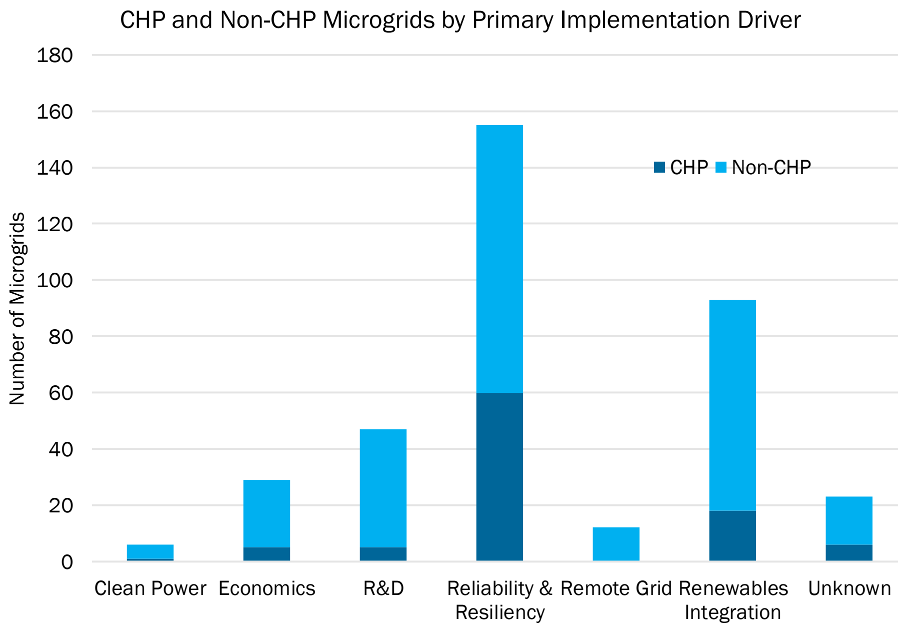
Microgrid Implementation Drivers

- End-users choose to install microgrids due to a combination of site-specific factors or implementation drivers

Implementation Driver	Description
Clean Power	Cut emissions using efficient and/or zero-carbon microgrid technologies
Economics	Reduce electricity, heating, cooling, and other costs through various mechanisms, such as self-generation (avoided utility costs), shared operation and maintenance, and lower fuel prices
R&D	Conduct research on new technologies, microgrid configurations, and financing arrangements
Reliability & Resilience	Improve electricity and thermal energy reliability and resilience during grid outages and other major disruptive events (critical infrastructure facilities)
Remote Grid	Provide power to remote locations that cannot rely on the power grid, such as an island community
Renewables Integration	Incorporate renewable technologies into power generation mix while using other technologies to offset the intermittency of renewables



Source: ICF Microgrid Database

Reliability, Resilience, and Power Quality Benefits of CHP Microgrids

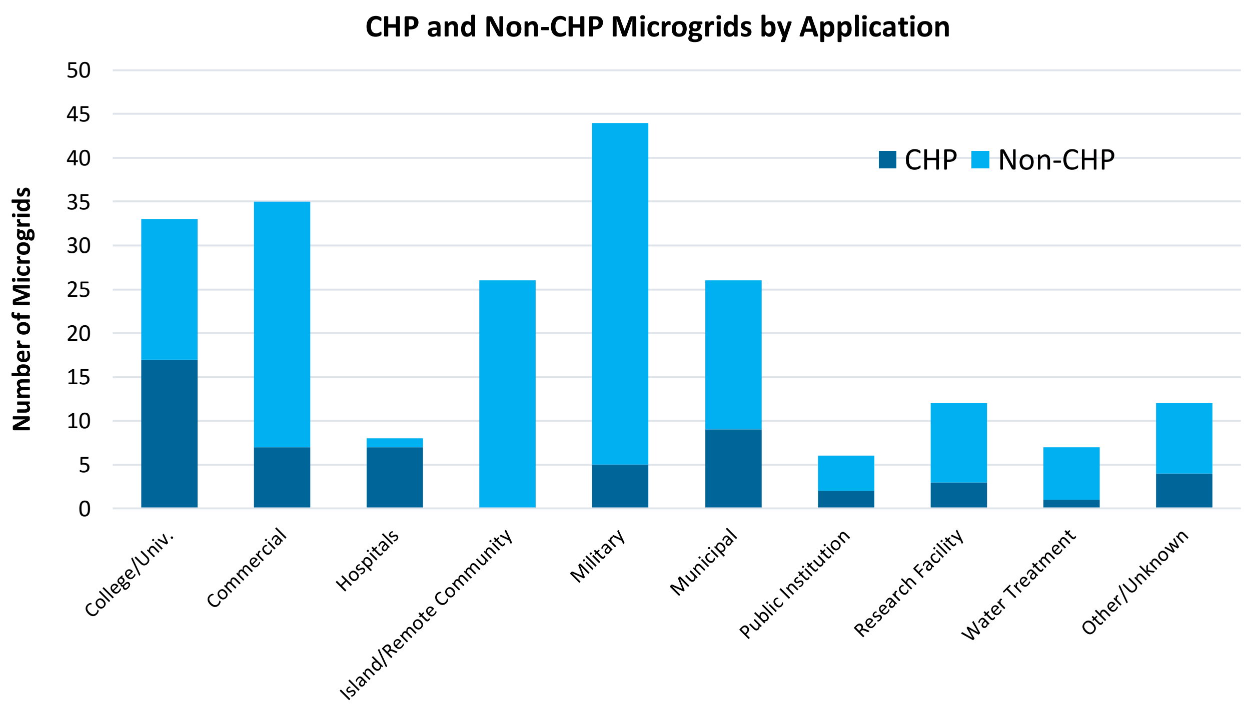
- Microgrids provide a variety of reliability and resilience benefits to customers located both within and outside the microgrid
- CHP systems are ideal for resilient baseload power

Reliability	Resilience	Power Quality
• CHP systems located closer to loads than central generators, reducing likelihood of outages • Fast-ramping capabilities allow quick response to changes in grid-supplied power, flexibility to serve dynamic loads • CHP systems reduce stress on local distribution grid, extending life of grid components and reducing risk of outage caused by individual distribution equipment failure	• CHP systems operate near-continuously, can provide firm backup generation during outages • Island-capable systems can maintain heat/power service to loads within the microgrid network during outages, fulfill load shedding requests during high demand periods • During Hurricane Sandy in 2012, every islanding-capable CHP that received NYSERDA incentives stayed online	• CHP microgrids serving large, power quality-sensitive C&I customers such as data centers, and high-tech manufacturing provide high-quality power without service interruptions or voltage dips • By locating generation closer to loads, CHP and district energy systems prevent voltage fluctuation and other power quality issues that typically arise on the distribution system

Source: ICF Microgrid Database

Microgrid Applications

- Microgrids are most often deployed in institutional campus settings, like military facilities, government buildings, hospitals, and universities
  - All buildings owned/operated by a single entity
  - Backup power and ability to sustain grid outages for critical facilities
- Microgrids could be tied to district energy "downtown loops", providing steam, hot/chilled water and electricity to various commercial/industrial facilities



Source: ICF Microgrid Database

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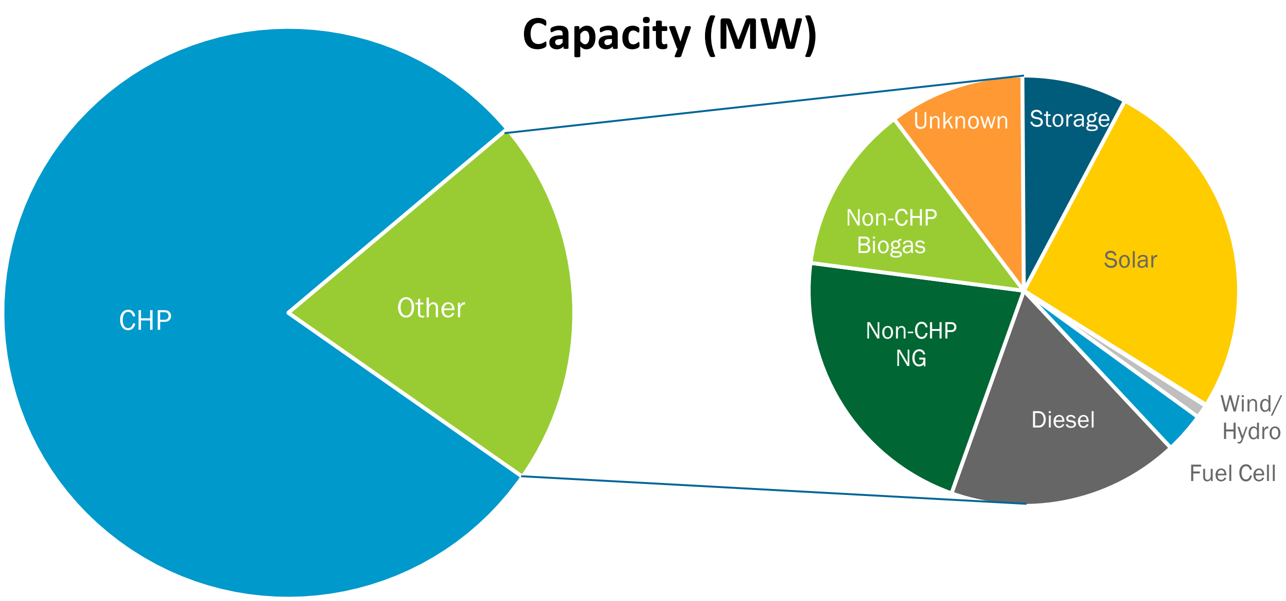
CHP Microgrids

- Many CHP microgrids do not incorporate other technologies, but there are several benefits of incorporating multiple DERs:
  - Stronger resilience
  - Higher operational flexibility
  - More use cases
- CHP can work together with PV, wind, energy storage, and other technologies in resilient microgrids with diverse resources and multiple value streams
- Technologies used with CHP in microgrids:



*Only operational microgrids with CHP

Source: ICF Microgrid Database

Microgrid Case Study: Montclair State University

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A Flexible Power Perspective, Montclair University

Kurt Koenig, VP-Project Development, DCO Energy, LLC

August 15, 2019

Discussion Points of Presentation

- Historical Energy Perspective at Montclair State University
- CHP Added to Campus under P3 Model
- Other Challenges on Campus
- Addition of microgrid plant
- Economics of microgrid plant
- Benefits to the University
- Summary

History

- 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.

Campus Utility Challenges

- 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.

Private Public Partnership

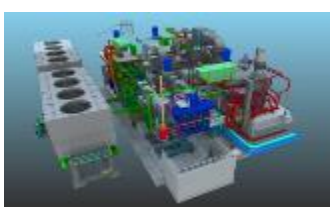
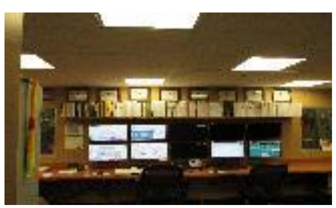
- In 2009 the NJ Economic Stimulus Act provided for the use of Public Private Partnerships (PPP) for Colleges and Universities.
- The Montclair District Energy System was the first PPP utilized for Energy.
- Project Financing Utilized
  - Taxable Bonds
  - Tax-exempt Bonds
- UMM Energy Partners and MSU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

Initial Installation

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

First Phase Results

- Commercial September 2013
- 86% of electricity from Cogen
- Availability of 97.38%
  - .03% unscheduled
- 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


Planning for the Future

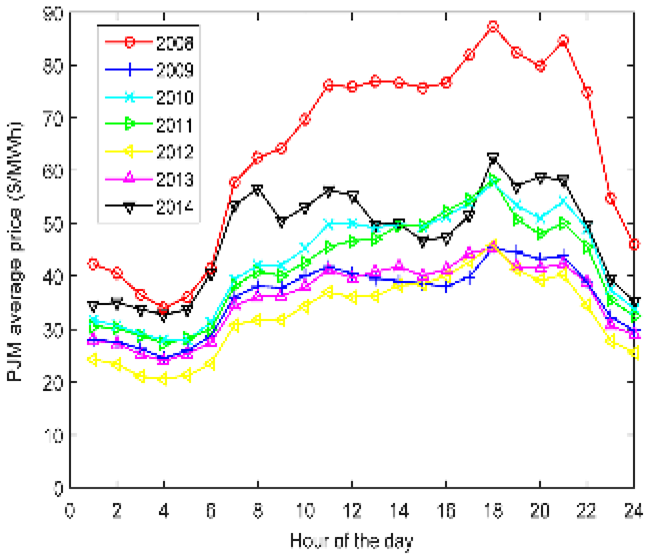
- Emergency Generation aging and in numerous locations Campus electric load growing.
- High Demand ratchet for supplemental power.
- Load Shed Scheme not in place.
- Improve Sustainability Metrics
- Average of 3 campus blackouts per year (30 minutes to 2 hours)
- Resiliency Issues – Super Storm Sandy

Microgrid Economic Drivers

- Cogeneration offsets campus base electric load. Fluctuations in campus load and generation stresses the grid, resulting in significant utility costs to the campus. These costs - demand and capacity charges - are increasing as a component of electricity bills.
- The anticipated continued buildout of transmission/capacity/distribution within to accommodate intermittent resources anticipated to result in much higher demand charges thus increasing savings and making the microgrid more valuable to university.

Microgrid Economic Drivers

- **<u>LMP Price $/kwh (Locational Marginal Price):</u>** Reviewed Energy Pricing on hourly $/kwh for summer and winter periods for MSU Zone
- **<u>Utility Peak Demand</u>** Reviewed 15 minute demand data to determine supplemental power peak loads; year by year adjustment
  - Summer Peak $/kw
  - Annual Peak $/kw
- **<u>PJM Generation and Transmission Obligation $/kw</u>**: 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



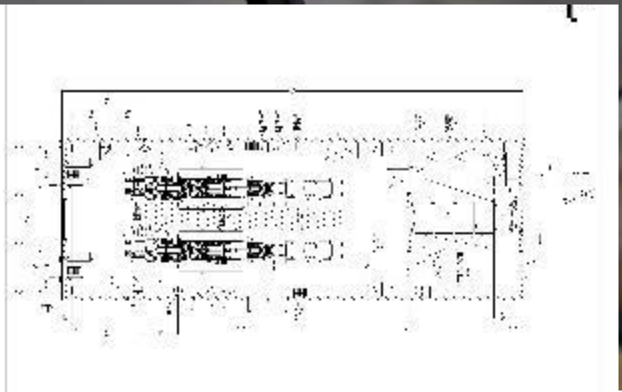
Microgrid Plant Design

- 2 X 2.6 MW GE Jenbacher JGS 616 natural gas fired reciprocating engine generators. (LNG Option)
- 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.
- Total functionality with loss of Utility Grid.
- Permitted for approximately 2,000 hours of operation.
- System is export capable

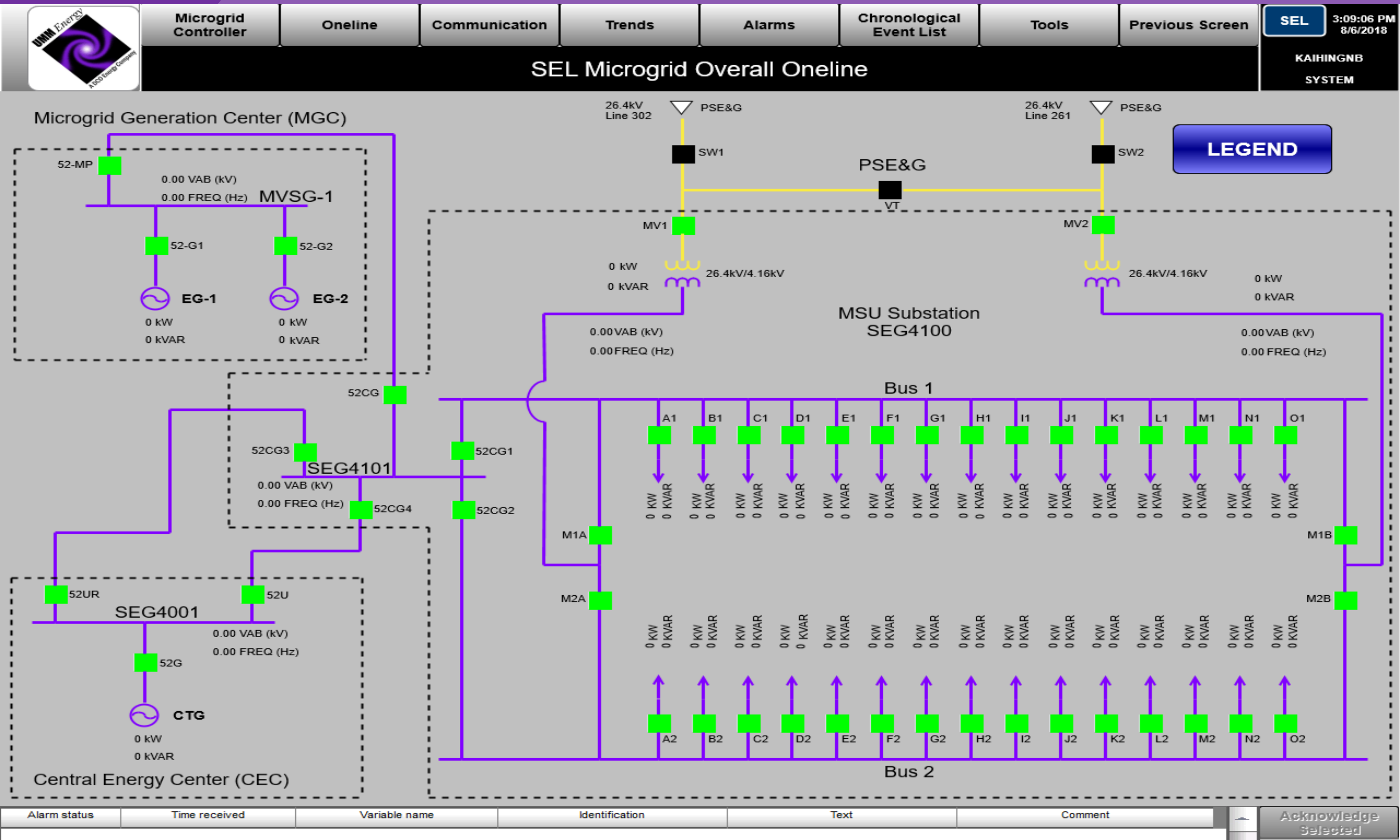
Projecy Completion, May 2018

DCO Energy

View Inside

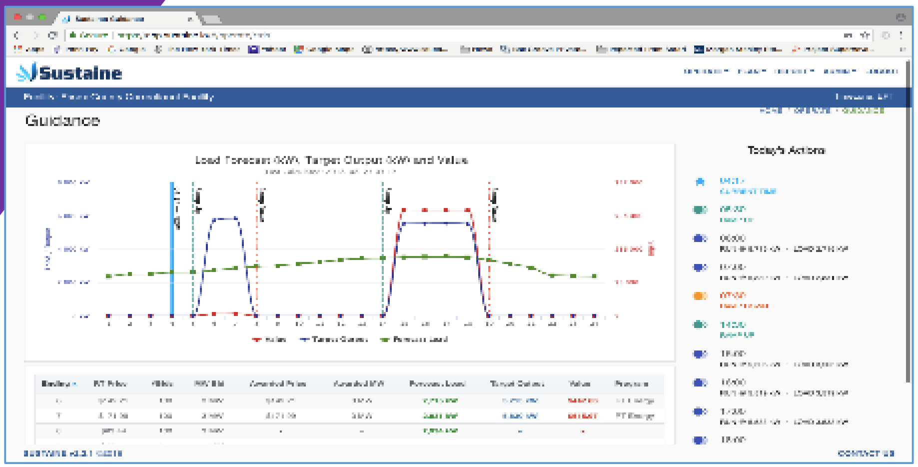


Single Line



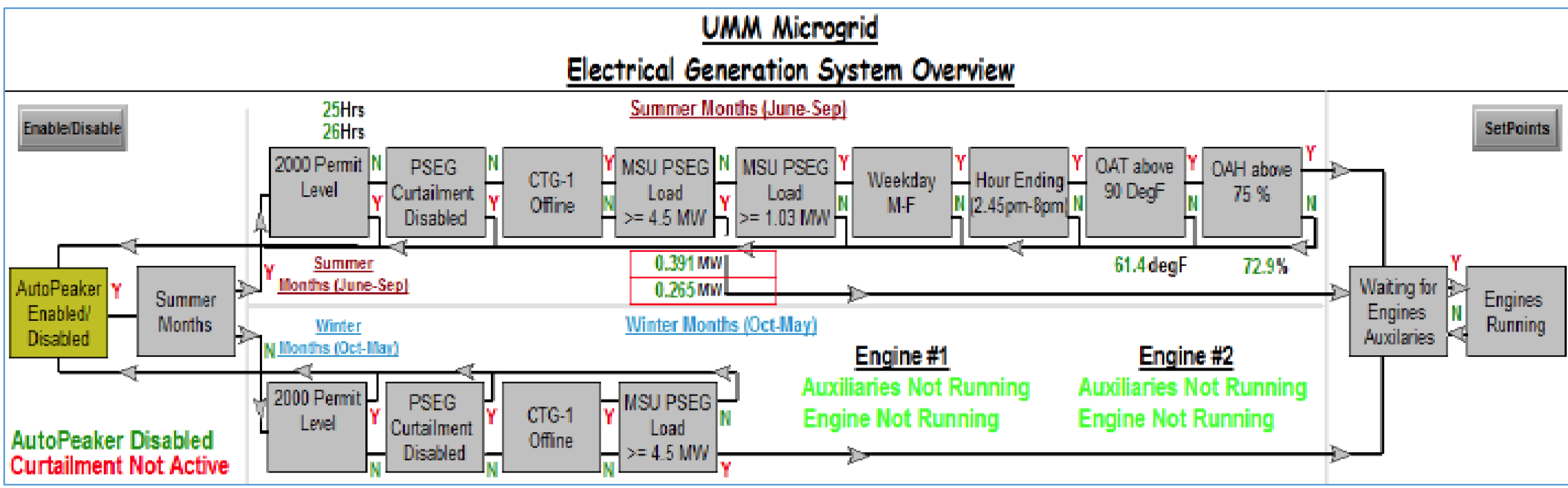
Microgrid Controller
Oneline
Communication
Trends
Alarms
Chronological Event List
Tools
Previous Screen
SEL
3:09:06 PM 8/6/2018
KAIHINGNB
SYSTEM
SEL Microgrid Overall Oneline
Microgrid Generation Center (MGC)
52-MP
0.00 VAB (kV)
0.00 FREQ (Hz)
MVSG-1
52-G1
52-G2
EG-1
EG-2
0 kW
0 kVAR
26.4kV Line 302
PSE&G
SW1
26.4kV Line 261
SW2
PSE&G
VT
LEGEND
MV1
MV2
26.4kV/4.16kV
MSU Substation SEG4100
52CG
52CG3
SEG4101
52CG1
52CG4
52CG2
Bus 1
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1 K1 L1 M1 N1 O1
0 KW
0 KVAR
M1A
M1B
M2A
M2B
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2 K2 L2 M2 N2 O2
Bus 2
52UR
52U
SEG4001
52G
CTG
Central Energy Center (CEC)
Alarm status
Time received
Variable name
Identification
Text
Comment
Acknowledge Selected

Microgrid Dispatch



Dispatch Criteria

- Weather
- Campus Load
- PJM Day Ahead
- Campus Summer Events
    - Move In day



Load Management Control Functions

- **Contingency Based Load Shedding** (CLS) – Open breakers to ensure Load = Generation during island condition to avoid a blackout.
- Backup simplified **Underfrequency based load shedding** (UFLS)
- **Generation control system** (CGS) to control generating assets
- **Load Restoration** – reclose breakers as additional generating assets are sync'd.

Bottom Line Objective: NO CAMPUS BLACKOUT CONDITIONS

DCO Energy

Summary

- Created Economic Value to MSU - Net Savings of $387,000
- Island Mode Operations for Resiliency for Environmental Events
- Increased Sustainable Results - CO_2 Reduction of 24,000 tons per year
- Easier Load Management - Zero Campus Blackouts
- Insulate MSU from increasing demand charges

DCO Energy

Questions

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Packaged CHP Accelerator Next Steps

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Packaged CHP Accelerator Next Steps

- eCatalog Update
  - 27 Recognized Packagers
  - 14 Recognized Solution Providers
  - 50 Recognized Packages (24 kW to 7.5 MW)
    - ✓ 139 individual product offerings
- Engagement Partner Actions
  - Enroll in the eCatalog
    - ✓ Review Packager/Solution Providers and “accept” for program recognition
  - Partner Roadmap Development
    - ✓ Individual partner call scheduling upcoming

Packaged CHP Accelerator Next Steps

- Continued webinar series
  - Next webinar on September 19th, CHP Feasibility Screening and Working with the CHP Technical Assistance Partnerships (TAPs)
- CHP Supplier Partner Meeting
  - November 18, PowerGen 2019, New Orleans
  - Engagement Partners welcome
- Staffing Changes
  - Isaac Chan – new Technical Partnerships Manager
  - Anne Hampson – leaving ICF, Nick Posawatz taking over Accelerator support

DOE Team

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