The Resilient Smart Grid
Brookhaven National Laboratory
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Corporate Overview

- Service territory population approximately 680,000
- Average household income approximately $64,500
Six components of resiliency

- Design/Construction
- Innovation and Automation
- Asset Management and Maintenance
- Weather Prediction Tools
- Forensic Analysis and Data Collection
- Emergency Response

- Evolving for 13 years
- Becoming increasingly “smart”, but foundational elements still important
Design/Construction

Central Hudson Exceeds NESC Standards

- NESC Grade B became our Standard Design in 2008
  - 65% strength derating factor
  - 45’ Class 2 Standard
  - Most spans <175’

- NESC Grade C required for most applications (Rule 250B)
  - 85% strength derating factor

- EPRI Grid Resiliency Project

The Warm Island Loading District includes American Samoa, Guam, Hawaii, Puerto Rico, Virgin Islands, and other islands located from 0 to 25 degrees latitude, north or south.
# Innovation & Automation – Evolution of Reclosers

<table>
<thead>
<tr>
<th>Hydraulic Reclosers</th>
<th>Electronic Reclosers</th>
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</thead>
<tbody>
<tr>
<td>• 2002</td>
<td>• 2008</td>
</tr>
<tr>
<td>• No Communications</td>
<td>• Complete replacement of Type D hydraulics by 2016</td>
</tr>
<tr>
<td>• Limited Protection Capability</td>
<td>• Communications via Sensus RTM</td>
</tr>
<tr>
<td>• Standalone Devices</td>
<td>• Flexibility of Protection Curves to enhance transient protection</td>
</tr>
<tr>
<td></td>
<td>• Instantaneous reclosing</td>
</tr>
<tr>
<td></td>
<td>• Automatic Load Transfer</td>
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</tbody>
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*Images*
Electronic Recloser Installations

VIPER Reclosers (top of pole)  Control Cabinet (bottom of pole)
Electronic Recloser Installations

Panel for SEL-651R Controller

Telemetric radio installed in controller cabinet
Innovation & Automation - Frost Valley Microgrid R&D Project

• Frost Valley YMCA
  – Catskill Mountains
  – 14 miles from Substation
Historical Reliability

- January 2002 – March 2006
  - Non-Storm
    - 6.5 Outages/Year
    - 3.2 Hours/Outage
  - With Storm
    - 8.8 Outages/Year
    - 9.9 Hours/Outage
Alternatives Evaluated

Microgrid Option Cost Effective

1. Re-establish 2nd Neversink feeder with Automatic Load Transfer

2. Re-locate feeder On-Road with Automatic Load Transfer

3. Create NYSEG Circuit Tie with Automatic Load Transfer

4. Install Microgrid Generator with Automatic Load Transfer
   - Lowest $/(Customer Outage Avoided) when full potential considered

<table>
<thead>
<tr>
<th>Central Hudson Expenditures</th>
<th>$610,387</th>
</tr>
</thead>
<tbody>
<tr>
<td>NYSERDA Contributions</td>
<td>$310,000</td>
</tr>
<tr>
<td>Total Expenditures</td>
<td>$920,387</td>
</tr>
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</table>
Work Scope & Objective

• Create an electric distribution load center using an isolated standby generator for backup power source
  – Output adjusts to match load
  – Performs voltage and frequency regulation

• During an upstream interruption:
  1) Load center isolates itself from normal source
  2) Generator turns on
  3) Source transfers to generator
  4) Operates independently of grid
Generator Specifications

• 1 MW Diesel Generator
  – Enclosed in noise-reducing cabinet

• 1,000 gallon fuel tank
Switchgear Specifications

• Two breakers to transfer load from normal to generator feed
• Asco Group 5 Controller Monitors
System Performance

- Operated 21 times since 2010
  - 4.2 outages per year saved
  - 29,000 customer minutes saved

- Provided resiliency benefits
  - “Twin Peaks” snowstorm – February 2010
  - Hurricane Sandy – October 2012
Lessons Learned

• Install Communications
  – Did not know when unit turned on until fuel was used up because customers didn’t call (no outage)
  – Later added satellite communications
    • Can request real-time data to website
    • Communications delay has negative impact
    • Sends emails to key personnel when states change

• Install sufficient fuel to ride through a long duration event
  – 1000 gallons lasted 1-2 days
  – Site accessibility in poor weather an issue
  – Later added an auxiliary fuel tank (6,000 gallons)
Microgrids of the Future

• Replicate the Frost Valley model
  – Include similar projects in our regular capital program where more cost effective than traditional T&D solution

• Develop a premium service where enhanced reliability is critical
  – Aggregated load greater than 500 kW
  – Turnkey solution to customer from Central Hudson
    • Partner with NYPA programs for schools and other state institutions
Asset Management & Maintenance - Vegetation Management

Significant changes in 2007 improve tree reliability by 36%

- Four year trimming cycle
  - 3 phase and single phase

- Ground to sky where feasible
  - No more “box” trimming

- Improves reliability and resiliency
Frequency of Interruptions due to Trees declined 36% in 6 Years

Tree SAIFI 2006-2012
### Asset Management & Maintenance – 5 Year Inspection Cycle

Severity Rating assigned to prioritize repairs

<table>
<thead>
<tr>
<th>Severity Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insignificant – No action needed</td>
</tr>
<tr>
<td>2</td>
<td>Very minor condition - No action needed at this time</td>
</tr>
<tr>
<td>3</td>
<td>Monitor for future action</td>
</tr>
<tr>
<td>4</td>
<td>Serious Condition – may cause a circuit outage or problem in the future</td>
</tr>
<tr>
<td>5</td>
<td>Critical Condition – likely to cause an interruption of service.</td>
</tr>
<tr>
<td>6</td>
<td>Immediate Condition – Immediate threat to life, property, or will cause a circuit outage or problem</td>
</tr>
</tbody>
</table>
Asset Management & Maintenance - Poles

Poles a major bottleneck in storm restoration

<table>
<thead>
<tr>
<th>Storm Name</th>
<th>Date</th>
<th>Number of Broken Poles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurricane Sandy</td>
<td>10/29/2012</td>
<td>289</td>
</tr>
<tr>
<td>September 2012 Wind Storm</td>
<td>09/20/2012</td>
<td>32</td>
</tr>
<tr>
<td>October Snow (Halloween)</td>
<td>10/29/2011</td>
<td>94</td>
</tr>
<tr>
<td>Hurricane Irene</td>
<td>08/28/2011</td>
<td>355</td>
</tr>
<tr>
<td>Ice Storm winter 2011</td>
<td>03/07/2011</td>
<td>40</td>
</tr>
<tr>
<td>Twin Peak 2010</td>
<td>02/25/2010</td>
<td>128</td>
</tr>
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</table>

- Sandy – average age 53 years vs. 39 year average for general pole plant
- Antidotal data suggests breaking at 3rd party attachment points and below grade rot
- Need to continue R&D on pole testing equipment
- Need to collect better data during storms
Central Hudson Damage Assessment Enhancement Goals

• Improve work efficiency by providing accurate data to the appropriate individuals as quickly as possible

• Increase accuracy of Estimated time of Restoration (ETRs)

• Augment post storm forensic analysis
Central Hudson Damage Assessment
Project Phases

• Phase I (2014 Q4)
  – Provide a tablet based assessment tool
    • Automate data collection
    • Develop summary reports and work packages generated
    • View damage location on OMS

• Phase II (TBD)
  – Integrate the data with logistics and enhanced outage management
    • Interface with logistics management software
    • Enhance OMS to include damage details in outage cases
    • Develop reporting tools to Engineering for forensic analysis and capital budget project development
Central Hudson Damage Assessment Enhancement – User Interface (Office)
Central Hudson Damage Assessment Enhancement – User Interface (Field)
Central Hudson Weather Stations

Goals

• Refine our line clearance program if appropriate

• Develop an electric service outage prediction model based upon weather forecast
  – Currently working with BNL to refine outage prediction model and tools

• Apply to future System Planning needs such as PV forecasting
Central Hudson Weather Stations Overview

- 24 Locations based upon FleetWeather study
- ~100% coverage
- Schneider provides web interface
Central Hudson Lufft WS600-UMB
Weather Stations

- Temperature
- Humidity
- Precipitation
- Pressure
- Wind Speed & Direction

Lufft WS600-UMB
Control Panel
-w-
Cell Modem
Data Collector
Resiliency is One Component of Central Hudson’s Overall Smart Grid Objectives

1. Implement a Distribution Management System (DMS)

2. Upgrade T&D System Infrastructure

3. Install intelligent devices/sensors
   - Conservation Voltage Reduction (CVR)
   - Distribution Automation (DA)

4. Integrate data through a two-way Communication System
Future Vision for Distribution: 2015 - 2020

- **Integrated Roadmap Developed**
  - GIS, DA, Communications Strategy, DMS

- **One source of the truth**

- **Optimized Operating and Planning Solutions**
  - Real time analysis and optimized switching through DMS
    - Include future integration of DERs, DR, and weather stations in addition to typical ADMS capabilities
  - Damage information through the OMS
  - Integration of DERs and Capital Deferral