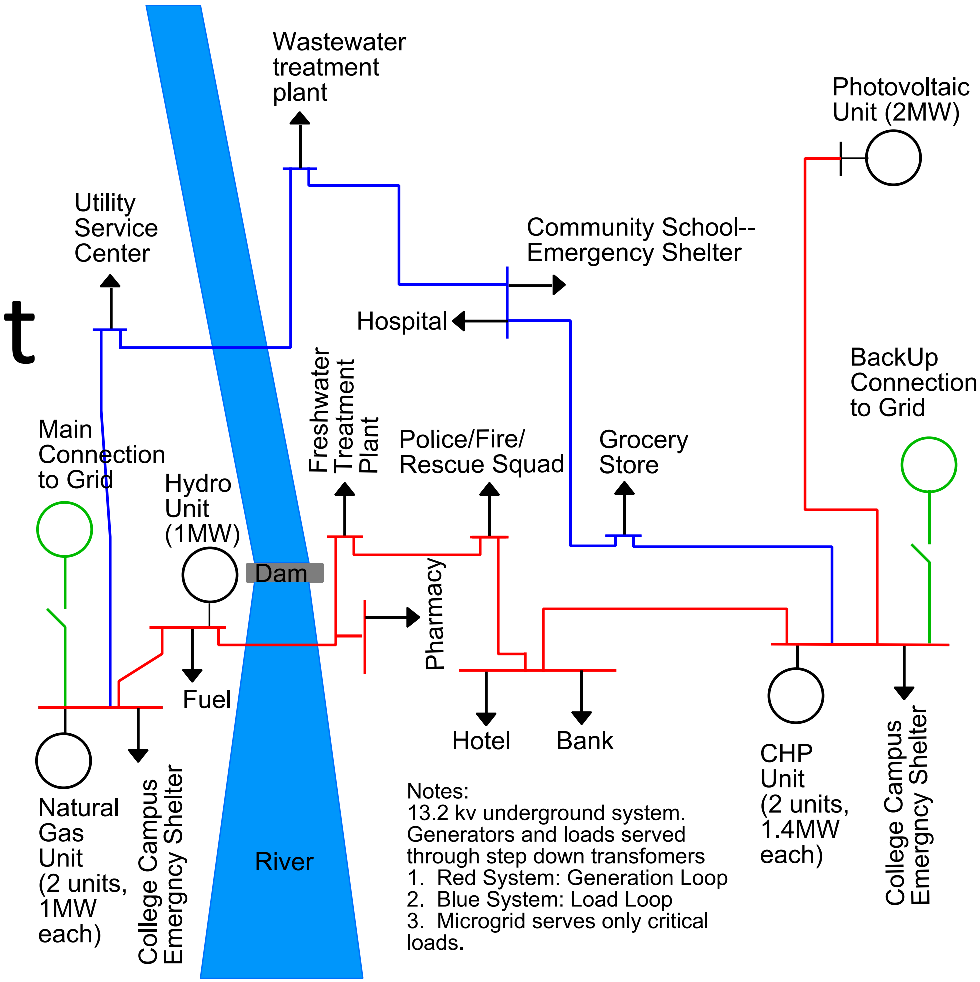
Planning and Benefit/Cost Results for the Potsdam Resilient Underground Microgrid

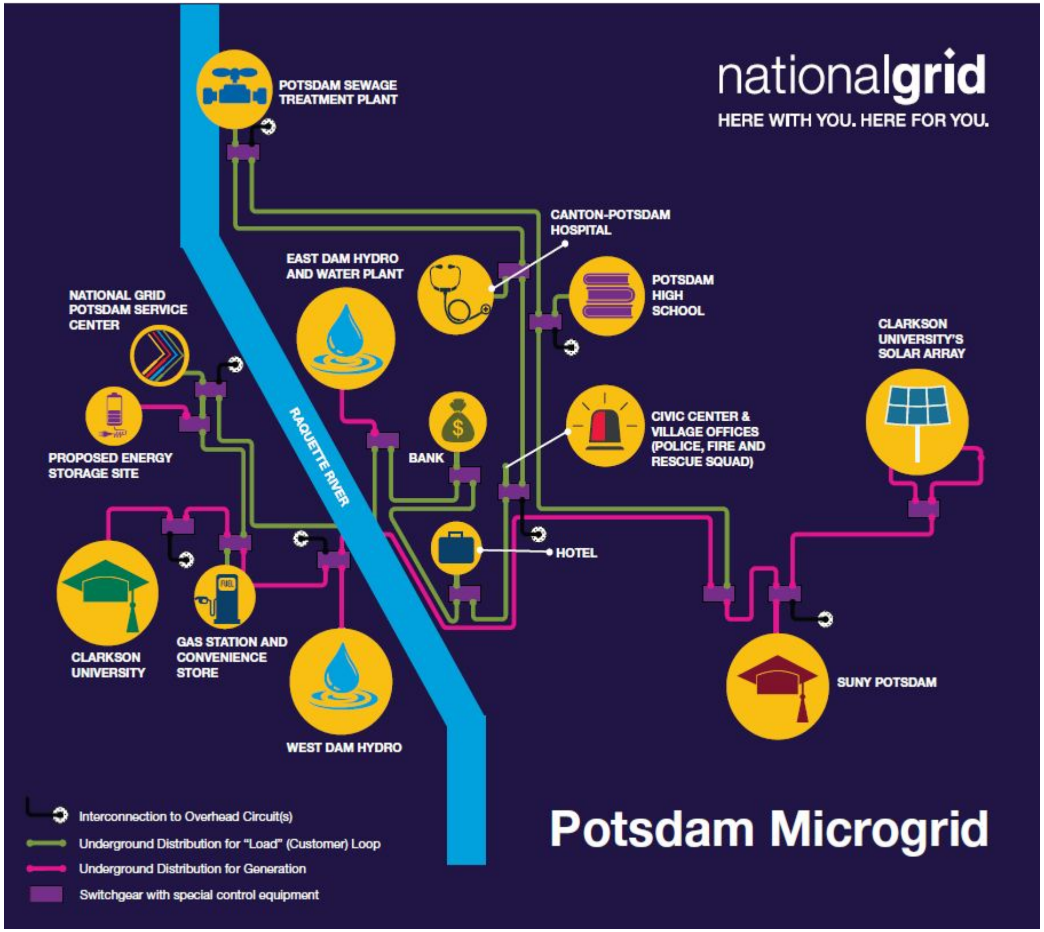
Thomas H. Ortmeyer

Clarkson University
defy convention
Wallace H. Coulter School of Engineering



Potsdam Resilient Underground Microgrid

- NYSERDA Project 41309
- Partnership of National Grid, Clarkson University, GE Energy Consulting and Nova Energy Specialists
- Co-funded by NYSERDA and National Grid
- Use Case for NSF PFI:BIC research project “Developing Advanced Resilient Microgrid Technology to Improve Disaster Response Capability”



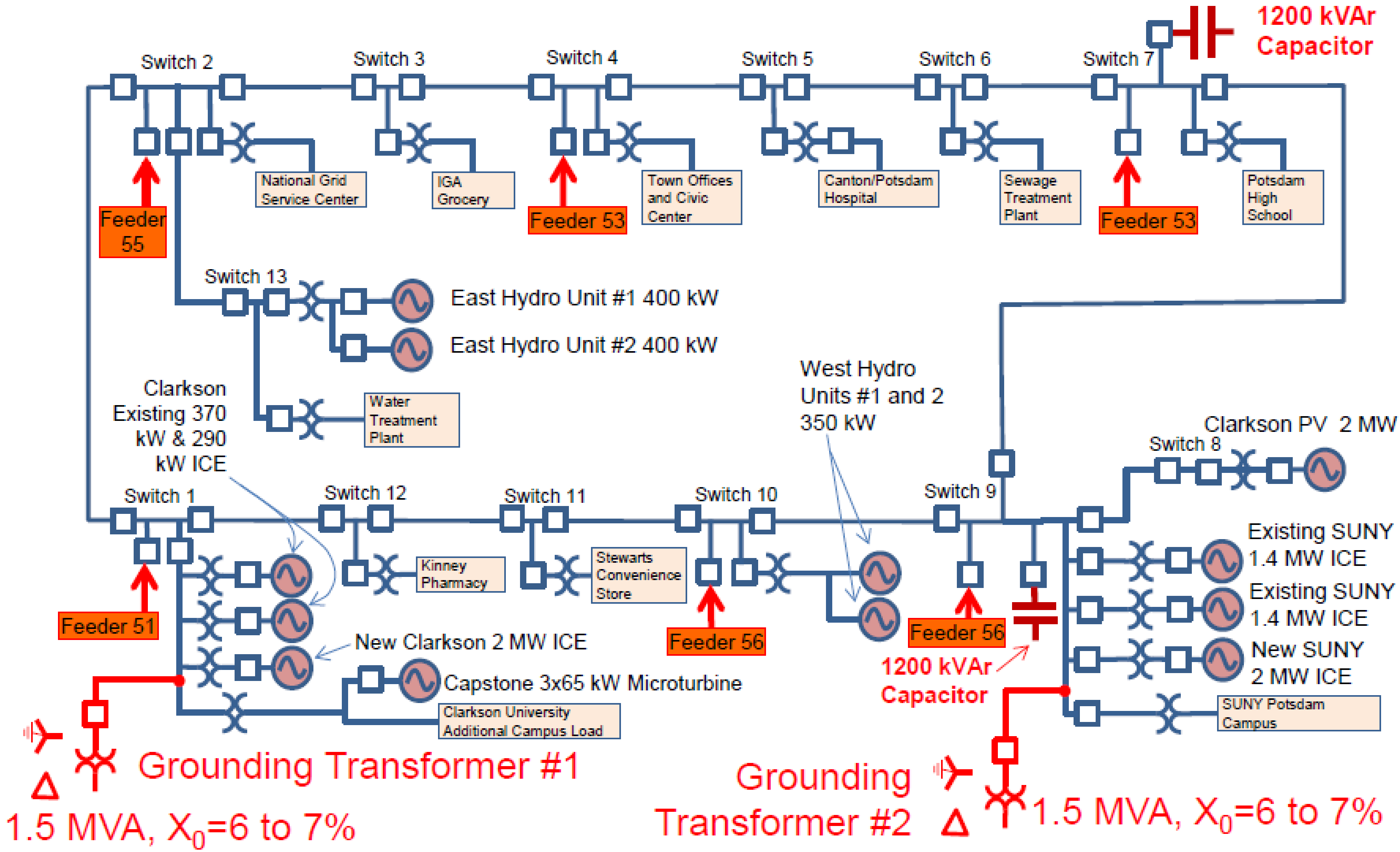
Resiliency

- Resiliency: Able to recover quickly from misfortune; able to return to original form after being bent, compressed, or stretched out of shape.
- Resilient microgrid: Able to serve to (critical) loads for a minimum of two weeks following a major impact causing loss of main grid service
- Community Resilient Microgrid: Multi-party entity that would serve the community through maintaining service to critical loads (water, waste treatment, hospital, emergency services…..)

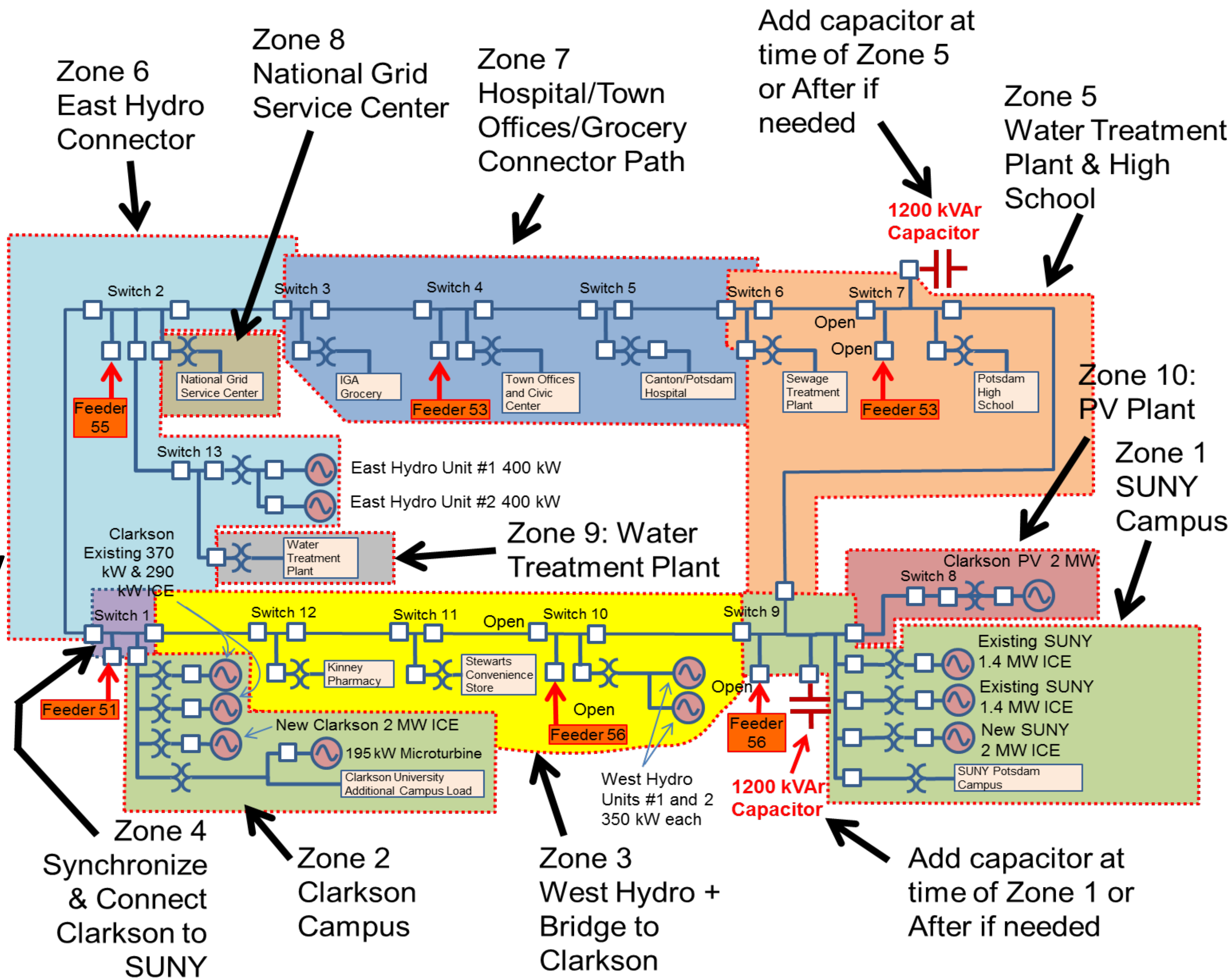
Electrical Study Highlights

- 10MW annual peak load, 4MW new generation
- Underground network
- Effective grounding to properly serve line to neutral loads, limit ground fault overvoltage, and provide ground fault detection.
- Switched capacitors to assist with VAR needs/voltage support
- Requirements for load step size and rates, and black start procedures to manage power quality impacts
- Adaptive relaying and controls for transitions between **islanded microgrid mode** and **utility grid parallel mode.**
- Link to PV farm will be overhead if installed
- Energy storage not required– likely advisable if PV included
- Demand response key to project practicality

Recommended Locations/Sizes of Microgrid Grounding Transformers



Black Start Strategy



Change in Operating Modes

(Grid Parallel versus Microgrid Mode)

Parameter	Grid Parallel Mode (Classical DG Operation)	Intentional Island Mode (a.k.a. Microgrid Mode)
Voltage Regulation	Generators "voltage follow". The utility LTC transformers/regulators control the voltage. Generators may contribute to regulation by fixed power factor mode or independent reactive dispatch control.	Generators are totally responsible for regulating voltage on the island
Frequency Regulation	Generators "frequency follow" leaving frequency regulation to the utility (unless provided as ancillary service to NYISO)	Generators have total responsibility to regulate frequency of the intentional island
Real and Reactive Power	The generators operate at a level of real and reactive power per dispatch center needs that can be independent of the loading on the microgrid	Generators will follow the load supplying the needed real and reactive power to exactly balance the load to generation
Fault Levels	Fault current levels on the microgrid primary will be from 100% of the normal utility source levels (with no generation running) up to roughly double those levels when all generation is running	Fault current from the generators on the primary will be anywhere from about 25% of the normal utility fault level if only partial generation is running, up to about 100% of the utility fault level in full generation scenario.
Islanding Protection and Protective Relaying	DTTs and anti-island protection is engaged at acceptable sensitivity levels. Overcurrent protection set to minimize interference with utility system fault protection. DG ride-through optimized for bulk grid stability.	DTTs disabled. Anti-island protection disabled or desensitized. Overcurrent protection compatible with islanded operation. DG ride-through settings optimized for microgrid stability.

Benefit/Cost Analysis (BCA)

BENEFITS

- Reduction in Generating Costs
- Fuel Savings from CHP/CCHP
- Generation Capacity Cost Savings
- Transmission/Distribution Capacity Cost Savings
- Reliability Benefits
- Power Quality Improvements
- Avoided Emissions Allowance Costs
- Avoided Emissions Damages
- Major Power Outage Benefits

COSTS

- Initial Design and Planning
- Capital Investments
- Fixed O&M
- Variable O&M (Grid-Connected Mode)
- Fuel (Grid-Connected Mode)
- Emission Control
- Emissions Allowances
- Emissions Damages (Grid-Connected Mode)

There are two principal scenarios to be considered in each case using the BCA model, which are

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions in normal/blue sky days).
- Scenario 2: The average annual duration of "major power outages" (i.e., days of outage in the year) required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.

Generation Options

Category	Equipment Costs	Installation Costs	Total	
Generation				
Option 1 (Dual Fuel Option)	$4,000,000[1]	$1,500,000	$5,500,000	
Option 2 (Natural Gas Only Option)	$2,700,000	$1,500,000	$4,200,000	
Option 3 (GE Hybrid Fuel Cell/Natural Gas Option)	$25,000,000[2]	$3,500,000	$28,500,000	

Distribution Equipment Options

49	Option 1 – 15kV Class Breaker, 1200A continuous, 20kA interrupting
30	Option 2 – 15kV Class Breaker, 1200A continuous, 20kA interrupting
2	Option 3 – 15kV Class Breaker, 1200A continuous, 20kA interrupting
19	Option 2 - 15kV Class Motor-Operated Fused Switch, 600A continuous, 20kA interrupting
5	Option 3 - 15kV Class Motor-Operated Fused Switch, 600A continuous, 20kA interrupting
2	Option 3 – 15kV Class Recloser, 600A continuous, 12kA interrupting
2	Option 3 – 15kV Class Capacitor Switcher, 400 continuous, 13.5kA interrupting

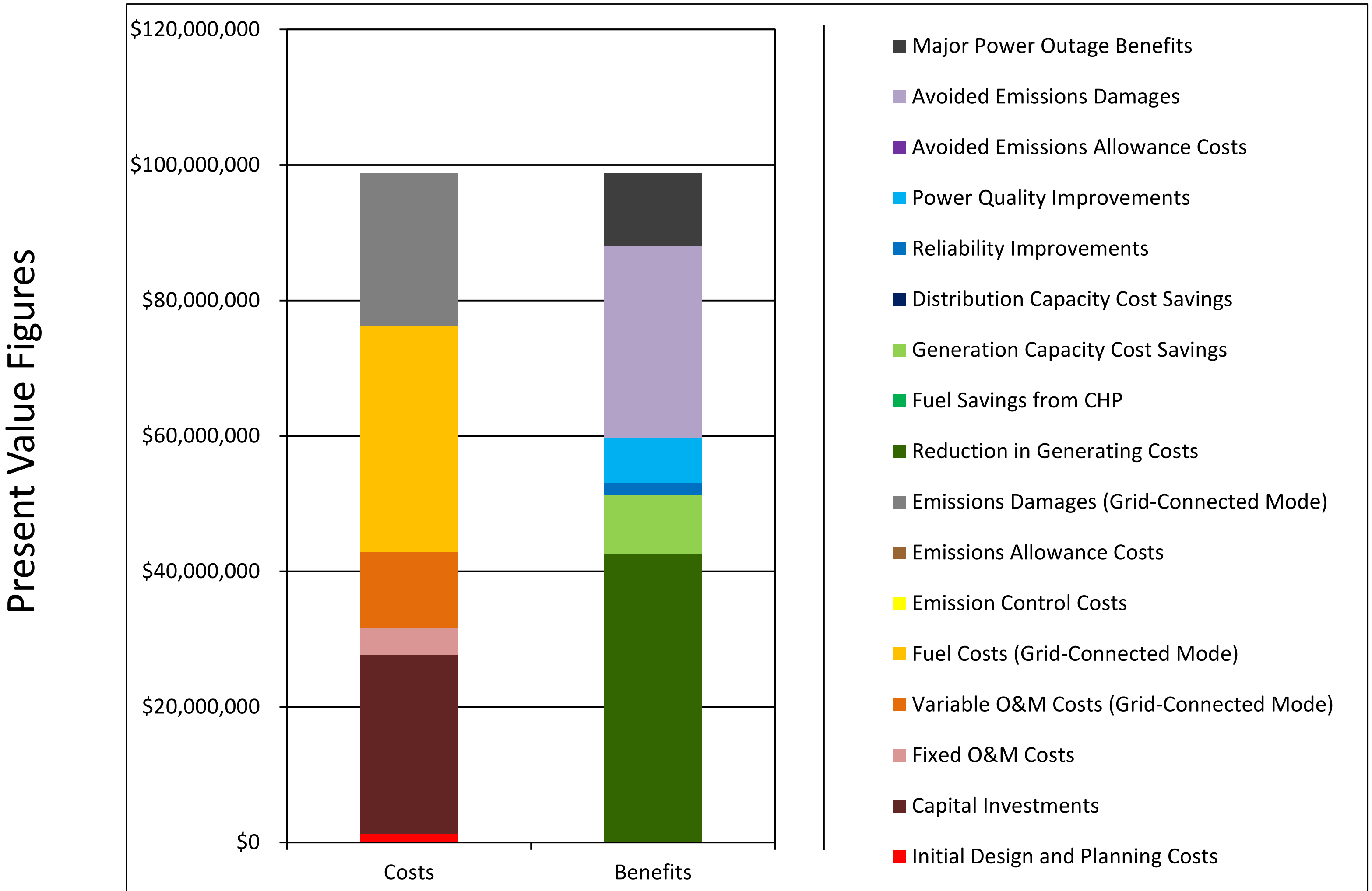
Initial Investment Cost Estimate for the 9 Alternatives

Design of a Resilient Underground Microgrid in Potsdam, NY — Estimated Cost Information

Estimated Project Totals	
Dual Fuel Engine with Option 1 Protection	$38,390,000[1]
Dual Fuel Engine with Option 2 Protection	$37,580000[1]
Dual Fuel Engine with Option 3 Protection	$27,820,000[1]
Natural Gas Engine only with Option 1 Protection	$37,040,000
Natural Gas Engine only with Option 2 Protection	$36,230,000
Natural Gas Engine only with Option 3 Protection	$26,470,000
Hybrid Fuel Cell-Natural Gas with Option 1 Protection	$61,340,000[2]
Hybrid Fuel Cell-Natural Gas with Option 2 Protection	$60,530,000[2]
Hybrid Fuel Cell-Natural Gas with Option 3 Protection	$50,770,000
Energy Storage Option Adder	TBD

1. Dual Fuel Engine cost is an estimate only due to no quote received from supplier
2. Hybrid Fuel Cell-Natural Gas Engine is in development and cost is an estimate

BCA, Gas only, Option 3 Protection, 0.36 days/year Major Power Outage



	Generation Option 1	Generation Option 1	Generation Option 1	Generation Option 2	Generation Option 2	Generation Option 2	Generation Option 3	Generation Option 3	Generation Option 3
	Distribution Option 1	Distribution Option 2	Distribution Option 3	Distribution Option 1	Distribution Option 2	Distribution Option 3	Distribution Option 1	Distribution Option 2	Distribution Option 3
Annualized Costs ($M)	8.67	8.61	7.88	8.57	8.51	7.78	10.40	10.34	9.61
Annualized Benefits ($M)	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12
Annualized Net Benefits ($M)	-1.55	-1.49	-0.75	-1.45	-1.39	-0.66	-3.28	-3.22	-2.49
Benefit/Cost Ratio	0.80	0.81	0.89	0.81	0.82	0.90	0.66	0.67	0.72
Outage Days/Year Needed for B/C=1	0.75	0.72	0.38	0.70	0.67	0.33	1.56	1.53	1.19

Microgrid Governance

- Operated by a consortium that would include
  - All Connected Generation owners
  - Representatives of Connected customers
  - National Grid
  - Community representative
- Consortium would house the controller, schedule operations and maintenance, collect and distribute revenues, interact with ISO

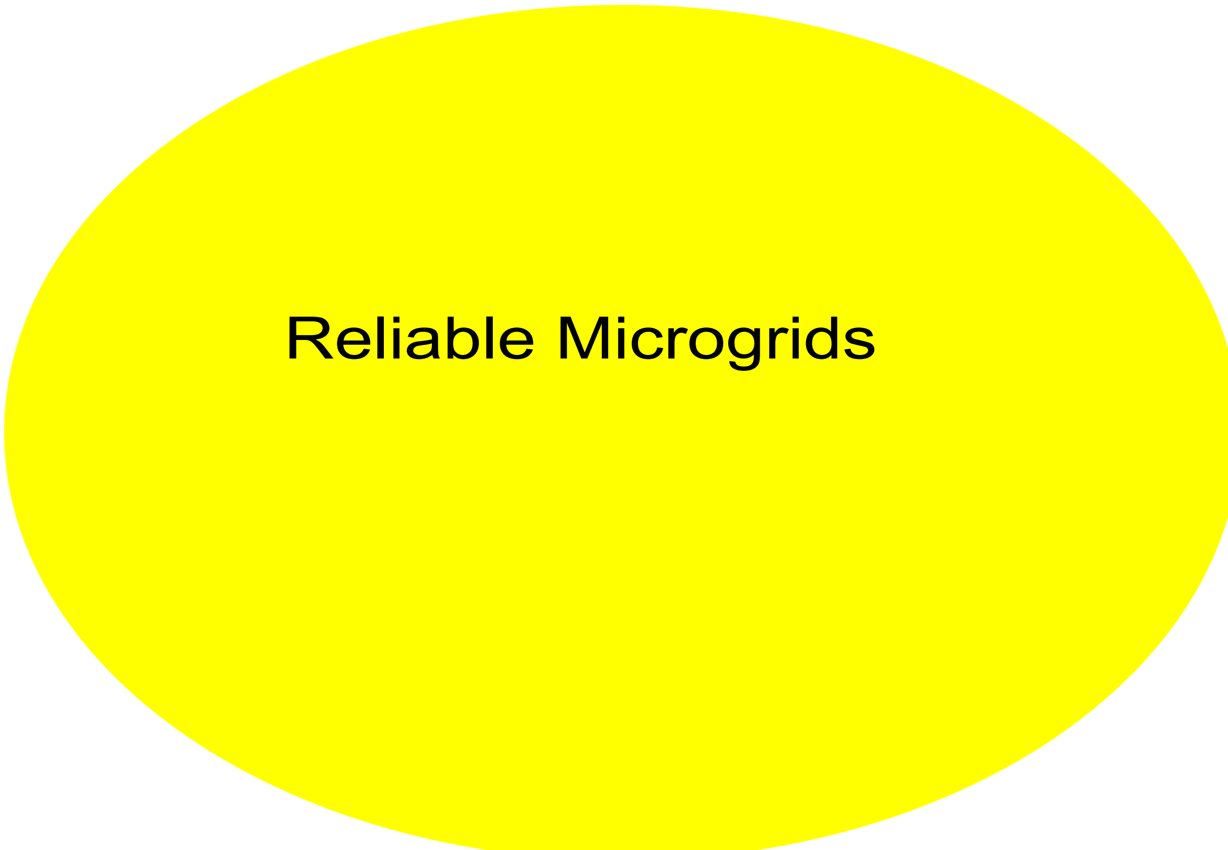
Cost Recovery Issues

- Governance Plan will impact participation in (revenue from) NYISO markets
- Governance Plan will impact demand and energy charges from National Grid
- Will DER provider model allow for efficiencies and operations and maintenance? In market operations?

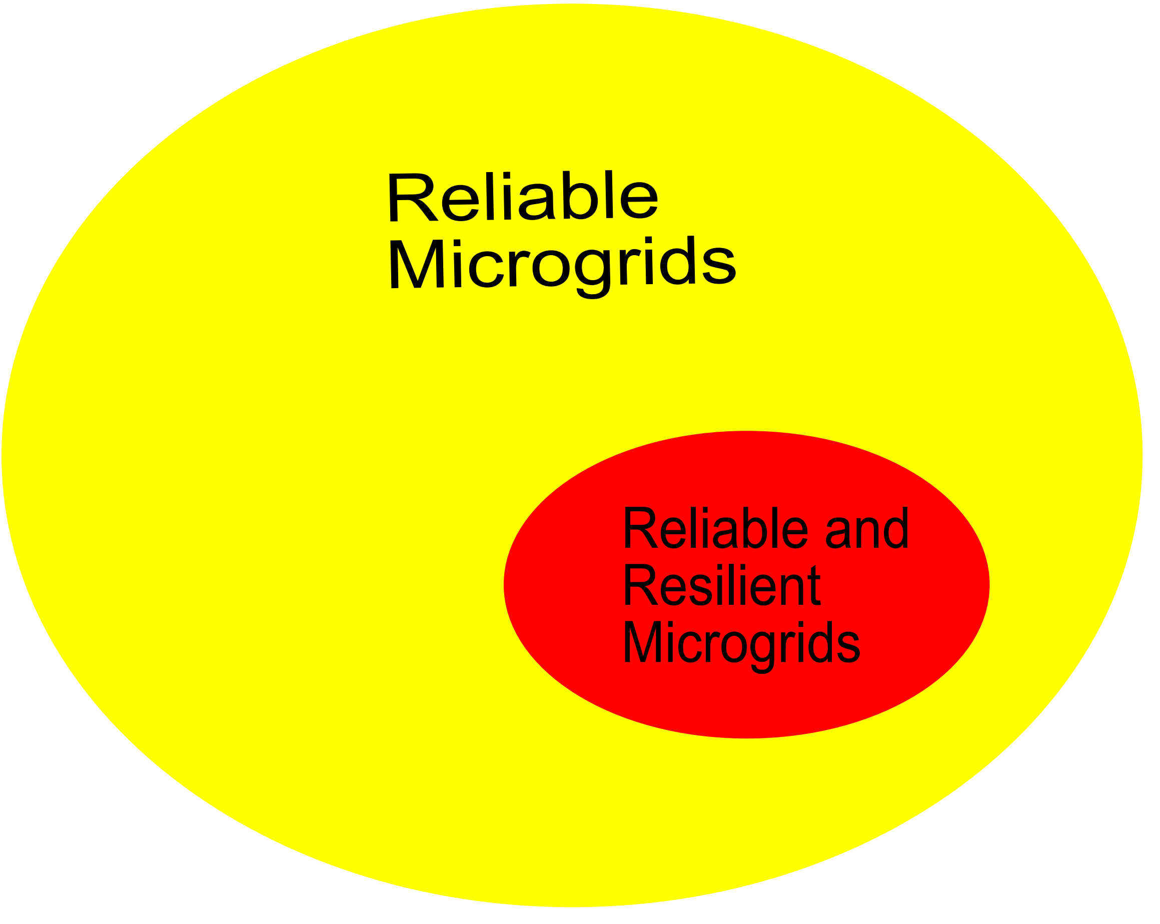
Major Cost Decision Points

- Primary distribution strictly underground
- Specify a seamless transition on overhead line faults
- Level of protection for the underground system
- Level of reliance on demand response
- Implementation of demand response
- Natural gas availability
- Footprint– can outliers be included?

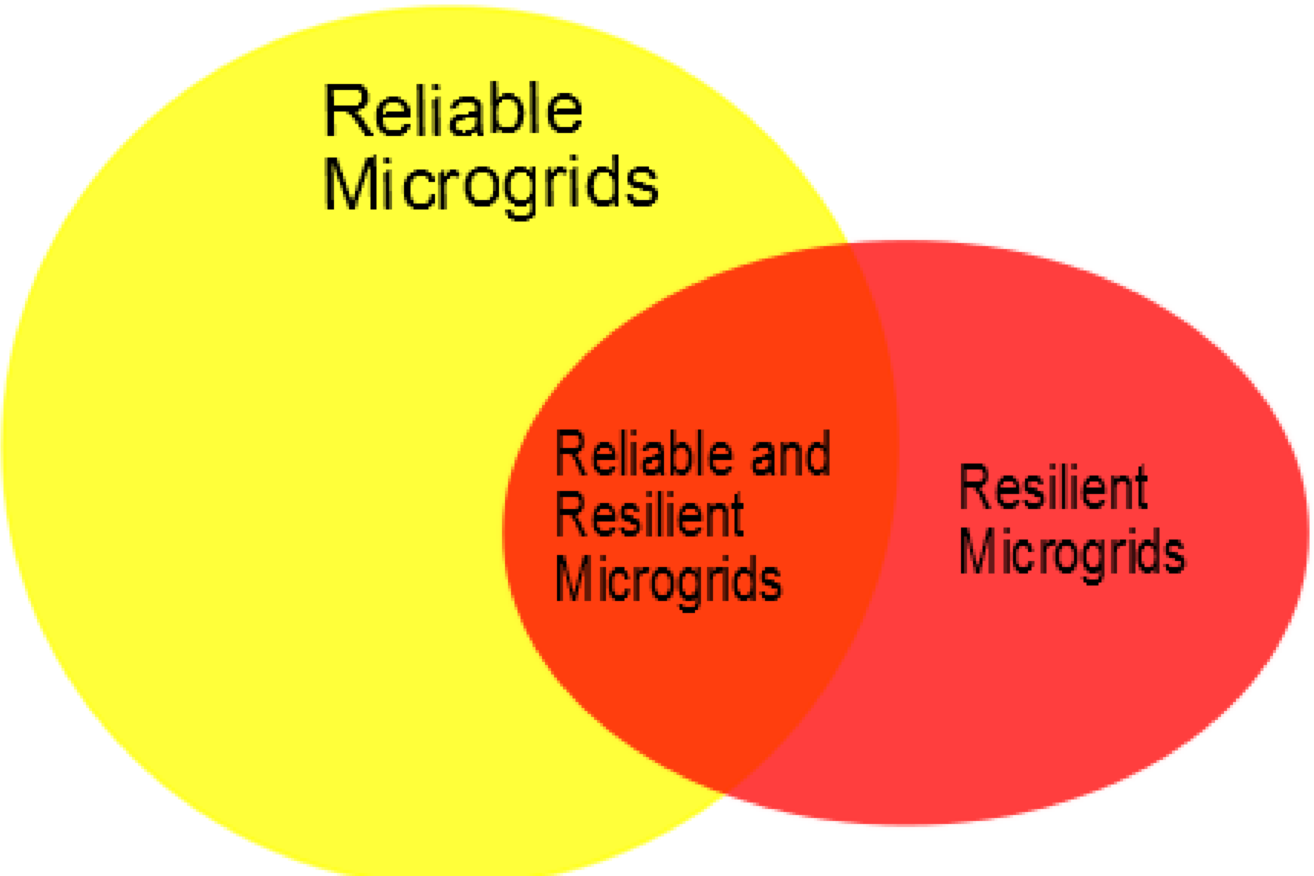
Reliable Microgrids–
Reduce SAIFI, CAIDI and MAIFI



Subset: Reliable and Resilient Microgrids



Resilient Microgrids– Built to address long term interruptions



Resilient Microgrid Options

- Allow limited amount of overhead distribution
- Seamless planned separation, black start for unplanned separation
- Larger feeder segments, TOC protection
- Generation lean– significant reliance on Demand Response
- Adaptive Demand Response
- Some generation has duel fuel capability
- Delayed deployment for network outliers

Conclusions

- Cost recovery is a significant issue with Resilient Microgrids
- Level of service expectations change during significant events
- Challenges to be resolved for community microgrids consortia