nationalgrid

HERE WITH YOU. HERE FOR YOU.

Distribution Power Electronics: Utility Perspective

Jim Perkinson

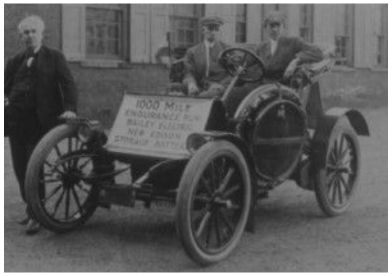
National Grid

James.Perkinson@nationalgrid.com

April 15, 2016

Thought for the Day…
Are Utilities Keeping Pace?

Circa 1900	Today	Future



Modernization leverages the application of state-of-the-art technologies to meet customer and operational demands

The Time is Now…

Policy and technology advances are pressuring the current electric infrastructure system.

Policy Driving Shifts

- Federal, state & local policy and community initiatives.
- Aggressive renewable portfolio standards and incentives.
- New investments in electric generation ($1.3 Trillion* by 2035) are changing where generation is located – more local and more distributed.
- New investments in gas infrastructure ($400 Billion* by 2035).

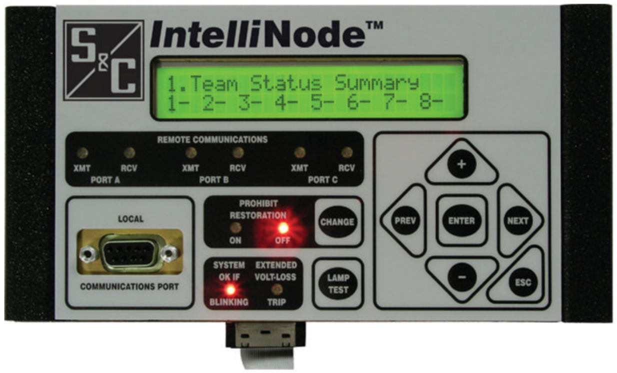
Infrastructure Delivery

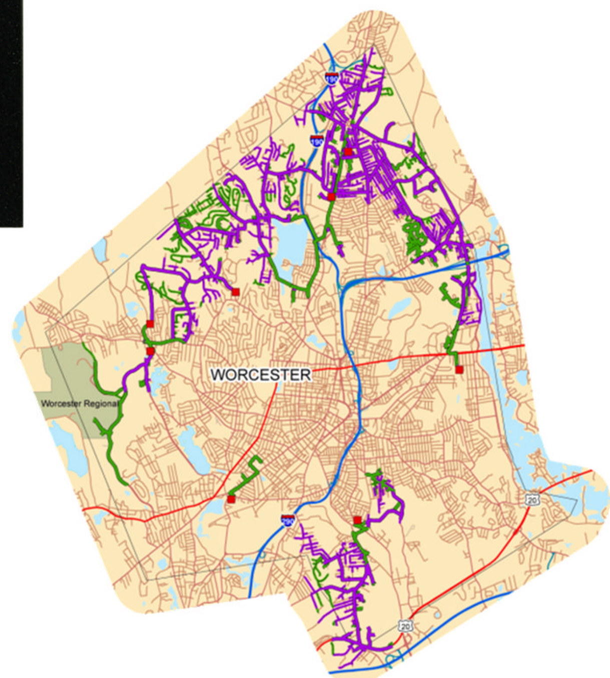
- Electric delivery sector is in need of major reinvestment ($1.0 Trillion* by 2035) driven by asset modernization (replacement, cyber-security).
- Climate change is causing more frequent and severe weather events and a need for more resilient infrastructure.
- Critical information for optimization and prioritization to enable policy for market demands.

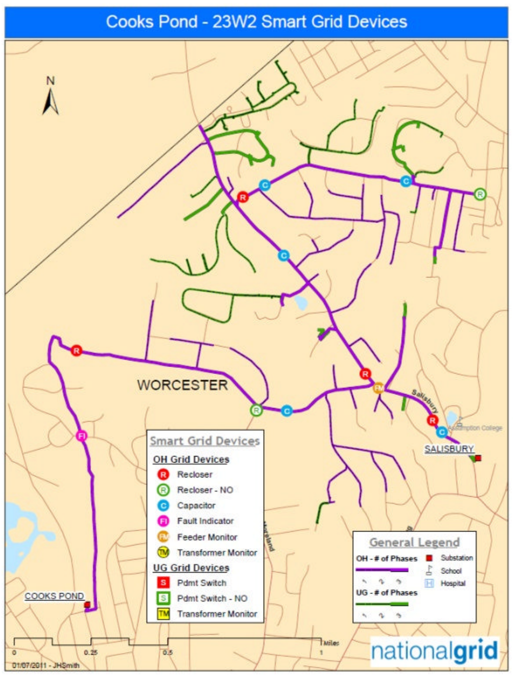
Technology & Customers Driving Shifts

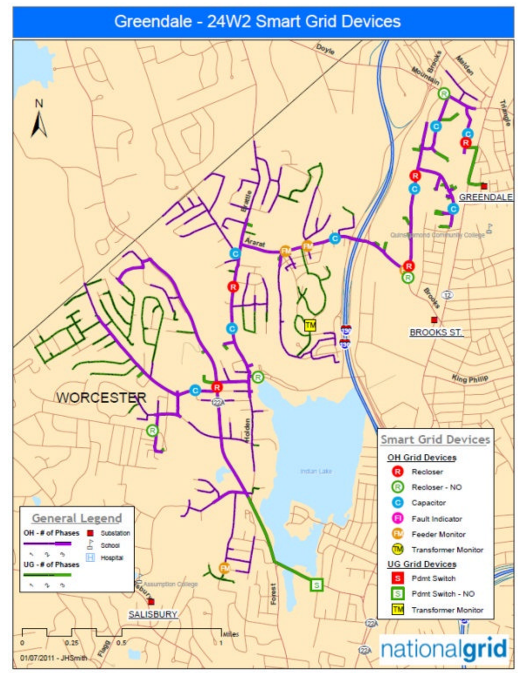
- Customers are dependent on energy to enable their daily lives and businesses.
- Customers are accustomed to getting more and seeking more value. Affordability and reliability are expected.
- More diverse customers with evolving needs. Technology is reshaping and playing a major role in their lives.

Worcester Smart Grid – Distribution Automation

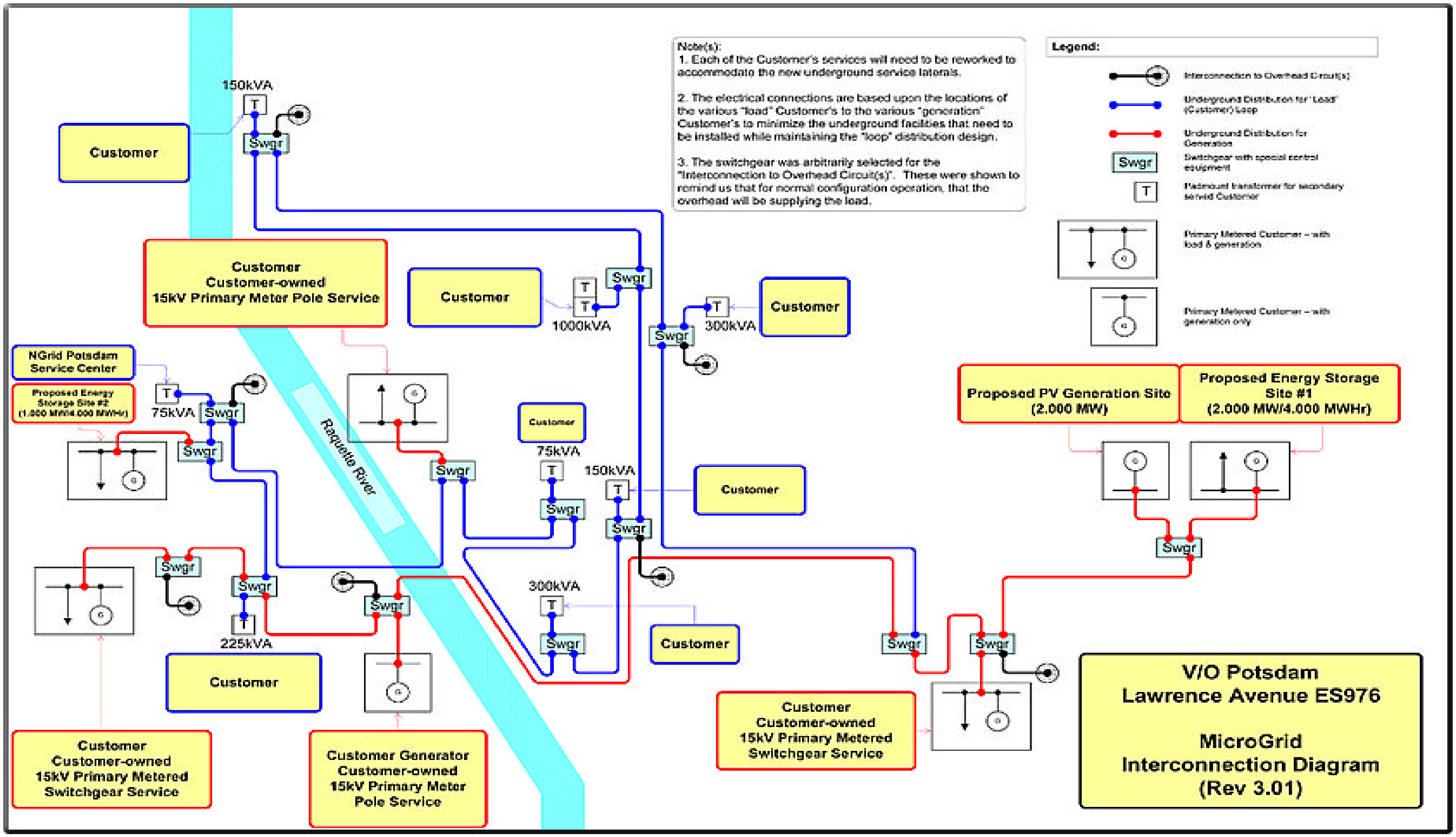




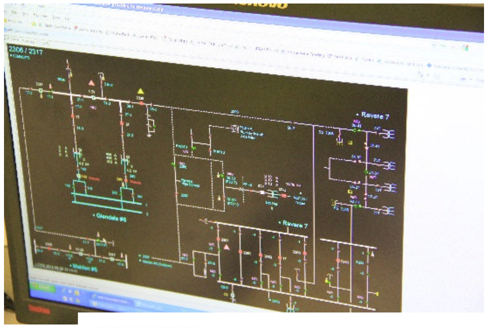


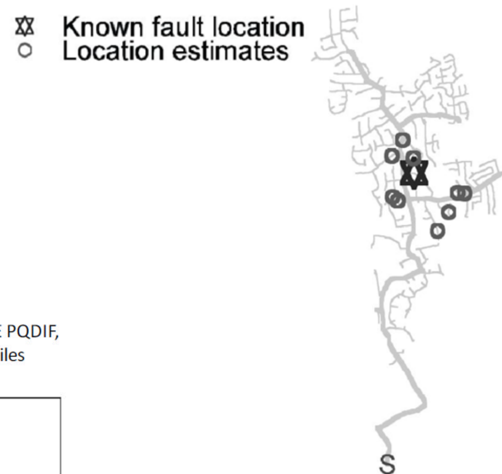


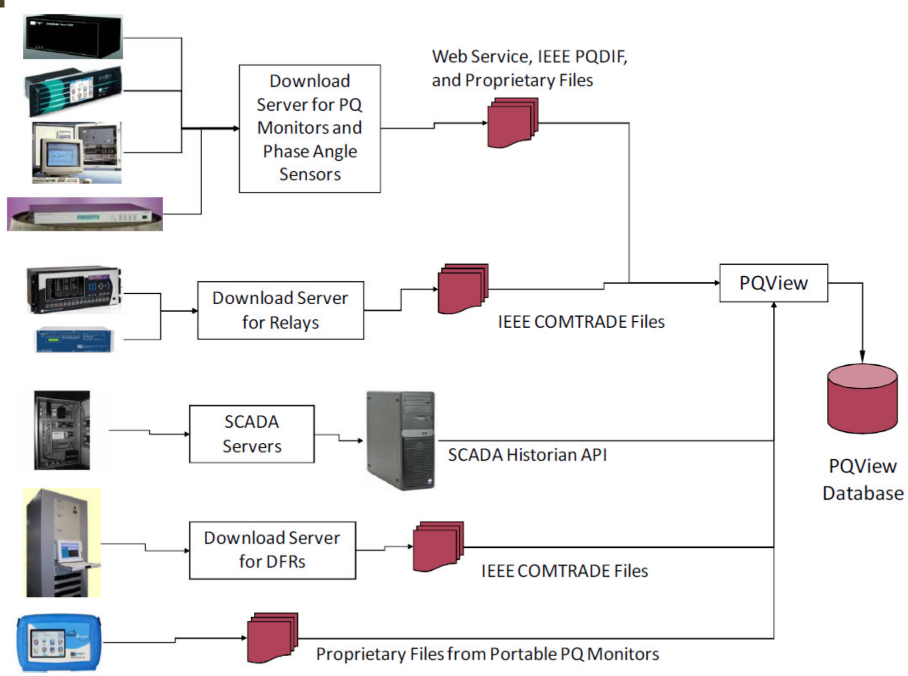
NY-
Potsdam UG Microgrid



Fault Locating Adventure







9:00 P.M
~
5:00 A.M
(8 hours)

X2=16 hours…

Phase II Solar "Integrate vs. Interconnect"

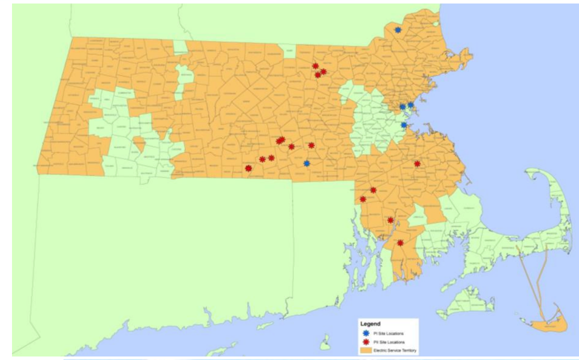
Purchase up to 20 MW's of turn-key solar sites, implemented with advanced inverters

National Grid's goal is to use these sites, to further solar development in the commonwealth through advanced technologies

- **Advanced Inverter Features**
- **PLCP DTT**
- **Construction Optimization**

Learn more about impacts of solar on areas by pre-selecting towns with:

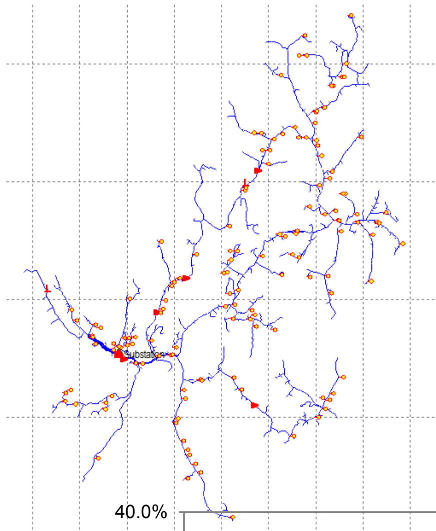
- **High PV penetration feeders**
- **Lightly loaded feeders**
- **Heavy loaded feeders**



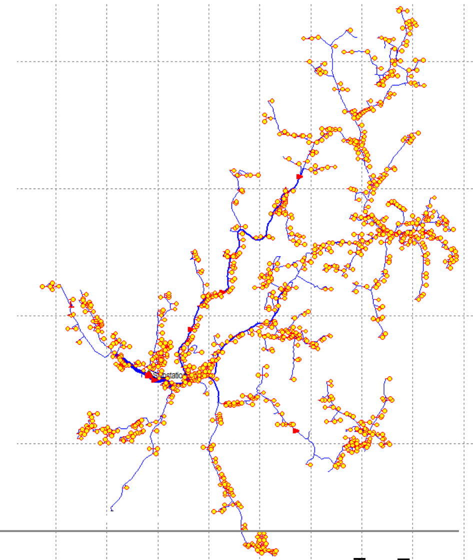
Advanced Control Modes

Functionality	Modes	Description
Active Power Control	Real Power Curtailment	Ability to limit the active power production of the PV site to a value below its potential
Active Power Control	Ramp Rate Control	Ability to limit the rate of change in magnitude of active power supplied
Reactive Power Control	Fixed Power Factor: Pffixed	Ability to maintain a power factor at the PV site's PCC by changing reactive power injection
Reactive Power Control	Fixed Reactive Set-point: Qfixed	Ability to inject a fixed amount of reactive power (percentage of nameplate) at the PCC
Reactive Power Control	Power factor compensation - Power factor/active power characteristic curve PF(P)	Ability to establish a Power Factor level at the PCC based on actual Active Power production
Reactive Power Control	Voltage Compensation - Reactive power/voltage characteristic curve Q(U)	Ability to inject Reactive Power at the PCC based on actual Voltage level
Reactive Power Control	Voltage Regulation – closed loop regulation of the voltage Ramp Rate Control	Ability to establish a Voltage level at the PCC by injecting Reactive Power. Ability to limit the rate of change in magnitude of reactive power supplied
Frequency Droop Response	Real Power Curtailment	Ability to curtail Active Power during higher than normal frequency at the PCC
Low Voltage Ride Through ("LVRT") & High Voltage Ride Through ("HVRT")	Ride Through or Modulated Power Output	Ability to configure the tripping of the PV site during Under and Over Voltage events at the PCC (beyond what UL1741 specifies)
Frequency Ride Through ("FRT")	Ride Through or Modulated Power Output	Ability to configure the tripping of the PV site during Under and Over Frequency events at the PCC (beyond what UL1741 specifies)

Example: Inverter Control Impact

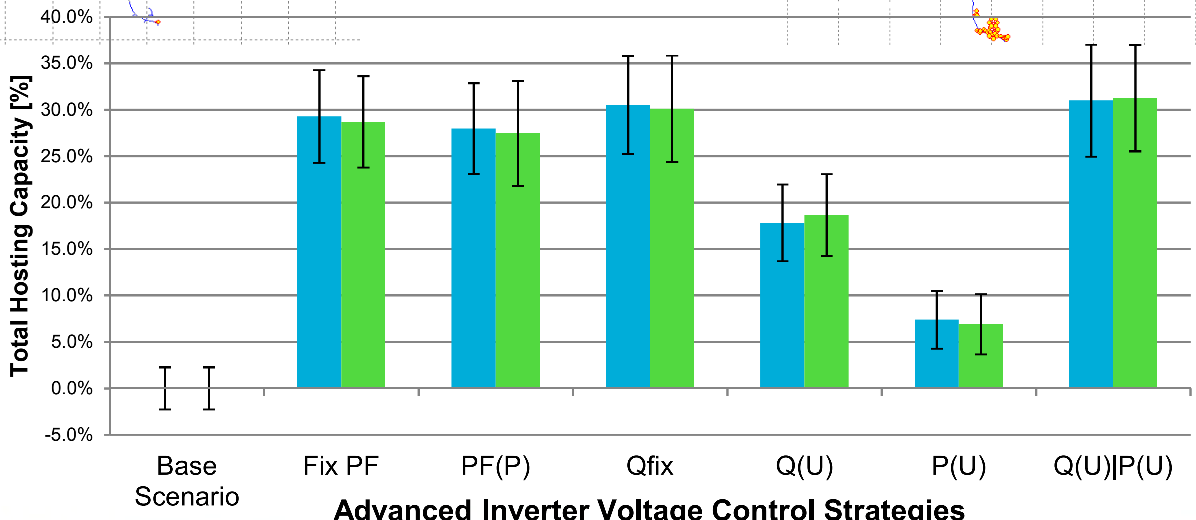


Control Strategies

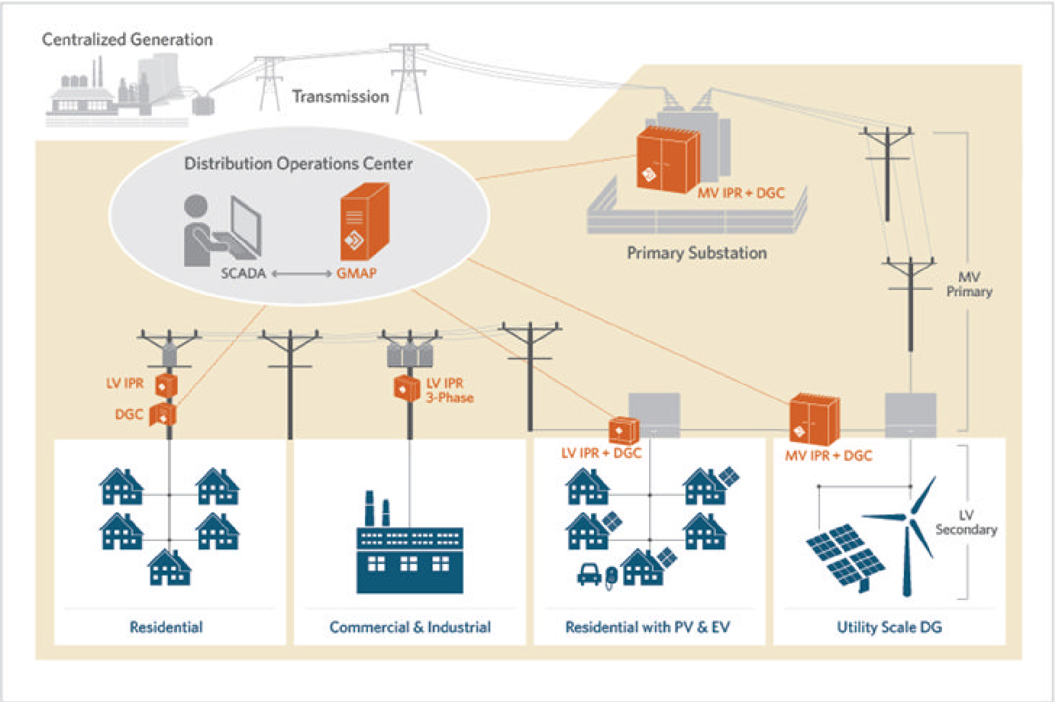


Simulation Results

2000 Iterations



Secondary Regulation



Thoughts on Implementation

Power Electronics have the promise to increase overall system

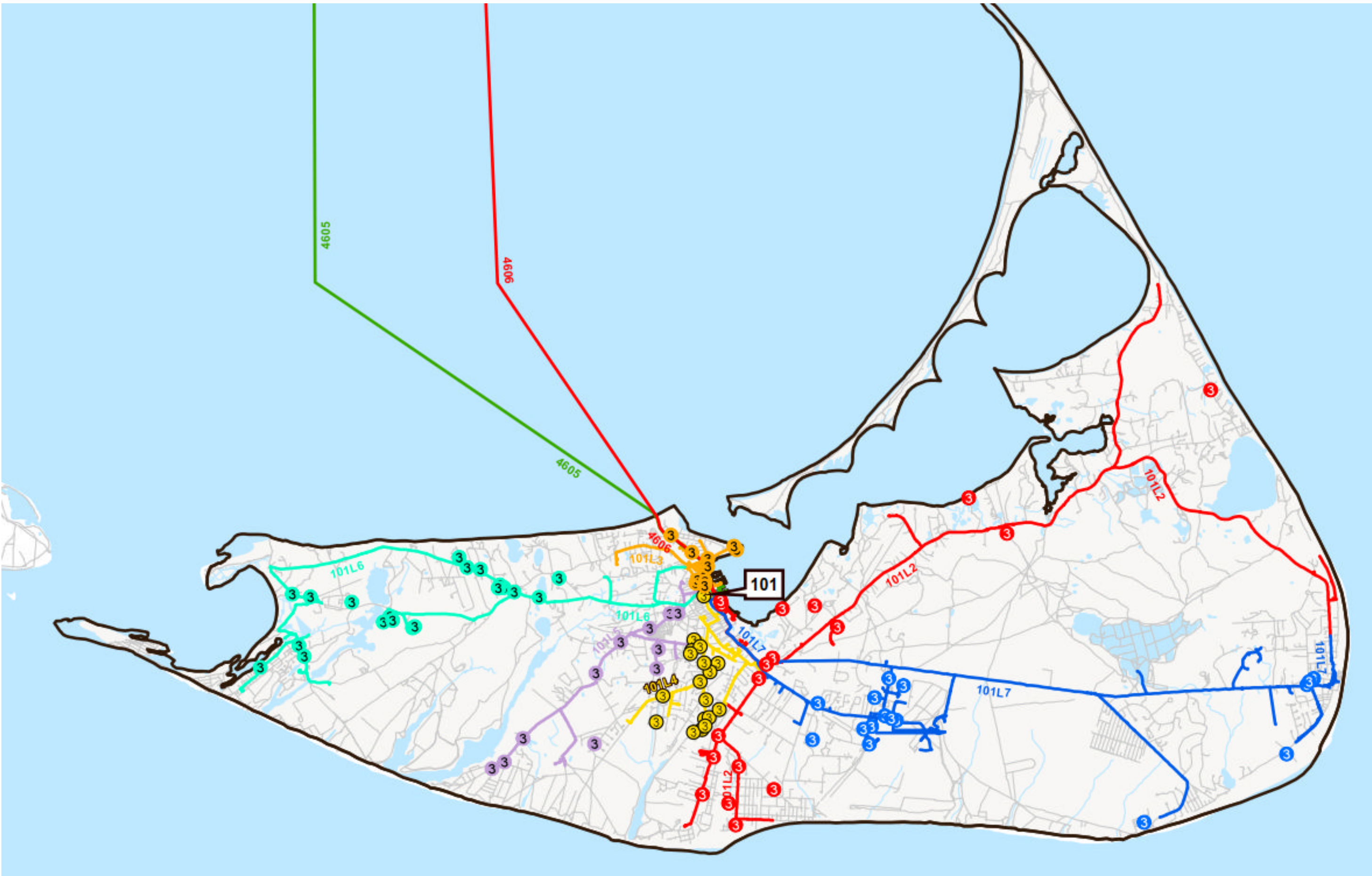
- **Observability**
- **Efficiency**
- **Resiliency**
- **Power Quality**

However, they also have the potential to:

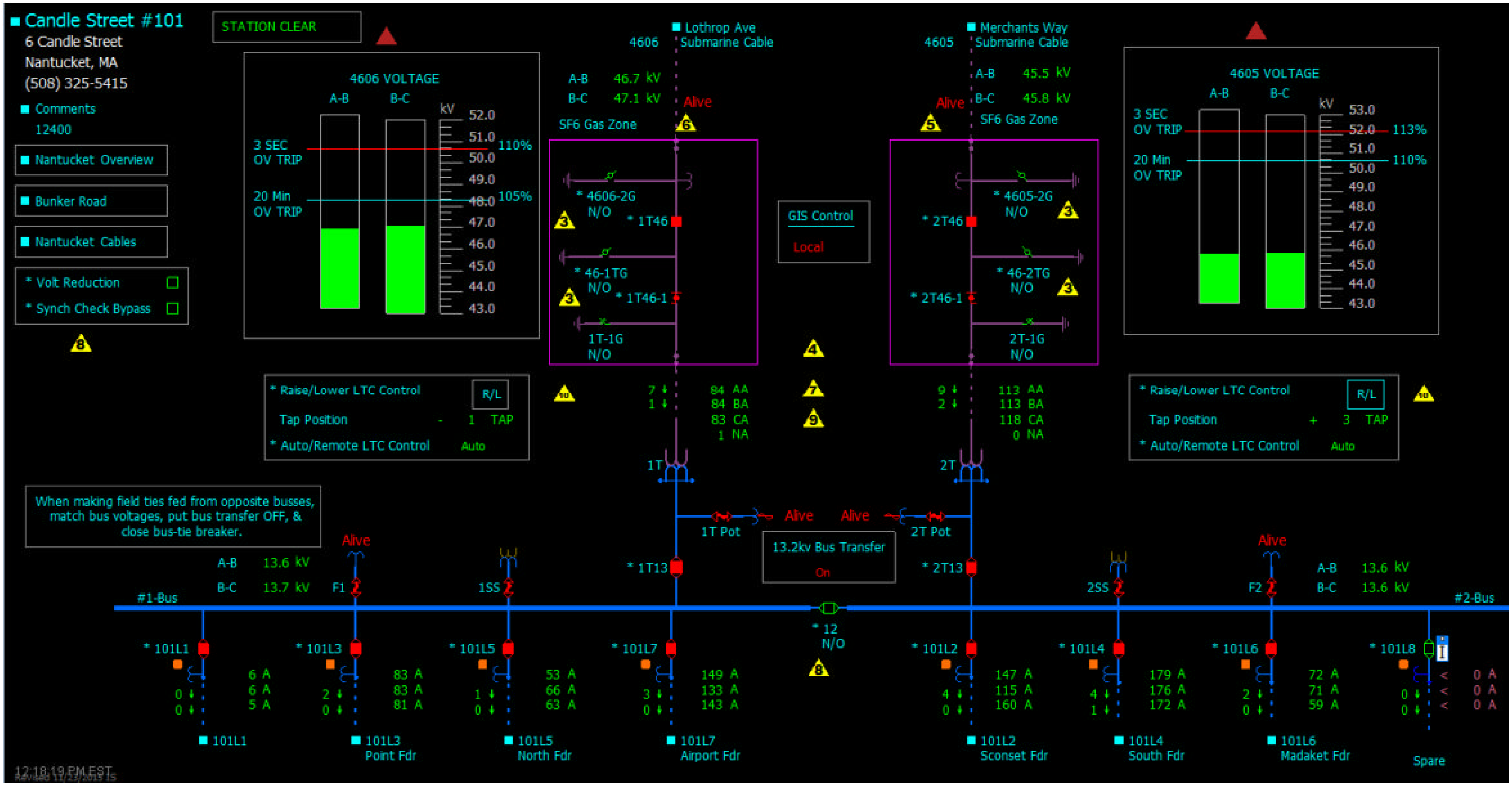
- **Introduce new failure mechanisms**
- **Increase Observability**
- **Information Overload Operators**
- **Tax Infrastructure**

- Communications bottlenecks
- Fail-out-of-the-way Pilots
- Pilot vs. Integrated into the business
- Security: Physical/Cyber

Potential Applications: Balancing the Distribution System



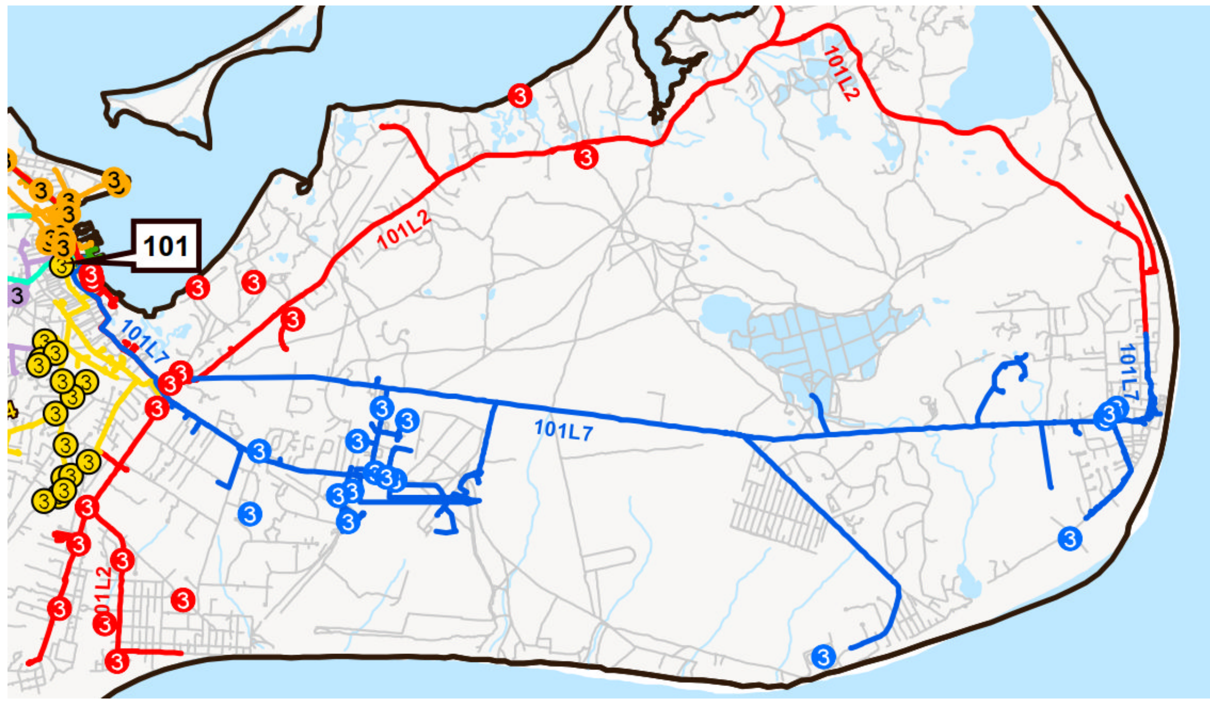
Potential Applications:
EMS Visibility: Cable Balancing



Potential Applications: Dynamic Feeder Balancing

Active electronics at Feeder Tie locations:

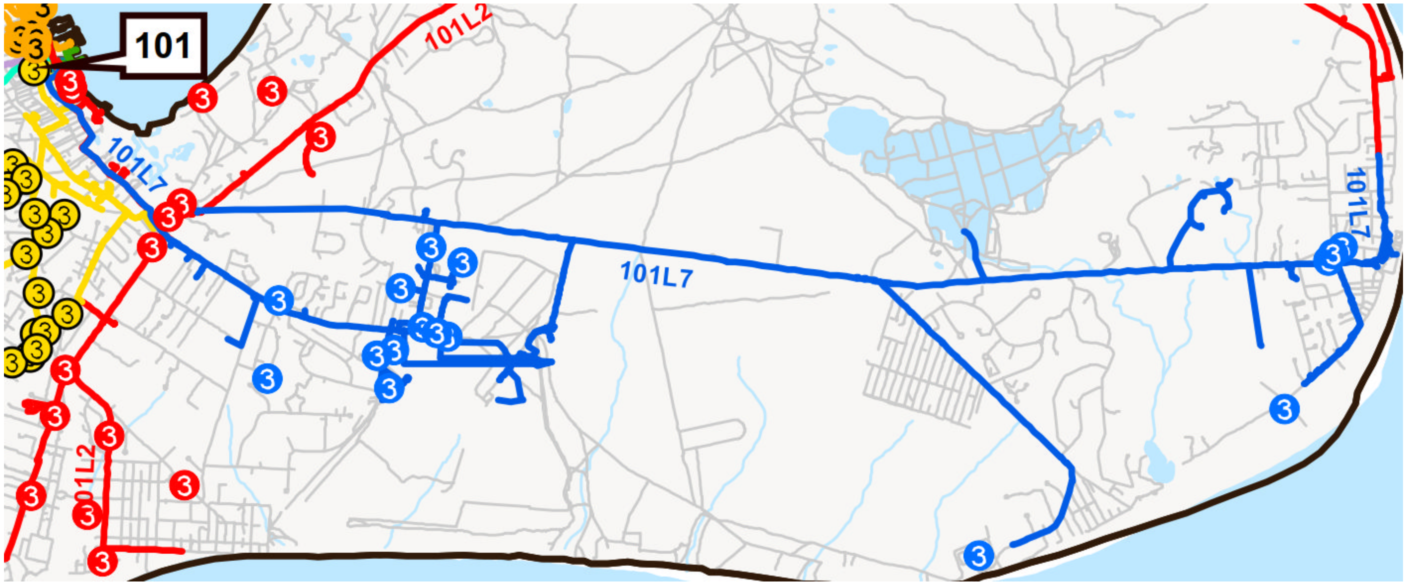
- Manage Power flow between feeders
- Assist in restoration and FLISR efforts
- Limit or mitigate fault current impacts
- Assist in reconfiguration for construction
- Voltage Support at EOL
- Fault Location



Potential Applications:
Lateral Feeder Balancing

Active electronics at Lateral locations:

- Sustain balanced power flows as load changes
- Supply local VARS as needed
- Provide lateral visibility
- Assist in restoration and FLISR operations



nationalgrid

HERE WITH YOU. HERE FOR YOU.

Thoughts?

James.Perkinson@nationalgrid.com