Pepco’s Reliability Enhancement Model

Using Predictive Reliability to Plan Investment in Electrical Infrastructure

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Panel Discussion – Predictive Reliability
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About the Speaker

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• System reliability improvement
• Reliability reporting
• Distribution system maintenance & construction standards
• Maintenance strategy & failure analysis
## Pepco at a Glance

<table>
<thead>
<tr>
<th>Category</th>
<th>Pepco Maryland</th>
<th>Pepco DC</th>
<th>Pepco Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Retail customers</td>
<td>537,000</td>
<td>264,000</td>
<td>801,000</td>
</tr>
<tr>
<td>Service Territory (miles²)</td>
<td>575</td>
<td>65</td>
<td>640</td>
</tr>
<tr>
<td>Distribution feeder circuit miles</td>
<td>8,564</td>
<td>2,264</td>
<td>10,828</td>
</tr>
<tr>
<td>Distribution Substations</td>
<td>63</td>
<td>46</td>
<td>109</td>
</tr>
</tbody>
</table>
Discussion Points

- Why do we model?
- About the model
- Results – *how well does it work?*
- Lessons learned, and next steps
Why Model?

- Pepco spends millions annually to invest in reliability and maintain the overhead electric system in Maryland and District of Columbia.

- Maximizing reliability is imperative!
  - Our customers deserve this
  - Our regulators require this
    - Maryland: Rulemaking 43 (RM43) standards
      - SAIFI / SAIDI targets
      - Major storm restoration standards
    - DC: Electric Quality of Service Standard (EQSS)
      - SAIFI / SAIDI targets
      - Major storm restoration plans
Why Model?

- To forecast and optimize benefits for dollars invested
- To support forward looking ratemaking
- To understand the strengths and weaknesses in our reliability programs
- To predict the future performance of our system
Discussion Points

• Background – the use of predictive reliability modeling at Pepco
• About the model
• Results – how well does it work?
• Lessons learned, and next steps
Modeled Reliability Solutions

We have various tools at our disposal to improve reliability:

Cycle Based Vegetation Management

- Increased clearance requirements
- Increased danger tree removals
- Significant reductions in outages due to vegetation as a result
Modeled Reliability Solutions

We have various tools at our disposal to improve reliability:

Feeder Improvement Work

Comprised of:

• Element 1 → Project specific vegetation management of target feeders before starting feeder improvement projects
• Element 2 → Replacement of failure prone assets (poles, wires cross arms, insulators, etc.)
• Element 3 → Hardening against future failures (increasing pole class, ACSR vs copper wires, polymer insulators, etc.)
Modeled Reliability Solutions

We have various tools at our disposal to improve reliability:

Electric System Automation & Added Sectionalization

- Automatic Sectionalizing & Restoration (ASR)
  - Isolation of faults, and providing automated switching logic to minimize customer impacts
  - Telecommunications / controls logic deployed to distribution substations
- Automatic Circuit Reclosers (ACR)
  - Reclosers added to feeders not a part of ASR schemes to provide improved sectionalizing of radial circuits
Brief History of REP Plan and Model

*We have been using predictive reliability techniques to manage investment in our system via these tools.*

<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
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</thead>
<tbody>
<tr>
<td>2012</td>
<td>Start of REP Model</td>
</tr>
<tr>
<td>2013</td>
<td>Developed pilot model using small sample of reliability improvement data for one jurisdiction (Pepco MD)</td>
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<tr>
<td>2013</td>
<td>Refinements to model made based on larger set of actual reliability improvement projects’ before &amp; after data.</td>
</tr>
<tr>
<td>2013</td>
<td>Rolled out model for other PHI jurisdictions</td>
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<tr>
<td>2014</td>
<td>Proactive use of model to develop proposed service level (SAIFI / SAIDI) targets</td>
</tr>
<tr>
<td>2014</td>
<td>Proactive use of model to set reliability targets</td>
</tr>
</tbody>
</table>

2013
Models used to respond to various commission requests

2014
Proactive use of model to set reliability targets
REP Model Overview

• Developed in partnership with PA Consulting (a global management consulting company with deep experiences in utilities)

• Focuses on four drivers for forecasting reliability improvements:
  • Vegetation management
  • Feeder improvement
  • Distribution Automation / ASR schemes
  • Non-ASR scheme ACRs

• Employs Monte Carlo analysis
  • Expected improvement based on observed historical SAIDI and SAIFI improvements for each driver category.
# REP Model Mechanics

<table>
<thead>
<tr>
<th>REP Model Inputs</th>
<th>Impact Level</th>
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</thead>
<tbody>
<tr>
<td>Vegetation Management program</td>
<td>Feeder level</td>
</tr>
<tr>
<td>Feeder Improvement program</td>
<td>Feeder level</td>
</tr>
<tr>
<td>ASR Schemes</td>
<td>Feeder level</td>
</tr>
<tr>
<td>ACRs</td>
<td>Feeder level</td>
</tr>
</tbody>
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**REP Model**

- Rank feeders from worst to best based on MVE-SAIFI contribution
- Is feeder to be included in analysis (Y/N)
- Establish number of feeders to be included in analysis
- Establish outage reduction targets
- Only the first 26 feeders in the analysis qualify for recloser installation

**Projected Jurisdictional level SAIFI / SAIDI improvements**

- Apply Feeder Hardening improvement %
- Apply Recloser improvement %
- Apply ASR improvement %
- Total feeder improvement percentage

The total feeder improvement is the sum of feeder hardening and one or both of the other initiatives, if they apply.
Discussion Points

• Background – *the use of predictive reliability modeling at Pepco*

• About the model

• Results – *how well does it work?*

• Lessons learned, and next steps
Results

The model has accurately forecasted measurable reliability benefits within an acceptable margin for the past two years.

Differences between the forecasted and actual results are attributable to reliability programs not accounted for within the model.
Model Benefits

• High level view of drivers behind jurisdiction-wide reliability metrics
• Based on simple and robust theory
• Flexibility to perform quick “what if” analysis
• Uses readily available historical data
• “Intermediate” rather than “extensive” (and cumbersome) detailed data
Discussion Points

• Background – *the use of predictive reliability modeling at Pepco*

• About the model

• Results – *how well does it work?*

• Lessons learned, and next steps
Lessons Learned and Next Steps

• Lessons learned
  – Data quality paramount
  – Diminishing returns for improvement projects
  – Model calibration to improve accuracy
  – Ability to separate out the contribution of different components
  – Recognition of variable impact of “data noise” from outage causes not directly addressed by initiatives modeled

• Next steps
  – Further Enhancements
    • Incorporate impacts from undergrounding feeders
    • Capture benefits from additional initiatives to improve model accuracy
  – Smart Grid analytics and static vs. dynamic modeling of reliability impacts
  – Further integrate reliability planning model into PHI’s long range planning process
Summary

- Ultimately, it’s about data and what we can do with it.
  - Start simple and build in complexity and accuracy over time with more data and understanding of what it means
  - Reasonably forecast future outcomes based on historic results
  - Gain insight into reliability improvement drivers
  - Prioritize work for best bang for the buck
  - Set future investment levels
  - Forecast return on reliability investments
Questions