RELIABILITY & RESILIENCY IN NEW JERSEY

RICHARD WERNNSING
MANAGER ELECTRIC ASSET STRATEGY PSE&G
IEEE PES GM- PANEL
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Todays Discussion

• Utility Overview
• The Perfect Storm
• Damage and Aftermath
• PSE&G Energy Strong Proposal
• Future Vision
Serving New Jersey for 110 Years
PSE&G Background

Utility Overview
- New Jersey Based
- Total Assets ~ $17 Billion
- Total Revenue ~ $8 Billion

Service Territory
- 323 Municipalities
- 70% of New Jersey’s population
- 2.2 million Electric customers
- 1.8 million Gas customers
- 2,600 Square Miles
- 22,223 Distribution Circuit Miles
- 1,735 Transmission Circuit Miles
The Perfect Storm
Pre-Storm Preparations

• Station Preparation
  • Block walls, Jersey barriers, concrete blocks and sandbags were deployed at 15 higher-risk switching and substation locations to prevent flooding
  • Diesel pumps were installed at high-risk locations that have flooded in the last two storms
  • Other actions included removing and de-energizing equipment at risk and pumping manholes and transformer pits to alleviate flooding
Damage Assessment

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
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<tbody>
<tr>
<td>Tree Locations</td>
<td>48,000</td>
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<tr>
<td>Poles</td>
<td>2,400</td>
</tr>
<tr>
<td>Circuits</td>
<td>2,900</td>
</tr>
<tr>
<td>Services</td>
<td>8,300</td>
</tr>
<tr>
<td>Lock Outs</td>
<td>2,900</td>
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</tbody>
</table>
Damage Assessment
What’s wrong with this picture?
Damage to Inside Plant – Sewaren
Pro-active Mutual Aide Teams
Total Customers Out – Total event
Regional view

Date: 11/7/2012 8:00:00 PM
Snowstorm Athena

Utilities:
- ACE
- CL&P
- ConEd
- JCP&L
- LIPA
- O&R
- PPL
- PSE&G
Why Make NJ Energy Strong?

• It’s clear that Superstorm Sandy, Hurricane Irene and the October ice storm in 2011 represent *extreme* weather patterns that may become commonplace.

• More than 30 distribution stations were impacted by Sandy and/or Irene, leaving over 850,000 during Irene and 2,000,000 people during Sandy without power.

• The state’s entire energy infrastructure needs to be rethought in light of weather conditions that many predict will continue to occur.
Extreme Weather Conditions

- PSE&G is proud of being named the most reliable utility in the country 5 of the past 8 years, including 2012
  - most reliable in the region for the past 11 years.
- Sandy, Irene and the October snowstorm show that extreme weather may become commonplace
- These recent weather patterns, along with an increased dependency on energy, led PSE&G to propose a re-thinking of the energy infrastructure and systems even though current investments provide recognized, award winning reliable service

“Hardening” our energy infrastructure and making our energy systems more “Resilient” are the major components of the Energy Strong filing providing a total solution
Storm Damage History

Percent of Customers Interrupted

<table>
<thead>
<tr>
<th>Date</th>
<th>Percent of Customers Interrupted</th>
</tr>
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<tbody>
<tr>
<td>Prior to 2010</td>
<td>11</td>
</tr>
<tr>
<td>3/10/2014</td>
<td>28</td>
</tr>
<tr>
<td>8/11/2014</td>
<td>40</td>
</tr>
<tr>
<td>10/11/2014</td>
<td>29</td>
</tr>
<tr>
<td>10/12/2014</td>
<td>90</td>
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</table>
Energy Strong: A Proposal To Invest in New Jersey’s Future

• In addition to other investments and activity to maintain a safe, adequate and reliable grid
• Non-routine work
• In addition to vegetation management

“Hardening” will never eliminate all outages, resulting in “Resiliency” improvements being strongly recommended.
PSE&G’s Energy Strong

BENEFITS OF THE “ENERGY STRONG” PROGRAM

• **Job creation.** PSE&G estimates that the Energy Strong program will create more than 2,000 jobs to bolster the state’s economy.

• **Little impact on customer bills.** The impact of the $1 billion investment on the typical residential combined electric/gas customer bill is expected to be approximately 2 percent in 2018 which will be more than offset by transitional charges stemming from deregulation that are expiring in the same timeframe.
“Hardening”: Physically changing the infrastructure to make it less susceptible to damage from extreme wind, flooding, or flying debris. Hardening improves the durability and stability of energy infrastructure, making it better able to withstand the impacts of hurricanes and weather events without sustaining major damage.

- **Station flood and storm surge mitigation**
  - Protect substations damaged by recent storms
  - (e.g. Hudson, Marion Sewaren, Newark, Linden, Bayonne and Hoboken)

- **Outside plant: higher, more robust design standards**
  - 4kV at 13kV standards and 26kV at 69kV standards

- **Improving pole infrastructure** (Composite Poles)
  - More non-wood poles (technology) and guy systems

- **Undergrounding of electric lines**
  - Convert 20 miles of overhead construction to underground
Station Flood Mitigation

This program will target the following stations for building flood walls, raising or replacing infrastructure, and/or relocating/eliminating stations –

- **Stations impacted by Superstorm Sandy**
  - Sewaren 230/138/26kV
  - Essex 230/138/26kV
  - Hudson 230kV
  - Linden 230/138/26kV
  - Bayonne 138/26/13kV
  - Marion 138/26kV
  - Newark Airport Bkr Station
  - Hoboken
  - Marshall St
  - River Rd
  - South Waterfront
  - Bayway
  - Madison
  - Hackensack
  - Jersey City 13kV
  - St Paul’s
  - Little Ferry
  - Howell
  - Cliff Rd
  - Third St
  - Port St

- **Stations impacted by Hurricane Irene and prior water intrusion events**
  - Marion 138/26kV
  - New Milford
  - Hillsdale
  - Somerville
  - Jackson Rd
  - Rahway
  - Cranford
  - Belmont
  - Garfield Place
  - River Edge

- A portion of (61) other stations located within the “NEW” FEMA Base Flood Elevations
Priority Restoration: Who's first?

• Contingency reconfiguration strategies
  • Expanding our 13kv self healing loops (two sources)
  • Contingency reconfiguration strategies for *high profile* customers by creating multiple sections, utilizing smart switches, smart fuses, and adding redundancy within the Company’s self healing loop schemes.
“Resiliency”: Ability of an energy facility to recover quickly from damage to any of its components or to any of the external systems on which it depends. Resiliency measures do not prevent damage; but rather they enable energy systems to continue operating despite damage and/or promote a rapid return to normal operations when damages/ outages do occur.

- Smart Grid (advanced) Technologies are the core and foundation of our “Resiliency” strategy
- Each Advanced Technology component plays a vital role in our Storm Restoration process
- The program will utilize new and significantly enhanced technologies to improve storm/emergency response and improve customer communications

The Advanced Technology “Resiliency” components are an integrated approach of critical system improvements
Major Storm Events – Common Themes

- **Multiple Damage locations on Circuits**
  - 48,000 tree locations in Hurricane Sandy
  - Damage behind fuses/devices after initial power loss
- **Reliable Communications for**
  - Telephone and SCADA
- **Smart Relays**
- **Customers communications**
- **Scalable logistics key to restoration**
  - Work identification, Assignment and Execution with mutual aid crews
  - Workforce increases of two to four times normal
Improved Storm Assessment

Gather Data
- SCADA and Microprocessor Relays
- Fiber Communications

Assess Damage
- Storm Damage Assessment

Execute Work Efficiently
- Work Prioritization and Scheduling

Results
- More accurate "Restoration Times"
- Increased Communications
Make it Stronger – $1.12B

“Hardening”: Physically changing the infrastructure to make it less susceptible to damage from extreme wind, flooding, or flying debris. Hardening improves the durability and stability of energy infrastructure, making it better able to withstand the impacts of hurricanes and weather events without sustaining major damage.

– $720 Million in Electric Distribution Investment
– $400 Million in Gas Delivery Investment

Make it Smarter - $100M

“Resiliency”: Ability of an energy facility to recover quickly from damage to any of its components or to any of the external systems on which it depends. Resiliency measures do not prevent damage; but rather they enable energy systems to continue operating despite damage and/or promote a rapid return to normal operations when damages/ouages do occur.

– $100 Million in Smart Grid Technologies
PSE&G’s Energy Strong
Capital Program addresses new reality

Electric System

- $620 million to raise, relocate or protect 29 switching and substations that were damaged by water in recent storms.
- $100 million to create redundancy in the system, reducing outages when damage occurs.
- $100 million to deploy smart grid technologies to better monitor system operations to increase our ability to more swiftly deploy repair teams.
PSE&G’s Energy Strong

Gas System

• $350 million to replace and modernize 250 miles of low-pressure cast iron gas mains in or near flood areas.

• $50 million to protect five natural gas metering stations and a liquefied natural gas station affected by Sandy or located in flood zones.
Technology Enables

The foundation of the Advanced Technology recommendations is to visually depict “where”:

- Circuits have been locked out
- Fault locations have been predicted
- Look-ups need to be performed
- Plant Damage has been identified
- Crews are restoring service
- Pending repairs still need to be made
Gather & Correlate Data

- Leverage Technology
- Dynamic Network Visualization
- Geographic and Schematic View of Network Model
- Information shared with all supporting operational processes
- Fault indicators incorporated
- Deeper understanding and visualization of distribution system performance

Installing additional modern devices, building a DMS and integrating into a Geographic Information System (GIS) provides an improved understanding of the impacts of the SCADA equipment.
Create a Communications Network (Fiber Network)

- Establish a reliable communications plan.
- A Fiber Network is will provide a dedicated and secure communications path for this mission critical data.
- Existing Transmission Fiber Network that runs on steel towers would serve as the backbone.
Fiber Network
Transmission Backbone

[Diagram of a fiber network with points labeled: Branchburg, Athenia, Bergen, West Orange, Lake Nelson, Trenton, Newark, New Freedom]
Fiber Network
Distribution
A New Way...

Station in the Sky

New FEMA elevations at Sewaren
Station in the Sky

New FEMA (plus 1ft) elevations at Sewaren
Plus one foot

FEMA FME
Smart Network Management

- Dispatch
- Fiber Cable
- Fiber Network
- PI Historian

Station

- Non-Operational Data SDAMS
- Operational Data SCADA
- Line Relays
- Bus Relays
- Data Concentrator
- Transformer Relays
- Transformer Monitoring
Enhanced Storm Management Systems

- Now that we have addressed “what” devices operated, we need to focus on “why”
- Improved information on the cause of the interruption and repairs required will enhance predicting estimated restoration times
- Major Components include:
  - Storm Damage Assessment
  - Work Prioritization & Optimization
  - Work Scheduling & Dispatch

The focus is on continuing to build Visual Geographic Awareness and merge the Operational SCADA Data with the confirmed Storm Damage Assessment Data to create a Master View of all key restoration activities
Storm Damage Assessment

• Improve the ability to capture and report the extent of the plant damage

• Mobile App Damage Report would allow us to consistently identify:
  • Cause of the outage
  • Assets Impacted
  • Extent of Plant Damage
  • Image Capture
  • Any safety issues or concerns

This major Advanced Technology improvement provides a deeper understanding of the extent of the damage, material necessary, and crew requirements to repair.
Distribution Management System (DMS)

- Now that we have a better understanding of the extent of the damage, we need to incorporate this information into our Master Storm Center Map
- The DMS allows us to merge Operational SCADA data with the Storm Damage Assessment Data to create a single geographical view

The merging of these two major data sources into a geographic Master View provides us with an insight and understanding that cannot be achieved with our current technology.
Now that all data resides in the DMS:
- we will be able to prioritize and optimize the work required to repair
- Intelligent Multidimensional Modeling
- Static Inputs
  - Criticality of Asset
  - # Customers Impacted
  - Network Relationship
- Materials Needed
- Estimated Job Duration
- Dynamic Inputs
  - Accessibility (Roads)
  - Material Location/Availability

This Advanced Technology improvement provides a way to better understand the level of effort required, the resources and material available and an optimized approach to restore power to our customers.
Work Scheduling & Dispatch

Now that we have a prioritized work plan, we propose investments that will allow us to schedule and dispatch our crews in an *optimized* manner.

- **Dispatch Scenarios**
  - Crew Proximity
  - Remaining Work Hours
  - Crew Capability
    - Equipment/Material
    - Truck Stock
- **Release work order to the field enabling the crew (PSE&G and Mutual Aid) to view, update and complete on the mobile device**

This Advanced Technology improvement provides a way to better understand the work performed in the field by the PSE&G and Mutual Aid crews and the assets that were repaired/replaced.
Customer Communications

• All of the previously mentioned Advanced Technologies were recommended to drive one key principle:

  “Improve Estimated Restoration Times and our Communications with Customers, Regulators and Municipalities”

• The Energy Strong proposal goes beyond today’s utility standards and envisions a more robust and integrated customer communication experience ahead of current industry trends.

Creating a holistic view of customer interactions and integrating traditional channels such as IVR with more modern options, such as text messaging, provides customers with more timely and accurate information.
Energy Strong Summary

- Collect data
- Centralize data
- Access Damage
- Create Actionable Information
- Drive Results
- Improved “Estimated Restoration Times”
Improving storm performance thru technology

Questions?