Lessons Learned from Microgrid Design Studies in New York

IDEA2019
110th Annual Conference & Trade Show
Pittsburgh, PA

Lavelle Freeman
Bahman Daryanian
GE Energy Consulting

June 25, 2019

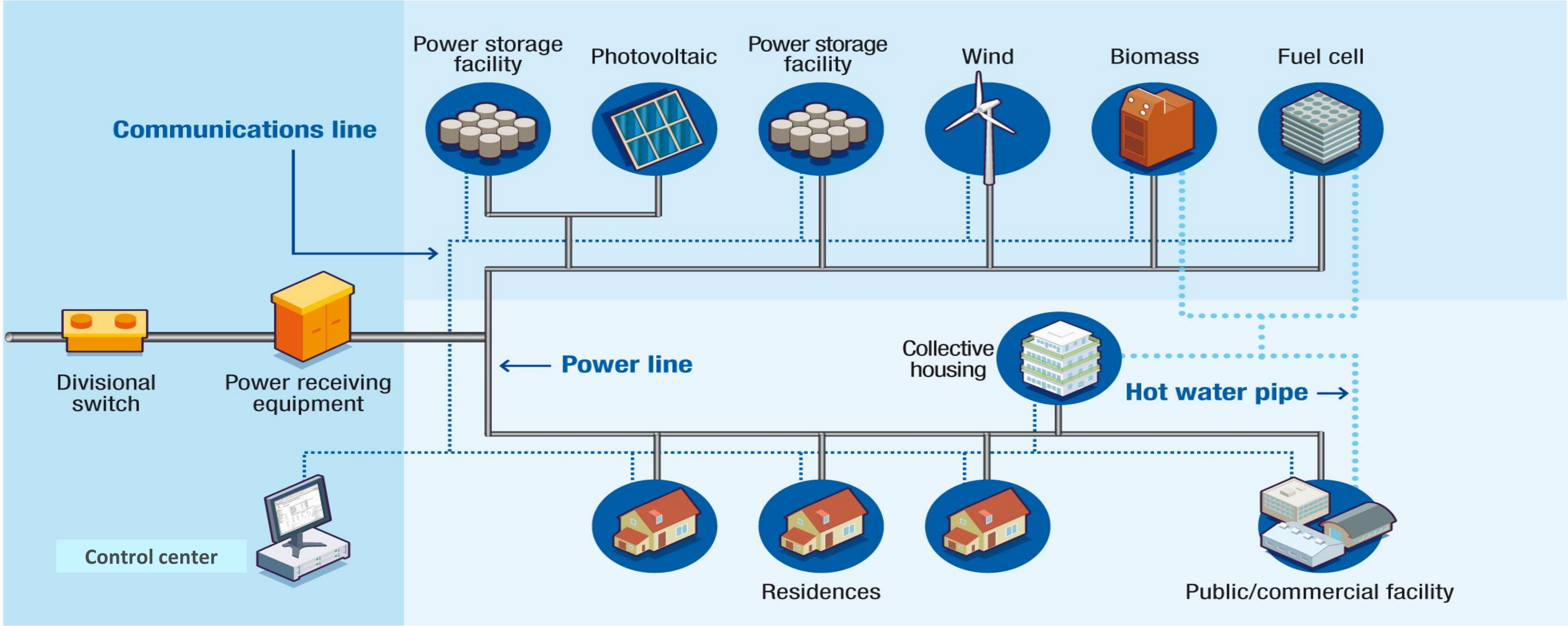
Agenda

- Background on Microgrids
- Design Process
- NY Prize Competition
- Project Examples
- Key Take-Aways

Microgrids Background

What are Microgrids?

MICROGRIDS = Integrated Energy System and Control + Distributed Energy Sources (Generation, Storage) + Loads (Demand Response)



Microgrids

An integrated energy system with distributed energy resources and interconnected loads, operated in parallel with the grid or in an intentional island mode.

Market Segments and Drivers

Energy Surety	Economic Value	Sustainability	Resiliency
MILITARY Bases w/ Critical Infrastructure	 **INDUSTRIAL** Mining/Refineries Ports	 **ISLANDS** Remote Grid Communities	 **Institutional / District** University/Hospitals Community/Utility Microgrids

DRIVERS

BASE ISLANDING	CRITICAL INFRASTRUCTURE	FOSSIL FUEL DEPENDENCE	ENERGY RESILIENCY
ENERGY SECURITY	COE REDUCTION	RENEWABLES INTEGRATION	CRITICAL INFRASTRUCTURE
CRITICAL INFRASTRUCTURE	ENERGY RELIABILITY	ENERGY RESILIENCY	COE REDUCTION
COE REDUCTION	ENERGY SECURITY	COE REDUCTION	ENERGY EFFIICIENCY
ENERGY EFFICIENCY	ENERGY EFFICIENCY	ENERGY EFFICIENCY	MICROGRID R&D
RENEWABLES INTEGRATION	RENEWABLES INTEGRATION	ENERGY SECURITY	RENEWABLES INTEGRATION

Primary Drivers
Secondary Drivers

Convergence of environment, energy cost/efficiency, security, and system resiliency and reliability prove to be the key drivers for Microgrids . . .

Principal Elements of Microgrids and Minigrids

Supply Side/DER

Distributed Generation

- Fuel Cells
- Gas Turbines
- Micro-turbines
- RICE
- CHP/CCHP
- Solar PV

Energy Storage

- Battery Storage
- Thermal Storage
  - Heat
  - Cool

Power Delivery

- Distribution infrastructure
  - Lines/cables
  - Transformers
  - Switchgear
- Protection and Relaying
  - Breakers/relays
  - Fuses
  - Reclosers/sectionalizers
  - Coordination
- Automation/Smart Grid
  - Smart devices
  - Dynamic reconfiguration

Demand-Side

- Load/demand
  - Critical loads
  - Discretionary loads
  - Curtailable loads
- Demand Response & Energy Efficiency
  - Event-Responding Demand Response
  - Price Responding Demand Response (Dynamic Pricing)
- Electric Vehicles (EV)

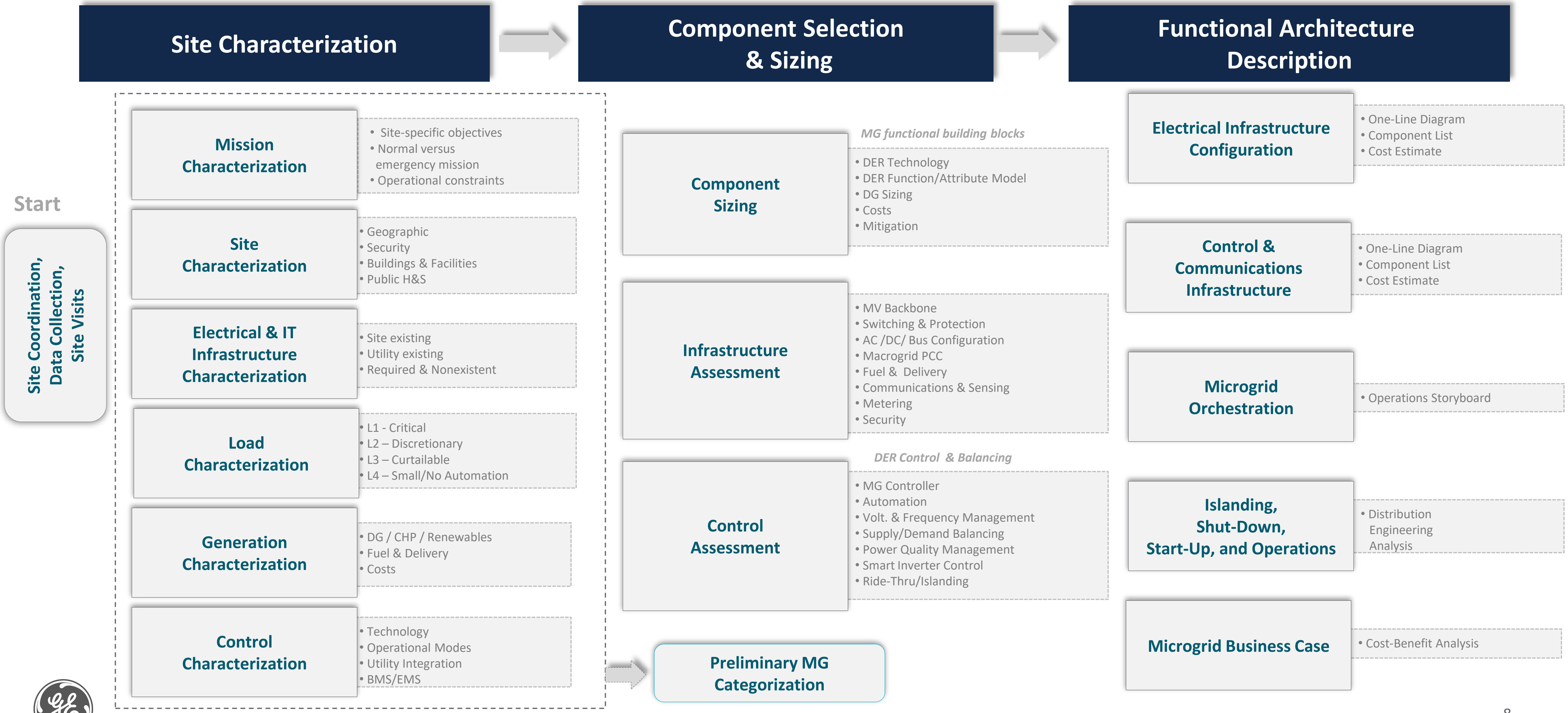
Control and Comms

- Microgrid Controller
  - Monitoring and Visualization
  - DER Dispatch
  - Optimized operation
- Command & Control
- Communications & IT
- DERMS/DMS integration
- Cybersecurity

Microcosm of an electric power systems with associated challenges and opportunities

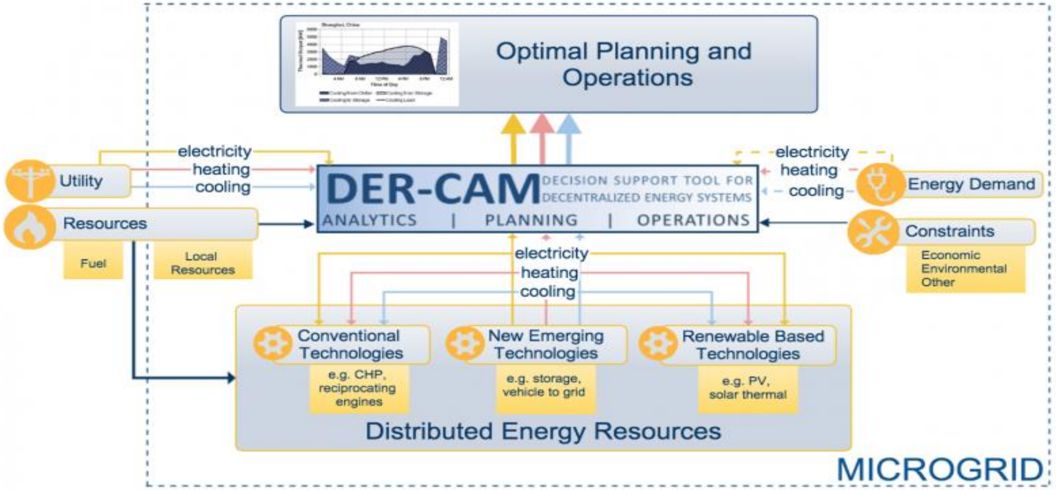
Microgrid Design Process

Microgrid Assessment & Task Workflow



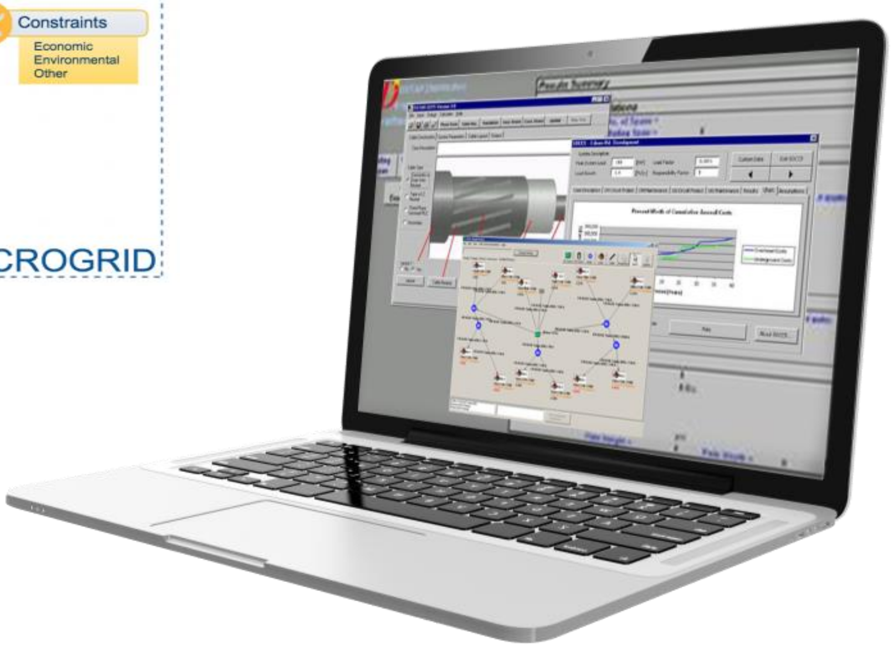
Design and Analysis Tools

- DER SELECTION, DER DISPATCH
- LOAD & SUPPLY ANALYSIS



- BULK POWER SYSTEM MODELS
- GE CONCORDA SUITE

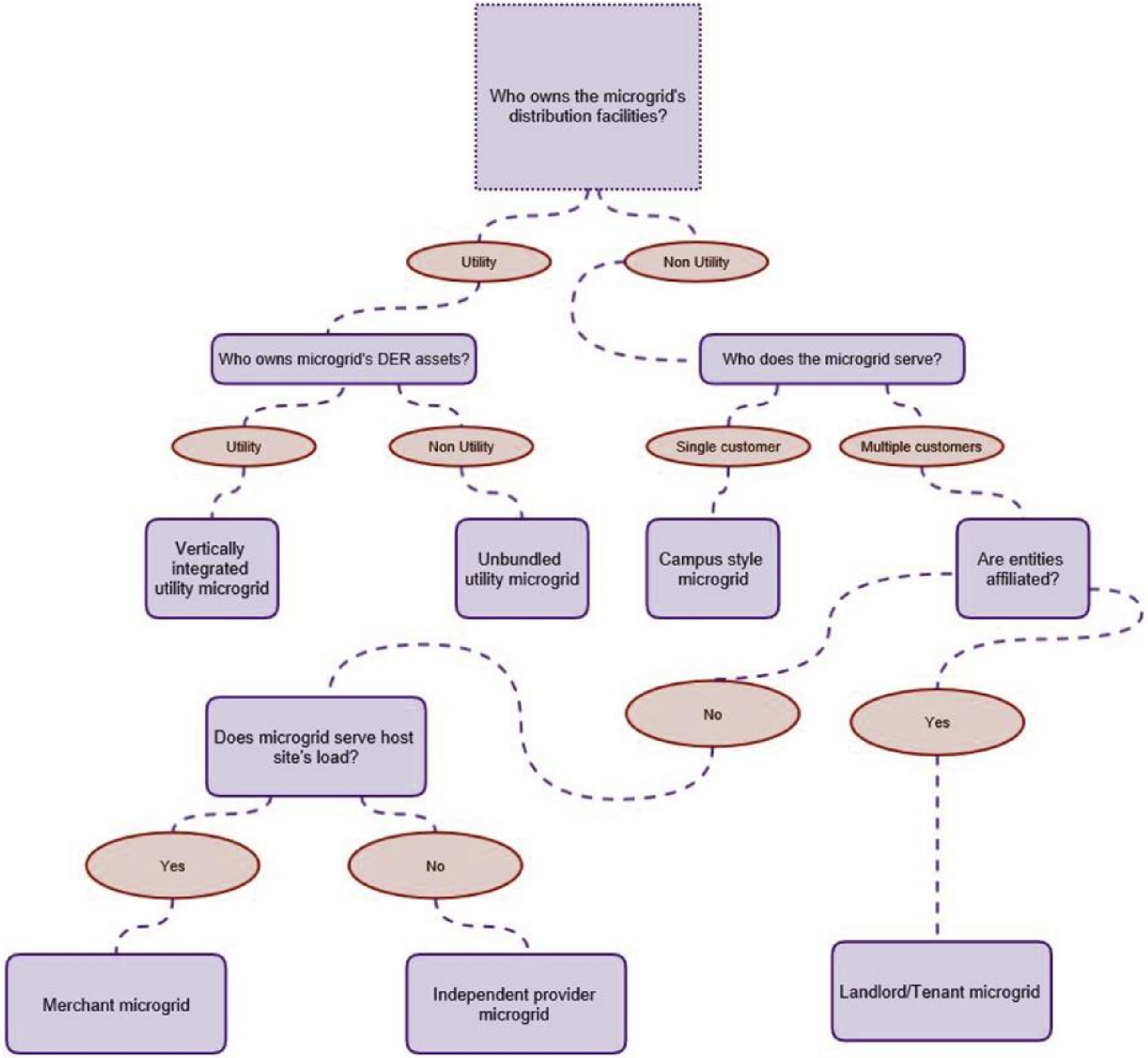
- DISTRIBUTION ANALYSIS TOOLS
- COMMERCIAL & CUSTOM



Combination of tools and techniques applied to evaluate system technical and economic operation

“Soft” Aspects of Project Development

- Ownership Model
  - Utility/NYISO Role
  - Developer/Owner/Operator Role
  - Customers/Tenants Role
- Regulatory/Policy Challenges
  - Service Model
  - Market Participation (Retail/Wholesale)
- Viable Financial Model
  - Business Case/Justification
  - Financial Model
  - State/Federal Incentives



NY Prize Competition

NY State Energy Plan for 2030

Regulation & Policy

- Reforming of Energy Vision (REV)
- Clean Energy Standards

Guiding Principles

- Fostering more DER
- Market Transformation
- Community Engagement
- Economic Efficiency
- Private Sector Investment
- Innovation and Technology
- Customer Value and Choice

Goals

- 40% reduction in Greenhouse gas (GHG) emissions from 1990
- 50% of electricity generation from renewable energy resources
- 23% decrease in building energy consumption
- 600 Trillion BTU increase in statewide energy efficiency

NY Prize Community Grid Competition

Complete

Stage 1:
Feasibility Study
(2015 -2016)

- Qualitative Characterization of the community grid
- Description of Technical, Commercial and Financial Feasibility
- Conceptual Design of Electrical and Communication Infrastructure
- Preliminary commercial structure
- Preliminary financial model
- Identify regulatory/policy hurdles

$100K per 83 projects

Near Complete

Stage 2:
Detailed Design
(2017-2018)

- Detailed Technical/Engineering Design
- Project Valuation and Investment Planning
- Regulatory/Legal, Environmental Assessment
- Development of Formal Commercial Terms/Contractual Relationships
- Final Detailed Project Development and Operational Proposals

$1M per 11 projects

Stage 3:
Project Buildout
(2019+)z

- Overall cost and benefits of the project
- Portion of project revenue requirements provided by private sector
- Project's contribution to public need
- Technical and operational performance
- Demonstrated reliability of microgrid configuration
- Use of clean and renewable generation resource

Funding levels TBD

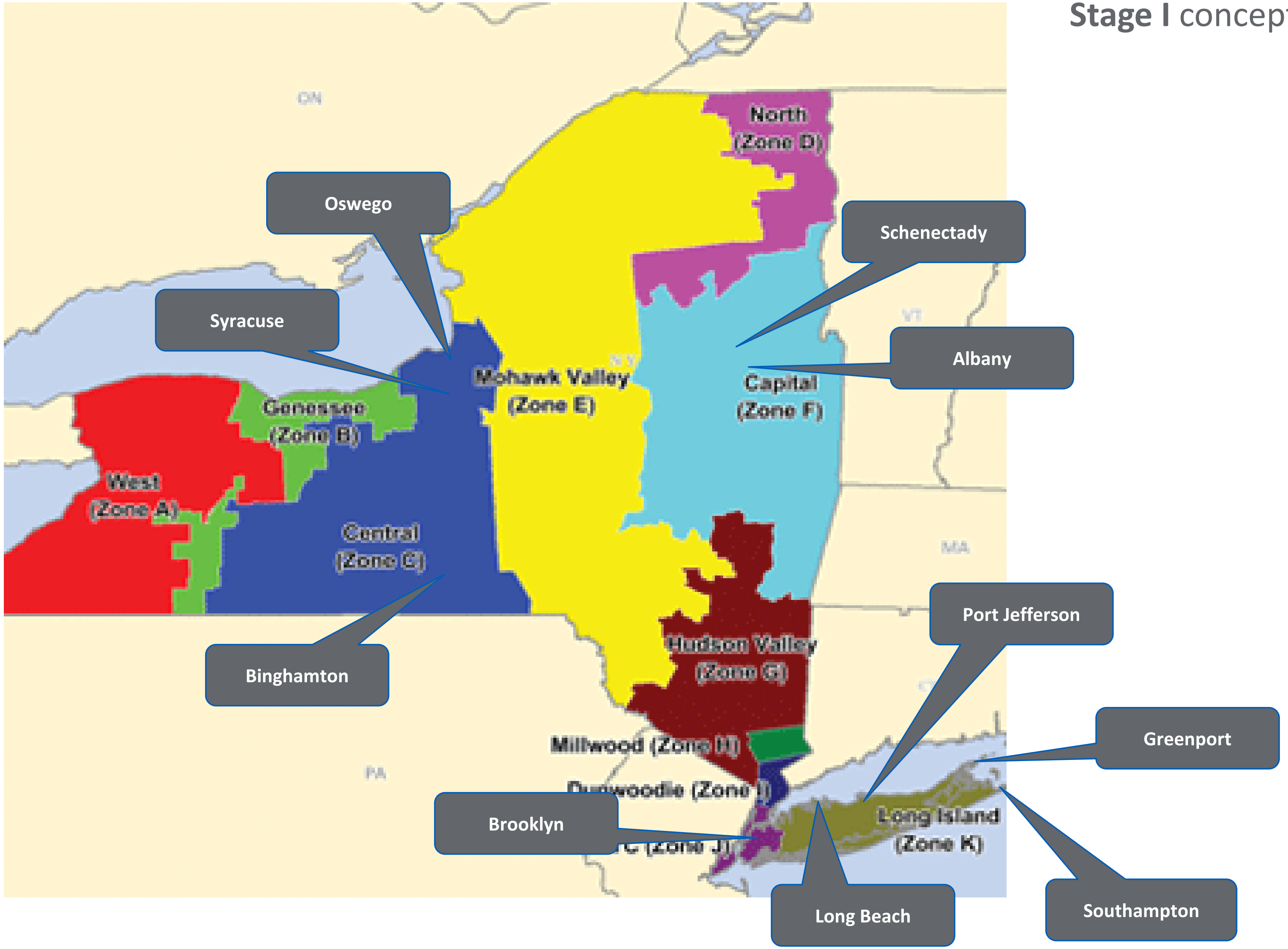
NY Prize Microgrid Design Elements

Project Features and Technologies

- Power critical facilities in the community during major events
- Use existing and/or new T&D infrastructure to connect loads to disparate sources
- Incorporate a variety of DER (not just diesel)
- Optimize operation using advanced communication and control technologies
- Significant societal benefit predicated on resiliency and reduced fossil fuel use
- Multiple Points of Interconnection (POIs) to the main grid

GE's Stage 1 Projects

Worked with **ten** communities and **five** utilities to develop **Stage I** conceptual designs



GE's Stage 2 Projects

Worked with **five** communities and **three** utilities to develop **Stage II** detailed designs

Binghamton Project Example

Impact of Tropical Storm Lee
Downtown Binghamton 2011

Critical Facilities Downtown Between the Two Rivers

Starting point for stage 1 design

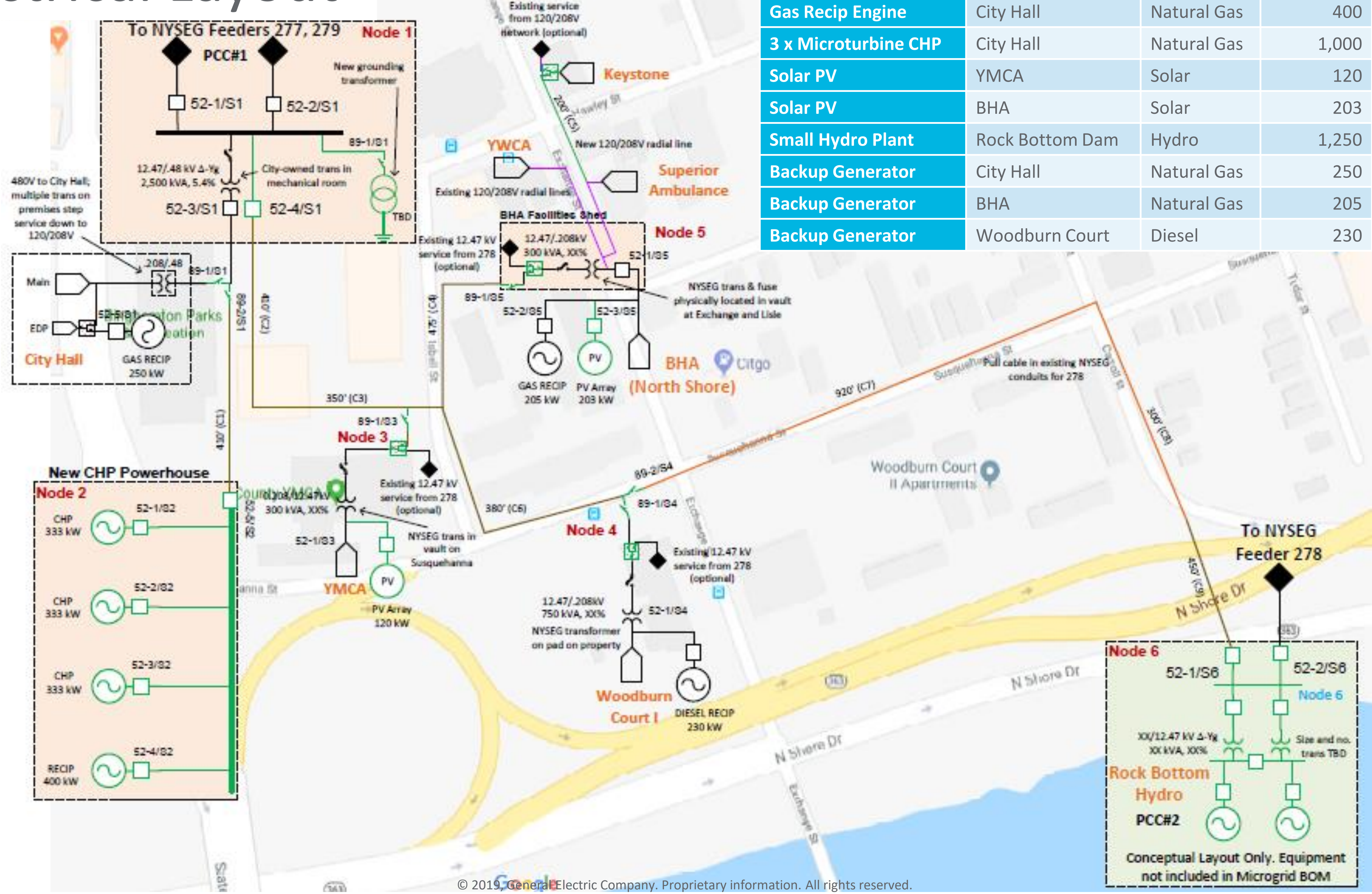
#	Participant
1	City Hall, Police & Fire Dept.
3	Holiday Inn
4	Twin River Commons
5	YMCA
6	YWCA
8	Keystone Associates
9	Kradjian Properties
13	PV - Rooftop, Groundmount, Canopy
14	Rock Bottom Dam
15	Veterans Memorial Arena
16	County Office Building
17	State Office Building

Final Stage 2 Participants

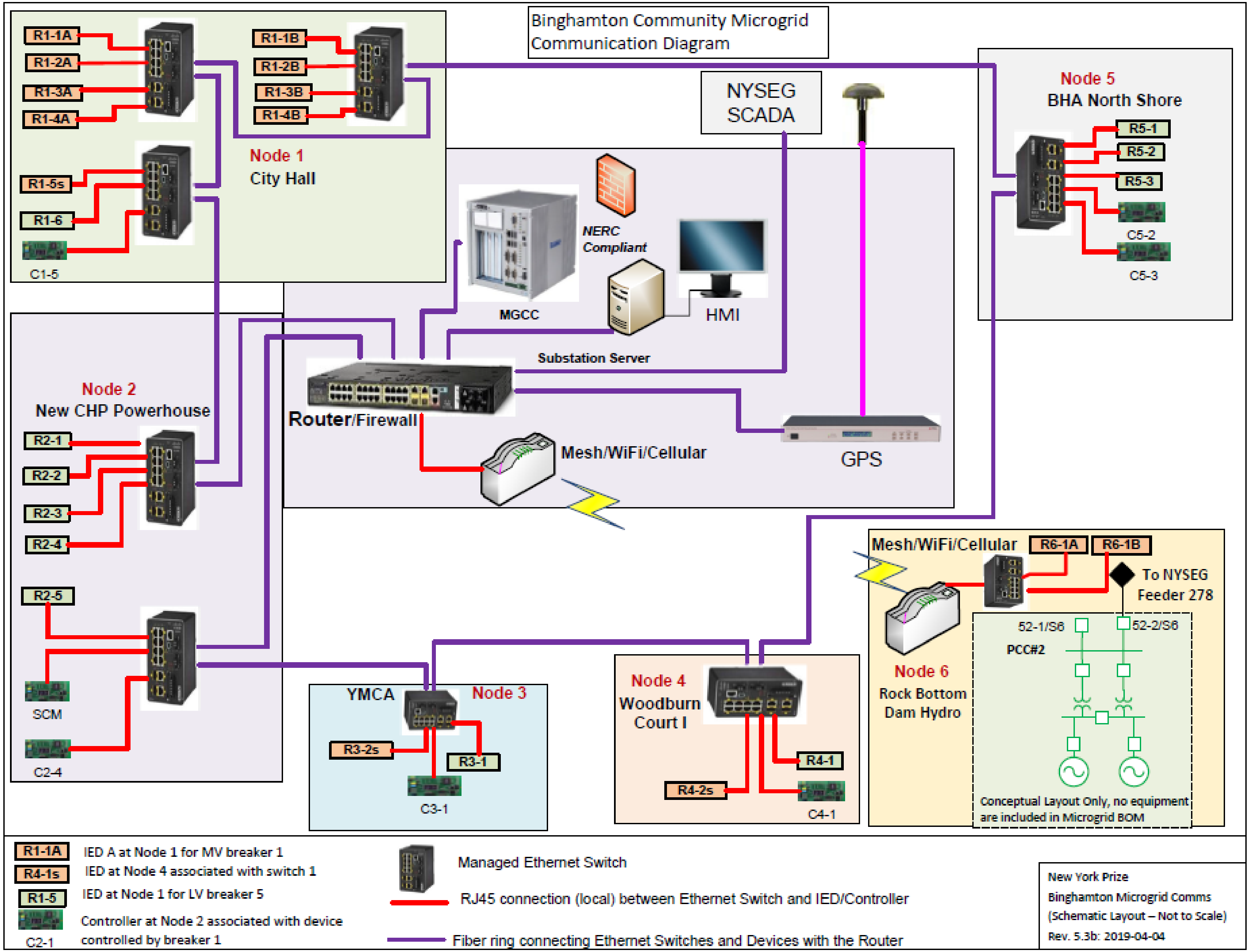
#	Participant
1	City Hall, Police & Fire Dept.
2	YMCA
3	YWCA
4	Binghamton Housing Authority
5	Keystone Associates
6	Superior Ambulance
7	Woodburn Court Apartments
8	Rock Bottom Dam

Electrical Layout

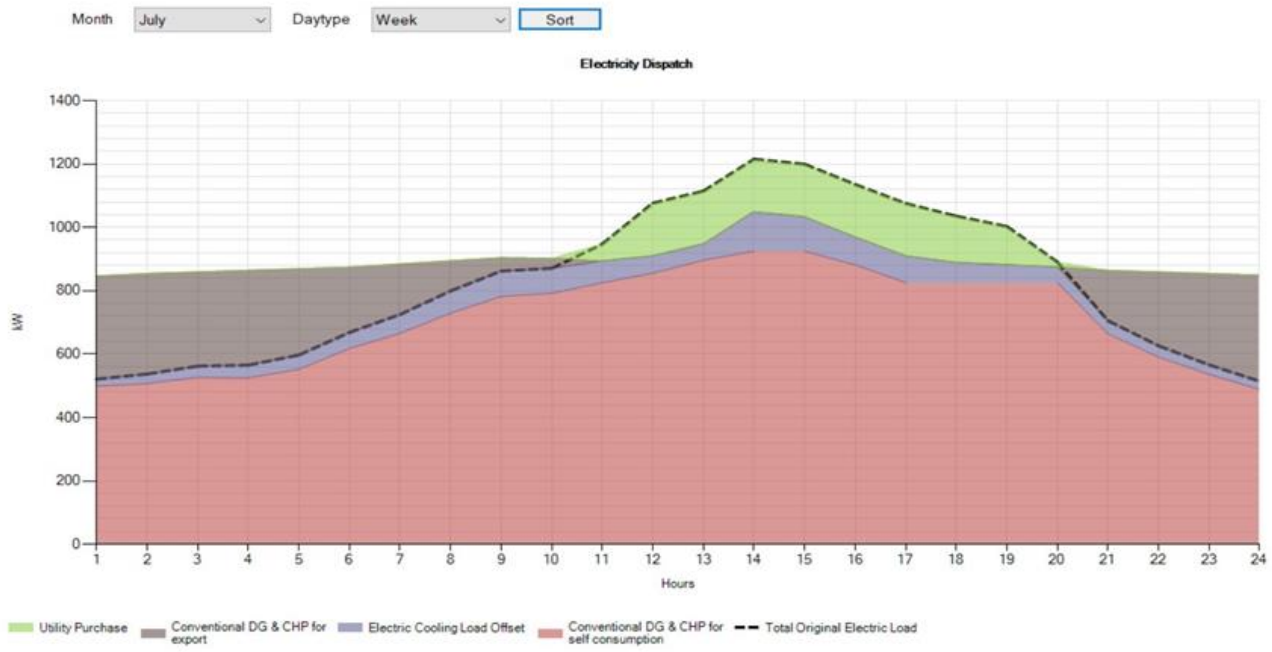
DER	Location	Energy Source	Capacity (kW)
Gas Recip Engine	City Hall	Natural Gas	400
3 x Microturbine CHP	City Hall	Natural Gas	1,000
Solar PV	YMCA	Solar	120
Solar PV	BHA	Solar	203
Small Hydro Plant	Rock Bottom Dam	Hydro	1,250
Backup Generator	City Hall	Natural Gas	250
Backup Generator	BHA	Natural Gas	205
Backup Generator	Woodburn Court	Diesel	230



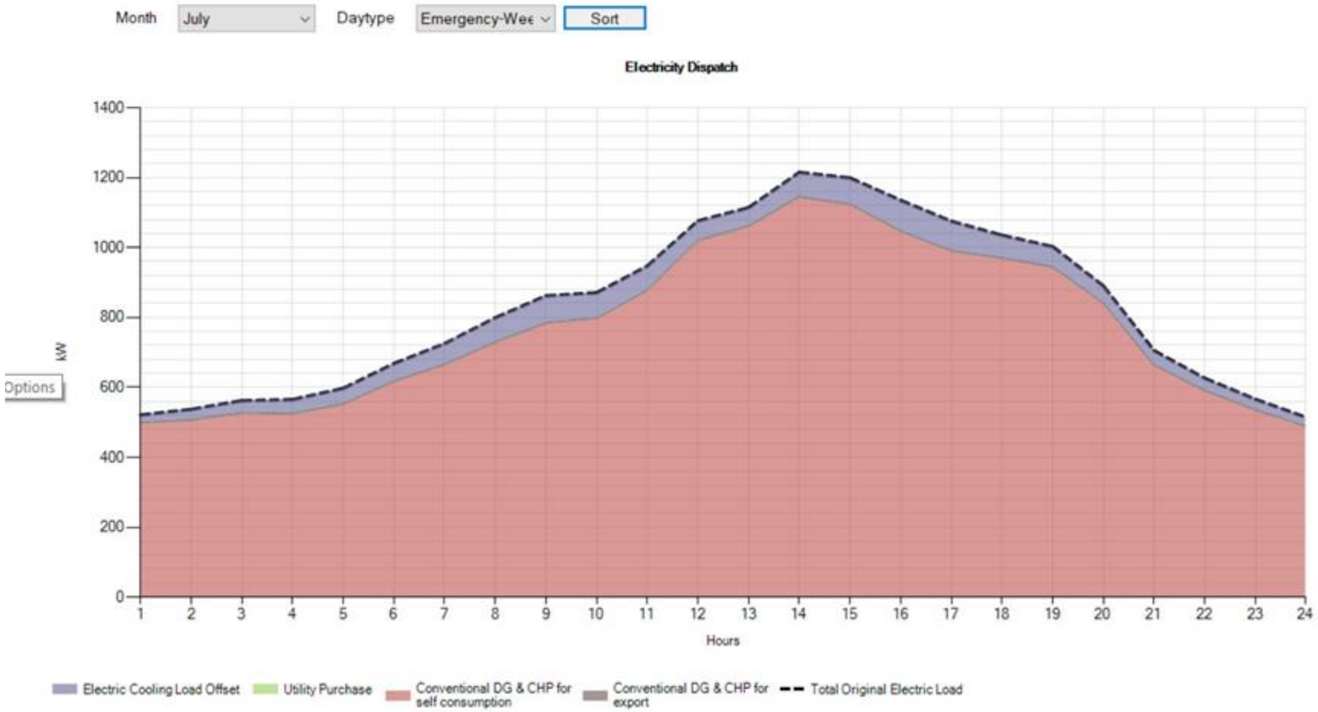
Control and Comms Layout



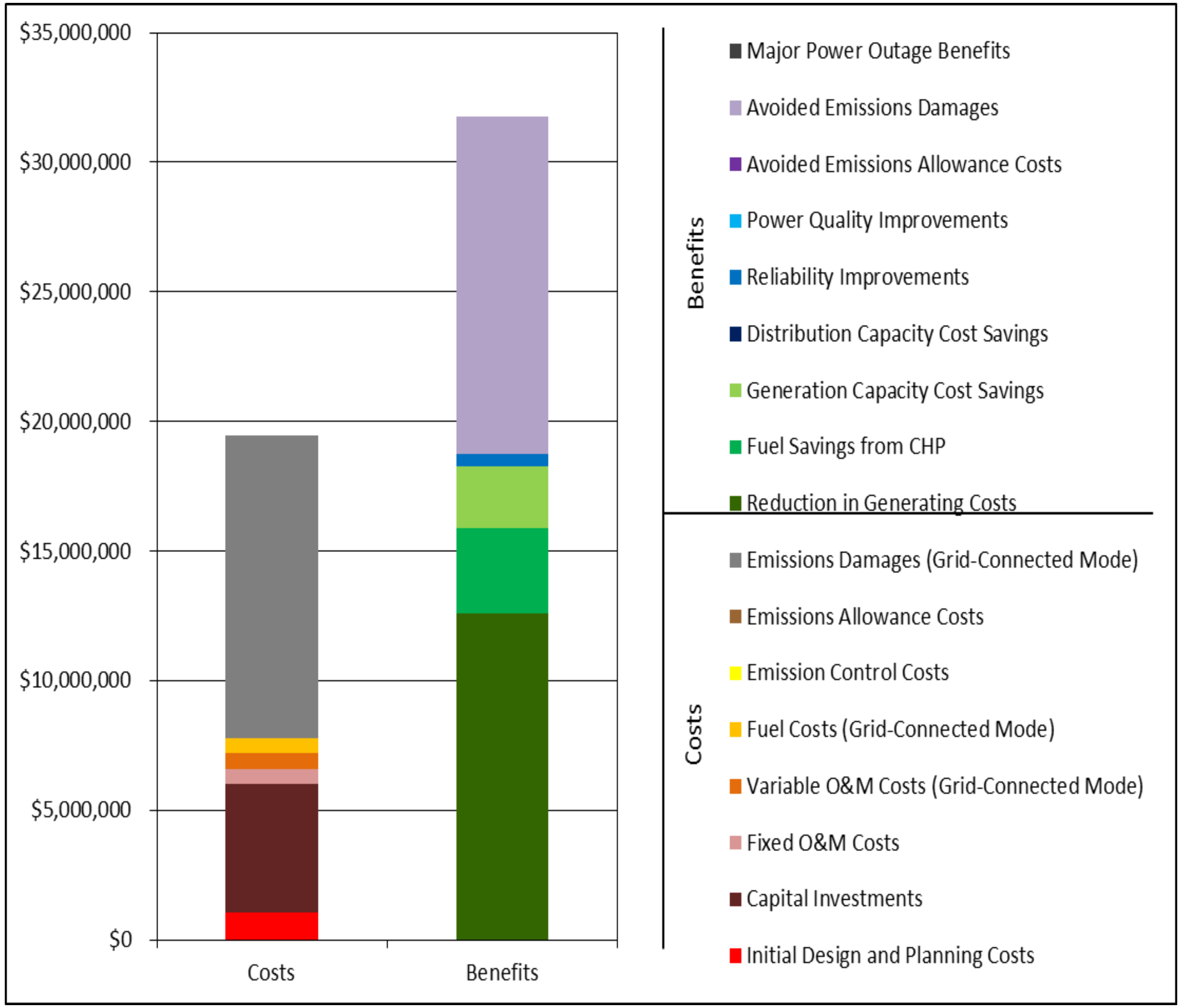
Microgrid Dispatch for Normal week in July



Microgrid Dispatch for Emergency week in July



Summary of Benefit-Cost Analysis (Stage 1) Binghamton



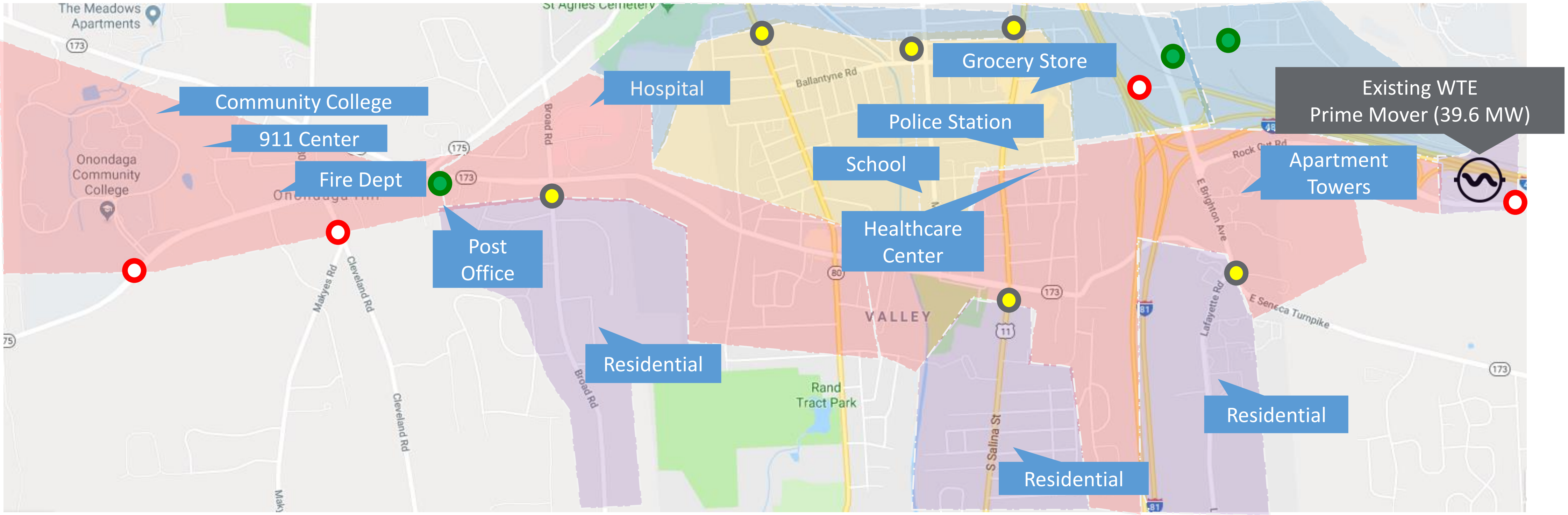
COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)
Costs	
Initial Design and Planning	$1,050,000
Capital Investments	$4,970,000
Fixed O&M	$567,000
Variable O&M (Grid-Connected Mode)	$626,000
Fuel (Grid-Connected Mode)	$559,000
Emission Control	$7,930
Emissions Allowances	$0
Emissions Damages (Grid-Connected Mode)	$11,700,000
Total Costs	**$19,500,000**
Benefits	
Reduction in Generating Costs	$12,600,000
Fuel Savings from CHP	$3,310,000
Generation Capacity Cost Savings	$2,370,000
Distribution Capacity Cost Savings	$0
Reliability Improvements	$465,000
Power Quality Improvements	$0
Avoided Emissions Allowance Costs	$6,910
Avoided Emissions Damages	$13,000,000
Major Power Outage Benefits	$0
Total Benefits	**$31,800,000**
Net Benefits	**$12,300,000**
Benefit/Cost Ratio	**1.6**
Internal Rate of Return	**28.4%**

Syracuse Project Example

Syracuse Microgrid Facilities

Facility Name	Facility/Customer Description
Onondaga Community College	Community College
SUNY Upstate University Hospital	Hospital
Van Duyn Center for Rehab and Nursing	Nursing home
Onondaga County Consolidated 911	911 Emergency Dispatch
Syracuse Community Police Department	Police
Onondaga Hill Fire Department	Fire Department
Betts Branch Onondaga Public Library	Library / Place of Refuge
Loretto Campus	Senior Housing
Various Apartment Buildings	Residential Dwellings
Betts Branch Onondaga Public Library	Library / Place of Refuge
Onondaga Middle School	School / Place of Refuge
St. Michaels Church	Place of worship / Place of Refuge
Mobile Gas Station	Fuel, food, ATM
Kinney Drugs	Drug Store, Food,
Over 2,000 Residential & Small Commercial Customers	Various
TOTAL Microgrid Load:	**17.4 MW peak load**

Microgrid Facility Layout



Generator

Facility

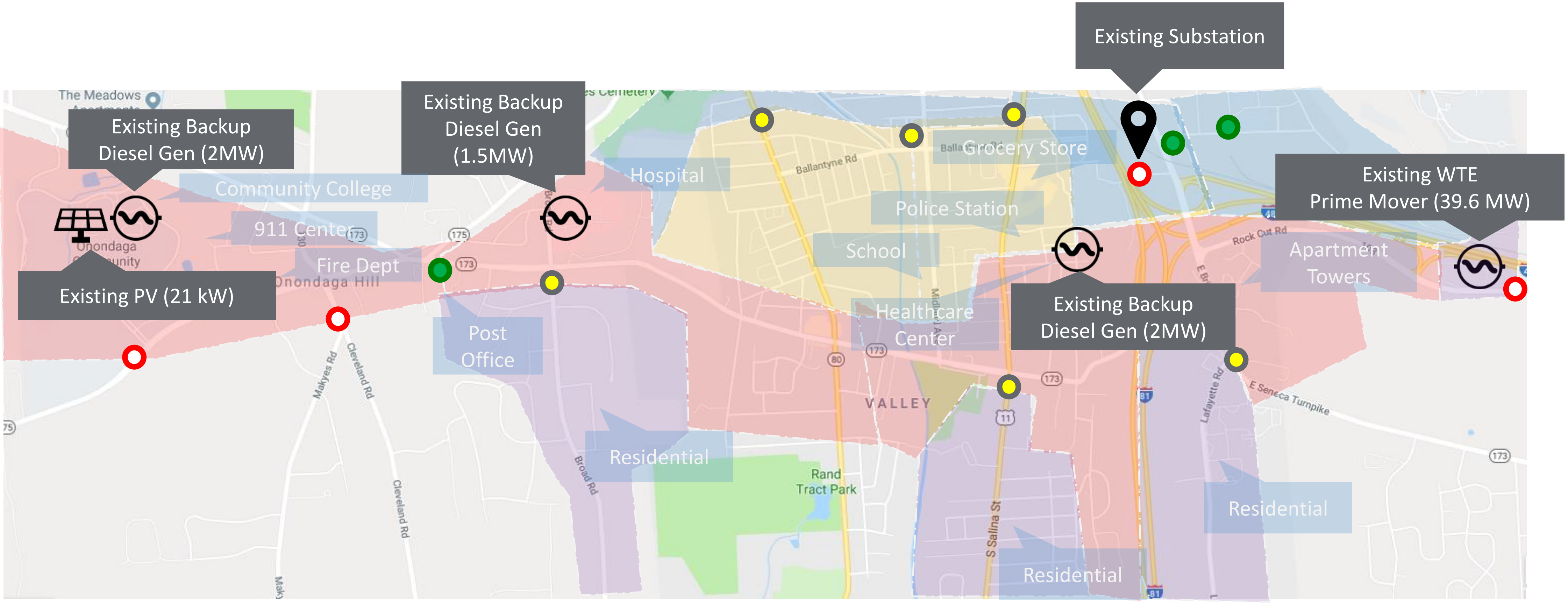
Open Switch

Load Shed Switch

Closed Switch

- 4 miles across
- Consists of 4 utility-owned feeders
- New switching to divide feeders
- Localized load shedding

Microgrid Existing Distributed Generation



Generator

Facility

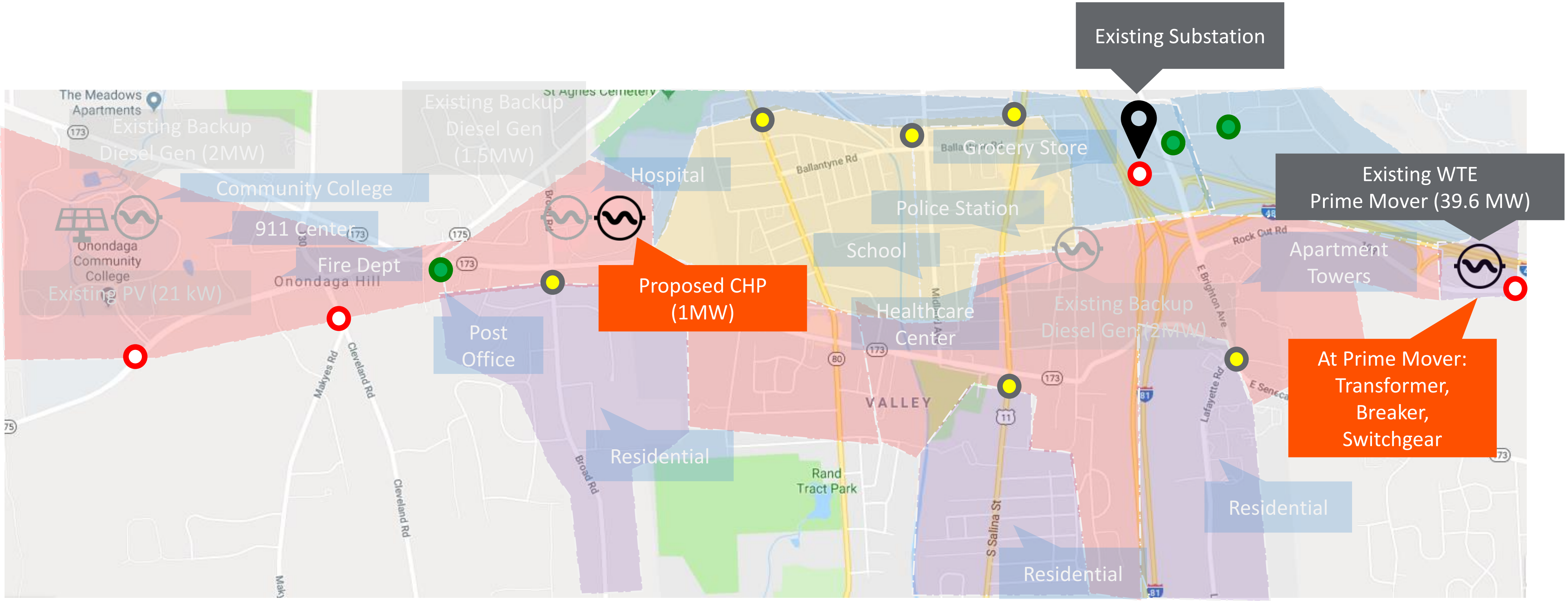
Open Switch

Load Shed Switch

Closed Switch

- Prime mover current feeds into transmission
- Step up transformer converts 13.8kV to 115kV
- Substation serves 2 of 4 feeders in microgrid

Microgrid New Equipment



Generator

Facility

New Equip

Open Switch

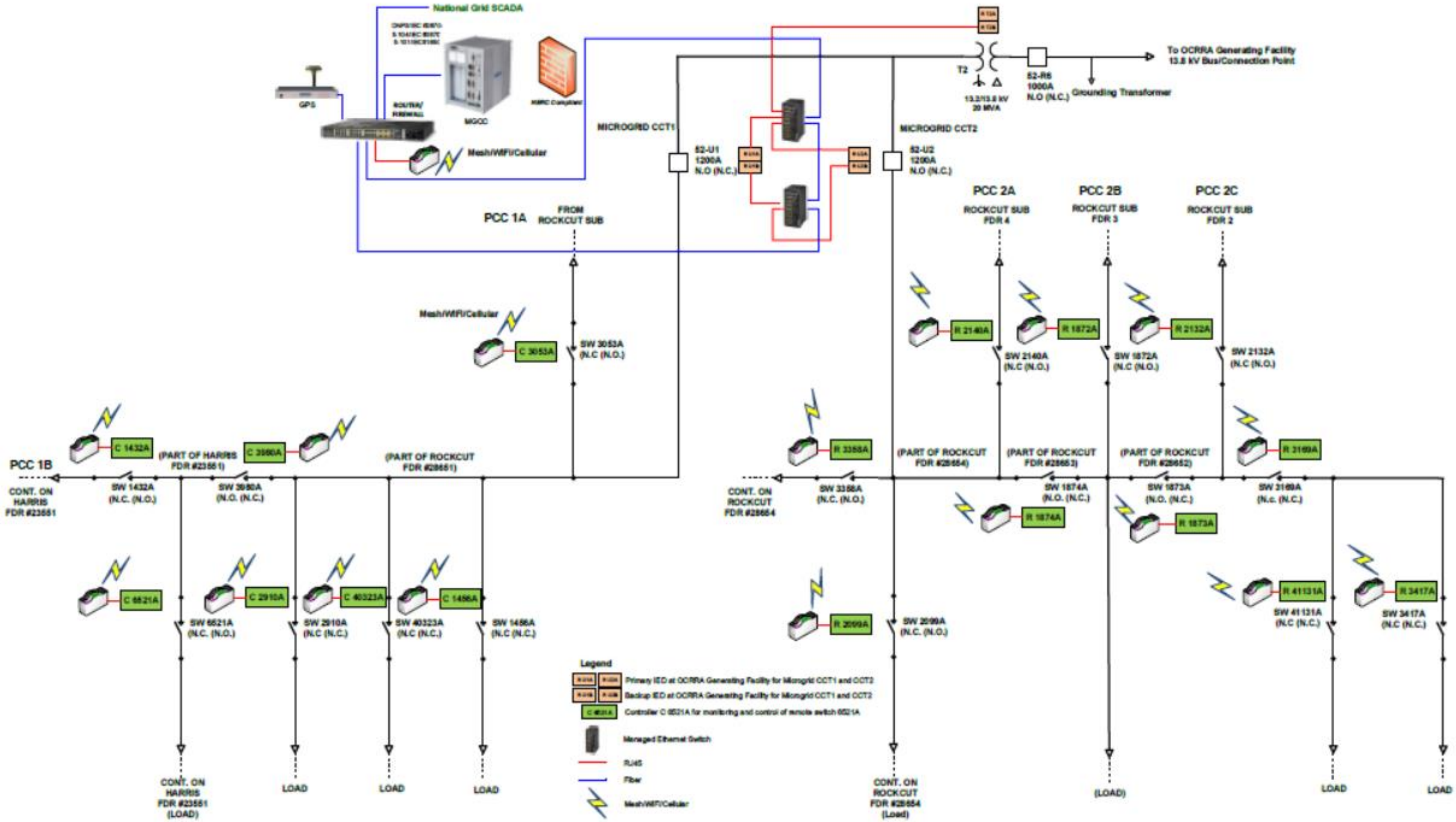
Load Shed Switch

Closed Switch

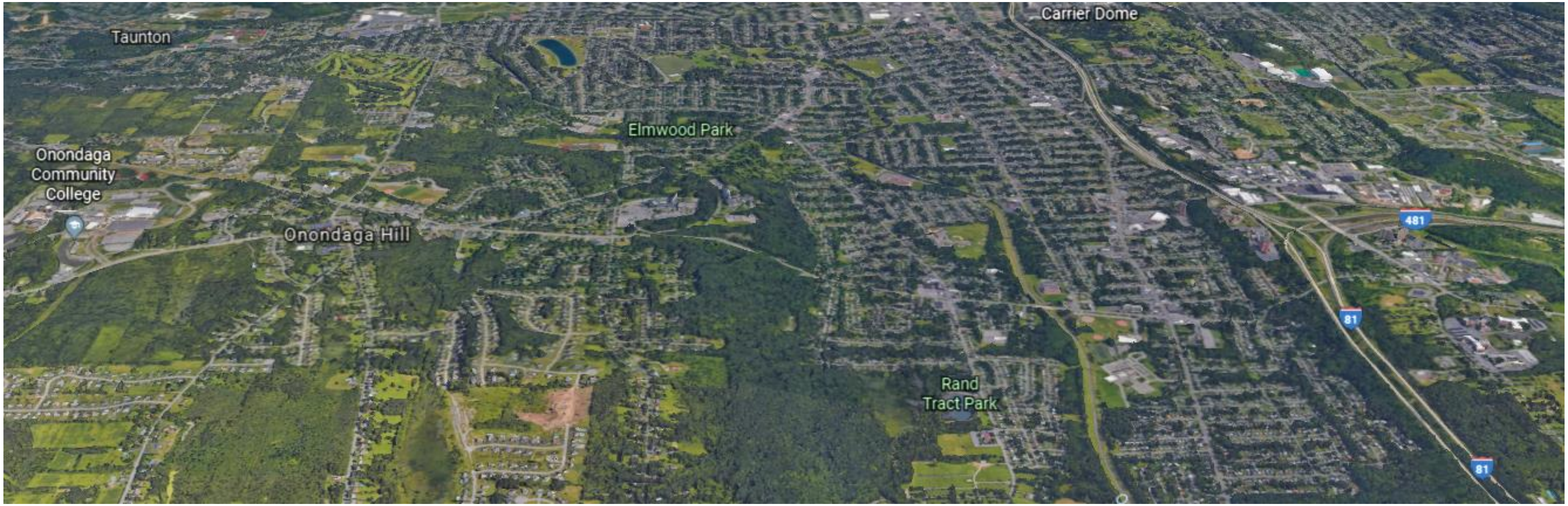
When forming microgrid:

- Prime mover would feed into distribution at 13.2kV
- New transformer to convert 13.8kV to 13.2kV
- Proposed 1 MW CHP at hospital

Microgrid Electrical, Controls and Comms Layout



Challenges with Forming Microgrid



- Microgrid critical facilities spread out over an area of ~4 square miles
- Facilities are normally served by 4 utility feeders from 2 distribution substations
- Over 2,000 residential and small commercial loads (7-9 MW) mixed in with critical facilities
- Primary generation source (WTE Plant) normally connected into the subtransmission system
- Multiple Points of Interconnection (POI) to the utility grid

Microgrid Operation

Normal ("Blue Sky") Conditions

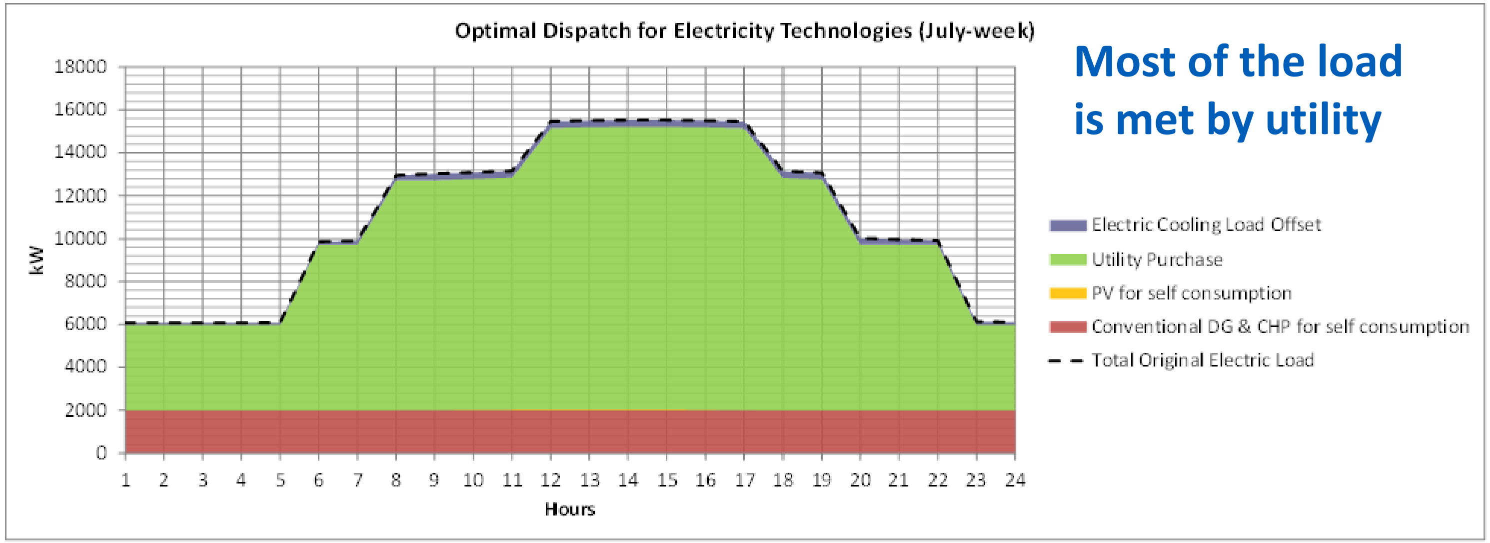
- OCRRA is connected via the existing 115-kV line to the National Grid transmission system
- OCRRA can sell to the utility or into available NYISO markets; UUHCC will operate to provide its own needs
- Microgrid customers have the current supply options that are available to them

Emergency ("Island") Conditions

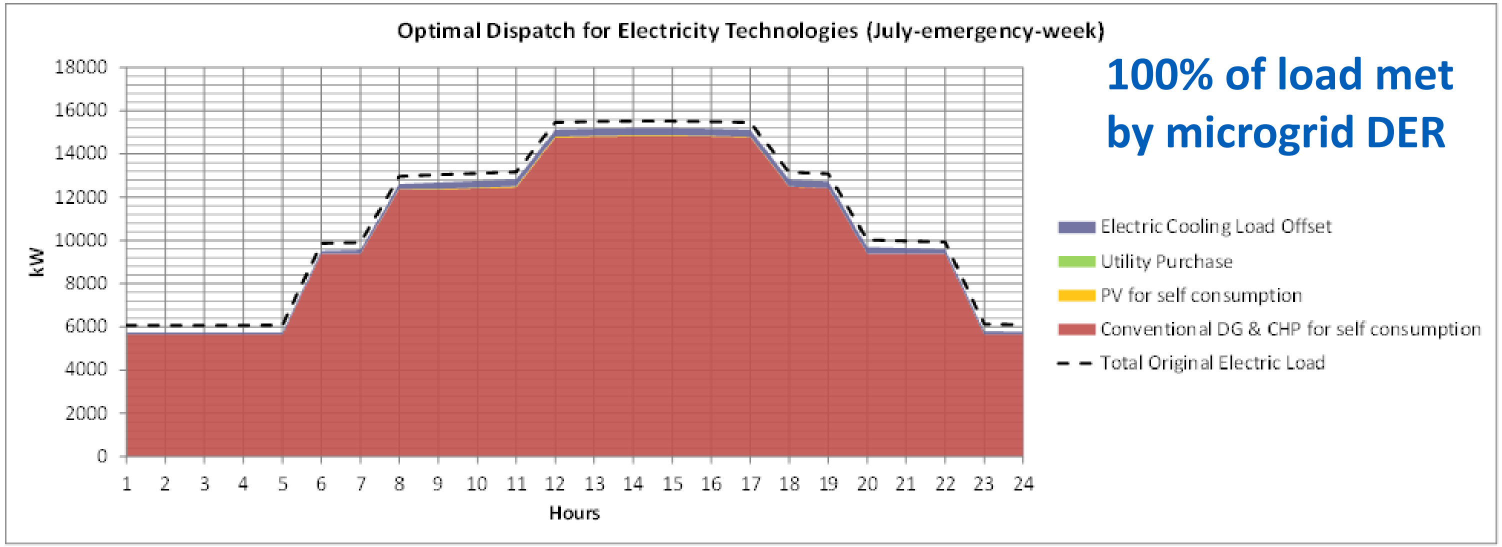
- Medium voltage system is reconfigured to allow OCRRA to directly supply microgrid customers
- OCRRA provides electricity to National Grid for delivery to the microgrid customers at a price
- National Grid or a special purpose entity ("SPE") is responsible for administering Microgrid operations

Microgrid Dispatch in Normal and Emergency Mode

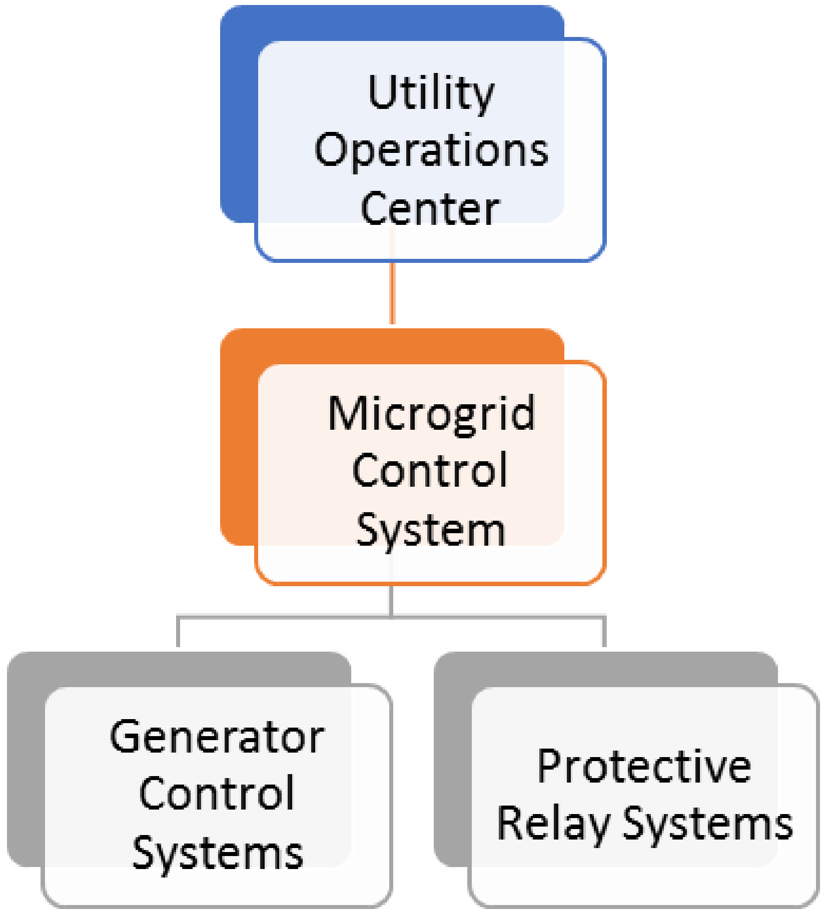
Microgrid Dispatch to Meet Electrical Load – Normal Weekday



Microgrid Dispatch to Meet Electrical Load – Emergency Weekday



Microgrid Control Hierarchy

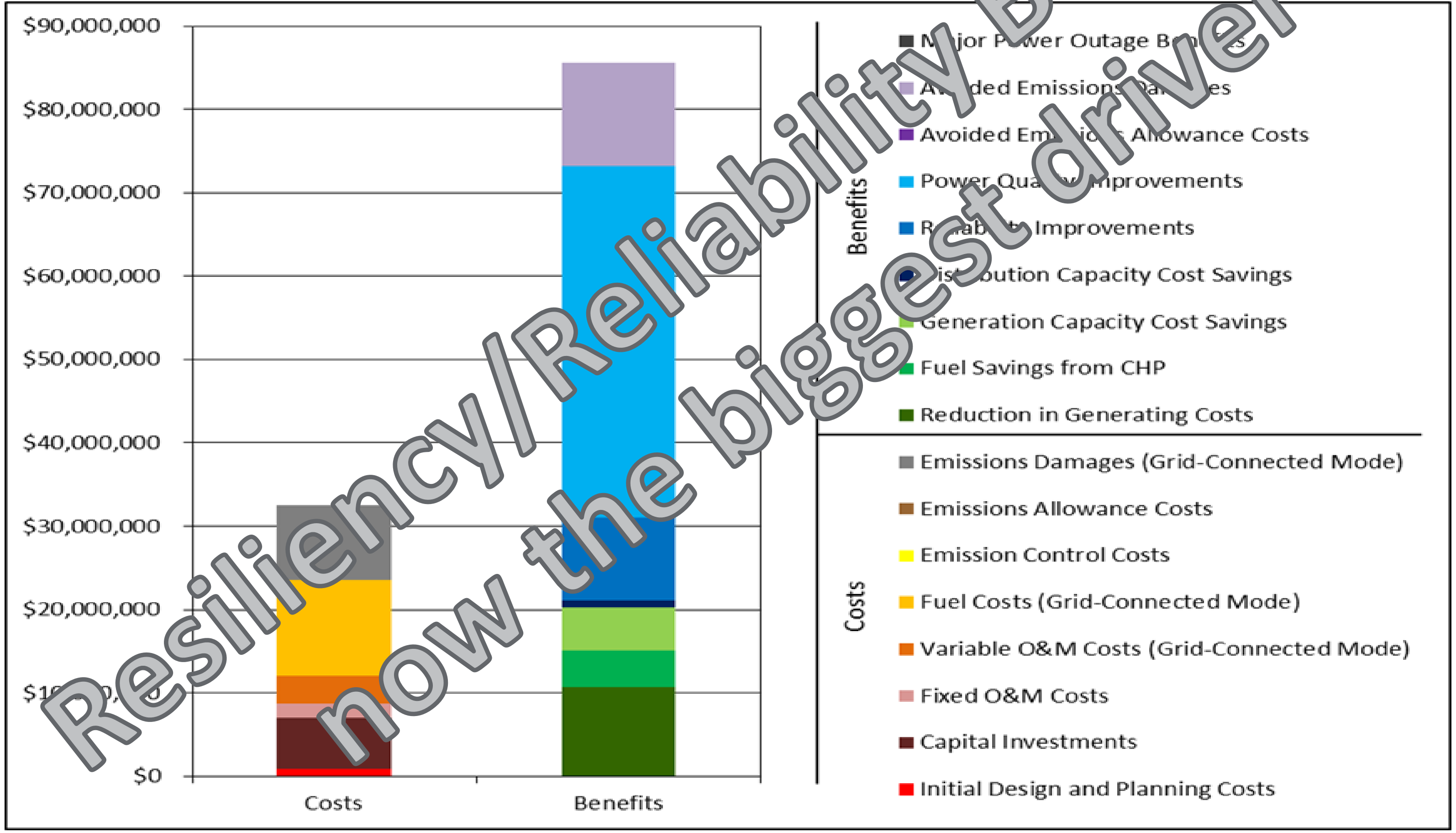


Control hierarchy governs operation, transition to island mode, and operation in island mode

- Utility might have ultimate supervisory control over microgrid operation
- Microgrid central controller (MGCC) operates (functionally) below utility operations to monitor and dispatch (but perhaps not in this case)
- Generation control systems responsible for primary voltage/frequency regulation
- Protective relay systems perform autonomously, decoupled from control systems

Summary of Benefit-Cost Analysis (Stage 1) Syracuse

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$53,200,000	Not Evaluated
Benefit-Cost Ratio	2.6	Not Evaluated
Internal Rate of Return	222%	Not Evaluated



Resiliency/Reliability Benefits now the biggest driver

Key Take-Aways

General Observations

- Microgrids bring together diverse engineering disciplines, including distributed generation, renewable resources, demand response, smart grid, and advanced control and communications and energy management systems
- Key drivers are: customers looking for energy independence/surety; resiliency/reliability in US communities; and electrification of rural areas globally
- The market is growing; expect to see a four-fold increase over the next five years
- GE's role is primarily technology provider, designer/consultant, integrator and enabler
- Many state, national and global investors are looking to invest in microgrids in the U.S.
- Microgrids can provide significant societal net benefits, as well as hard benefits/returns
- Resiliency (soft) benefits drive positive BCA scores for many community microgrids
- Microgrids with CHP and high thermal use loads can have positive BCA *even without* resiliency benefits

Lessons Learned

- Analysis/output is only as good as the data/inputs – and data collection takes time!
- Leveraging existing generation assets and distribution infrastructure could reduce investment needs, but adds to operational and commercial complexity
- Utility support is critical to designing a reliable viable microgrid delivery system - some utilities are more supportive than others
- Project value proposition improved significantly with participation of the microgrid assets in the utility DR programs and ISO capacity, energy, and ancillary markets
- Societal benefits are applicable for public funding but do not necessarily move the meter for private investors
- Operations and economics are significantly impacted by the regulatory environment and market conditions
- Developing an economically sustainable commercial structure and business model can be challenging and extremely complex

Thank you!