PECO delivers a Reliable and Resilient Smart Grid

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AGENDA

- PECO Background
- PECO's Smart Grid Project
- Reliability Benefits
  - Storm Resiliency and the Communications Network
  - Outage Management
  - Distribution Automation
  - Voltage Monitoring

PECO

Subsidiary of Exelon Corporation

Serving the greater Philadelphia Pennsylvania area for over 100 years

2,100 square miles (5,400 km^2) service territory

Electric and Gas Utility

- 1.7M Electric Customers, 8,932 megawatt peak load
- 525K Gas Customers

PECO's Infrastructure

Transmission System
- 500, 220, 138 & 69kv Transmission Lines
- 1,067 miles (1,720 km) of high voltage lines

Substations
- 449 Primary and Unit Substations
- SCADA coverage for all primary stations

Distribution System
- 2,242 Distribution Circuits covering 21,362 miles (34,378 km)
- 34, 13.2, 4 & 2.4kv Distribution Lines

Automation
- >1,600 Distribution Automation Reclosers
  - ~75% Communicating via Telco Circuits or Private Wireless
  - Supporting 34 & 13kv Systems
- Fully Automated Meter Reading
  - Landis+Gyr/Cellnet AMR 1-Way Fixed RF System serving 2.2M electric and gas meters
  - Transitioning to a Sensus FlexNet Smart Grid and AMI Platform
- Fully integrated AMR and Outage Management Systems

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The Smart Grid and PECO

PECO has been deploying and benefiting from the Smart Grid for many years, as evident in our:

- SCADA Platforms, both Transmission and Distribution SCADA
- Distribution Automation Solutions
- AMR Deployment

The State of Pennsylvania has recently passed legislation requiring all Utilities to modernize their systems, including Smart Meters

- Funding mechanisms are included in the legislation
- This program has been complemented with additional $200M US Federal funding

This combination of programs is the catalyst for PECO to create the Smart Future, Greater Philadelphia program, whose goals include:

- Promoting Innovation, Opportunity and Sustainability Through Smart Grid Technology

Smart Grid Greater Philadelphia Program

PECO's $650 million Smart Grid / Smart Meter initiative is one of the largest investments in the company's more than 100 year history and will enable us to provide electric service more reliably and efficiently and provide future new products and services to our customers

- Work is underway at PECO to deploy Smart Meters for all of our 1.6 million electric customers thanks to $200 million stimulus grant awarded by the US Department of Energy
- Currently over 950,000 Smart Meters have been installed
- We expect to complete the full system-wide deployment by the end of 2014.

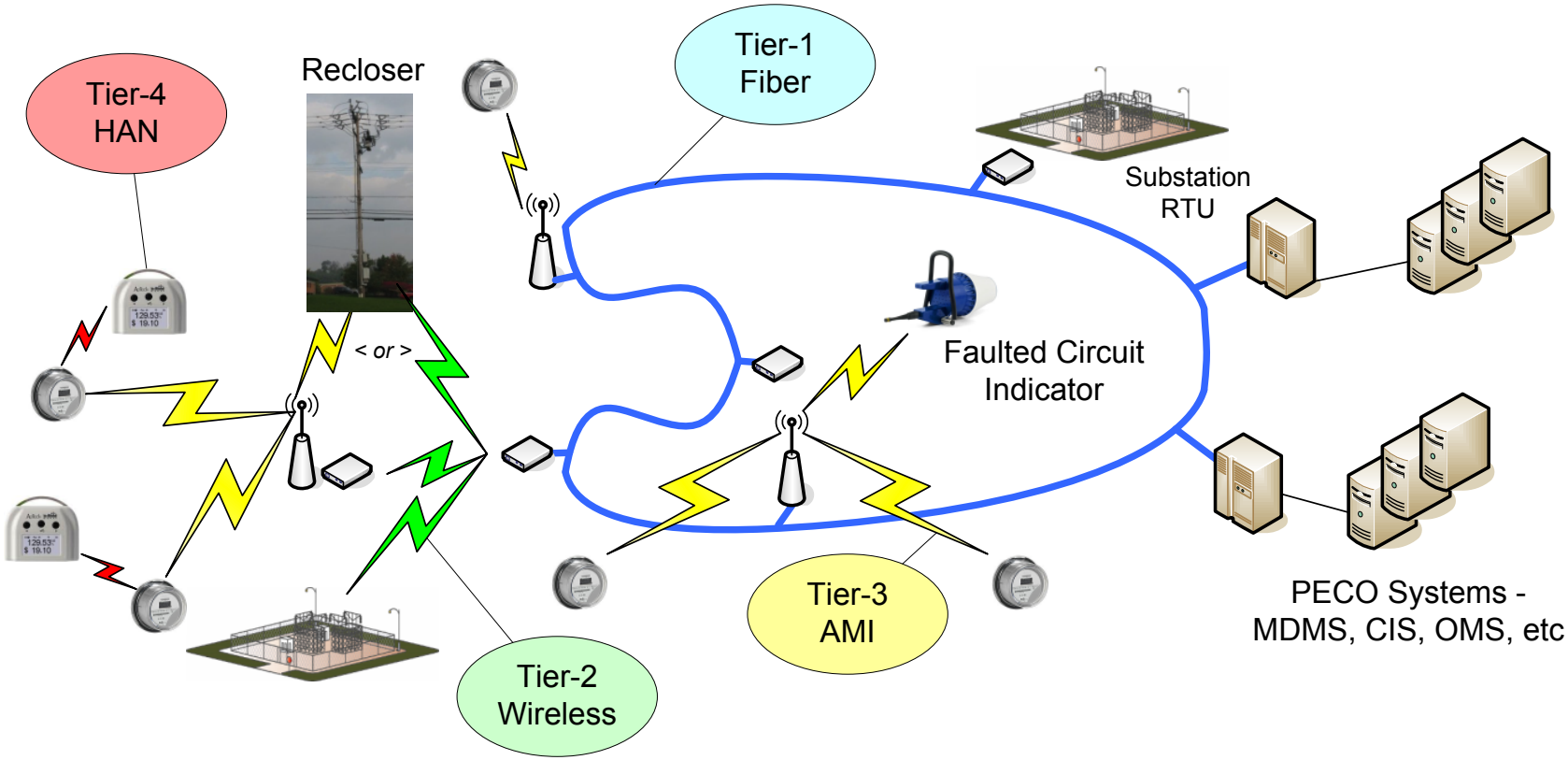
The two-way information system created by the Smart Grid / Smart Meter network is designed to improve electric service reliability and also help advance use of renewable energy sources

- Smart Meter technology will equip customers with the information they need to better understand how they use energy and how they can save energy
- With this technology PECO also will be able to offer customers enhanced rates and other 'dynamic pricing'

Key Components of PECO's Smart Grid

- To PECO, the Smart Grid is firmly rooted in a strong & resilient communication network
  - PECO designed a best-in-breed hybrid communications network
    - Backhaul with Fiber Optic, Microwave and WiMax Communications
    - RF End-Point Communications – Licensed RF
      - Principally point-to-point
      - Single hop mesh where needed
- The end-points connected to the network create operational benefits
  - Smart Meters
  - Distribution Automation Devices
    - Recloser
    - Capacitor Controllers
  - Monitoring Devices
    - Faulted Circuit Indicators
    - Voltage Sensors

PECO's Multi-Tiered Smart Grid Network



Communication Tiers:

- ✓ Tier-1: ~375 miles of high speed/high bandwidth fiber optic communications
- ✓ Tier-2: WiMax wireless communication network
- ✓ Tier-3: AMI Network, low-speed, low bandwidth network
- ✓ Tier-4: HAN In-Home Communications

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Smart Grid Network Resiliency

- PECO's Smart Grid Network is designed to be storm tolerant with high reliability and resiliency
  - A backbone network of Sonet Fiber Optic Rings
  - Redundant communication paths were necessary
  - Each end-point communicates to numerous towers

- During Hurricane Sandy (Oct 2012), PECO's Smart Grid performed well with the following results:
  - Network Impact – Resiliency
    - During the Storm, 60 out of 163 TGB sites either lost communications or land power for an extended period of time
      - Due to the magnitude of the storm, backup batteries were depleted
      - Portable generators were dispatched to priority sites
    - Analysis indicated that only 2% of the meters that had power were unavailable

Outage Detection and Restoration Benefits

Benefit	Hurricane Irene *	Hurricane Sandy **
Total Customers Impacted	~508,000	~1,130,000
Peak Customers Impacted	480,000	608,000
Single Customer Event Cancellations	2,300	4,257
Primary Event Cancellations	350	820
Escalations – Single Events to Primary Events	700	1,042
Total Events (avoided and/or more effective truck rolls)	3350	6119
Estimated Fewer Days to Total Restoration	1-2 days	2-3 days

Cancellations – Power On verified, OMS event cancelled
Escalations – Verified neighboring meters out, job escalated from single event to multiple event

*Hurricane Irene August-September 2011; 100% AMR
**Hurricane Sandy October-November 2012; 90% AMR / 10% AMI

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Avoided Generation Benefit

PECO recently completed a project to install a second transmission feed its Clay substation

- A twenty-five (25) day substation outage was required
- During the outage, over 50 distribution circuits within the southern Chester County service territory were affected and out of configuration
- This temporary configuration affected 32,779 customers

There was a need to closely monitor these circuits to ensure that voltage is maintained within the established tariff limits

- Standby generation was strategically placed at points of concern
- The AMI system was used to monitor voltage in these areas
  - ~175 AMI meters were installed to provide hourly voltage data

The AMI meter data based analysis helped avoid running the standby generation saving over $1.25M (USD)

PECO's Smart Grid Distribution Automation Vision

PECO's goal is to deploy an AMI network with the capability to support Smart Grid applications and communicate AMI and Distribution Automation data on a converged network:

- Distribution Management System (DMS)
  - Automatic Fault Detection, Isolation, and Service Restoration
- Distribution SCADA control of reclosers, regulators and capacitor banks
- Conservation Voltage Reduction (CVR) Application
- Communicating Faulted Circuit Indicators
  - Real Time Fault Locating
- Analytics

Analytics for Distribution

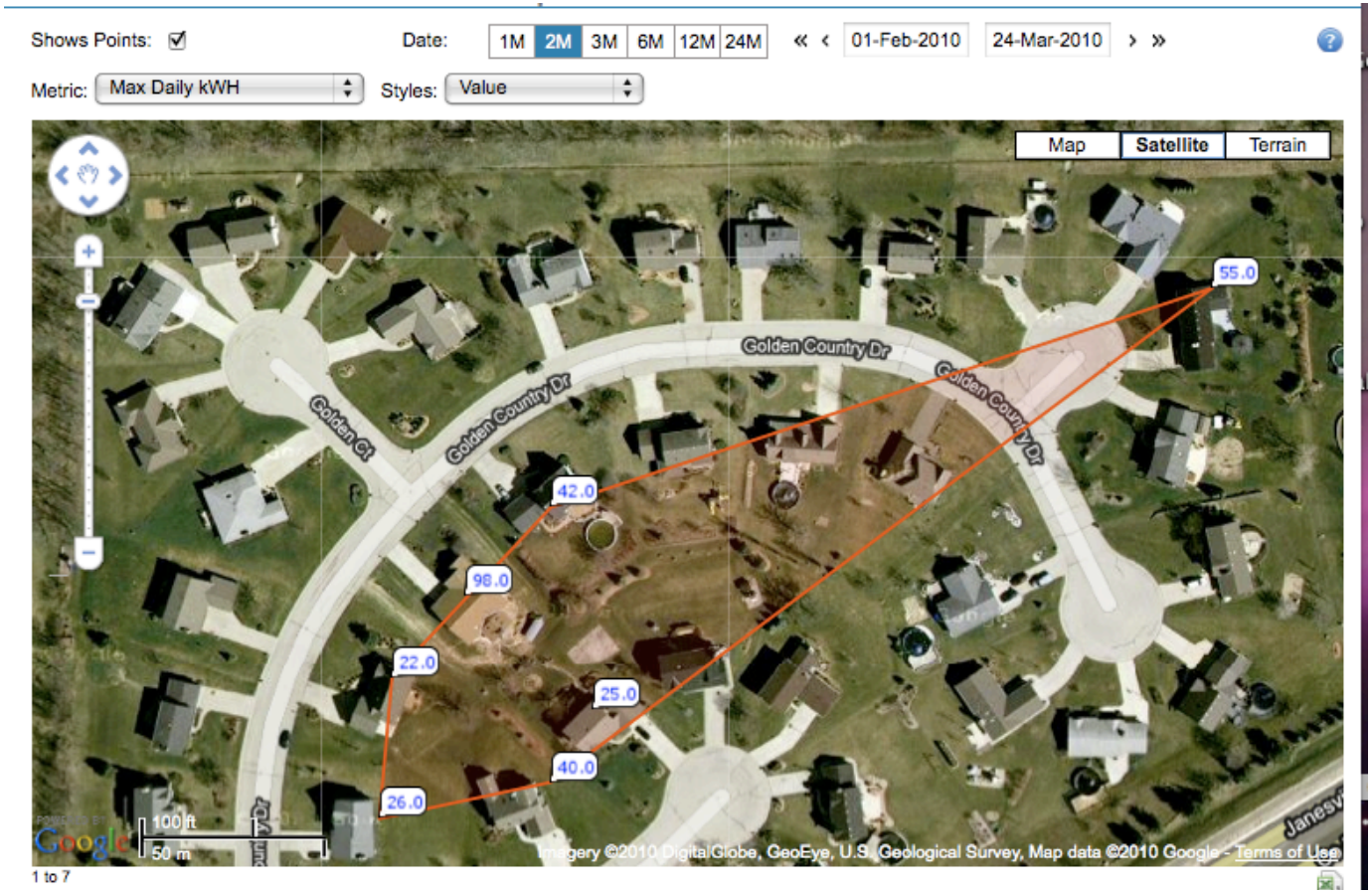
There are many opportunities for integrating Analytics into a Smart Grid Solution

- Connectivity Model Improvements
  - Auto-Generating Secondary Circuit Models
  - Correcting Meter Phasing
  - Detecting Transformer Connectivity Problems
- Identifying Overloaded/Stressed Assets
  - Proactive Transformer Replacement
- Locating Transformer Voltage Problems
- Using AMI Data to Detect Theft and/or Unmetered Load
  - Unbilled revenue
  - Tamper detection & Irregular Usage Patterns
- Improved Fault Locating
  - Using Substation Power Quality and Relay Data
  - Using Feeder Monitors to Locate Faults and Estimate Cause
- Reliability Analysis, Storm Analysis and Momentary Analysis

Connectivity Model Improvements

- A complete and accurate connectivity model is necessary to achieve many of the benefits.
  - Principally, the meter to transformer relationship is needed for:
    - Outage Management
    - Transformer Load Modeling and Asset Management
  - A full circuit model is important for
    - Circuit modeling
    - Phasing
    - Voltage Management
- Most model improvements are done manually when discrepancies are noticed by an operator, dispatcher or field crew
- The Smart Gird and Analytics can offer solutions to automatically identify discrepancies and errors. They include:
  - Outage & Event Analysis
  - Outlier Analysis
- 100% accuracy should always be a goal, but recognizing the current state will help drive opportunities
  - Known problem areas can be prioritized and addressed

Outlier Analysis



During a routine transformer outage, outlier customers are identified and corrections to the connectivity models are made

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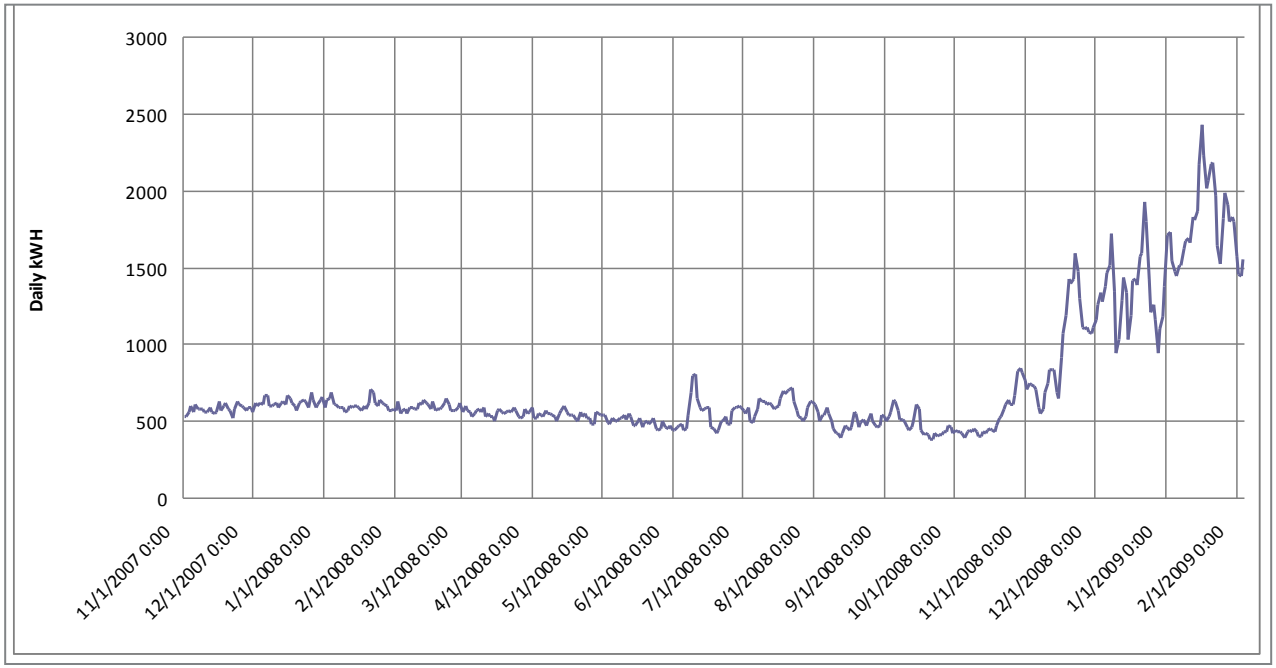
Transformer Monitoring

PECO uses analytics to determine transformer overloads and predict failures based on metering data from the AMR / AMI data

A program was initiated to investigate daily transformer consumption data (aggregated from meter data) for failures that occurred during winter peak load days

Transformers with yr-to-yr load increase of more than 25% (3,764 winter, 1,233 summer) were flagged for investigation



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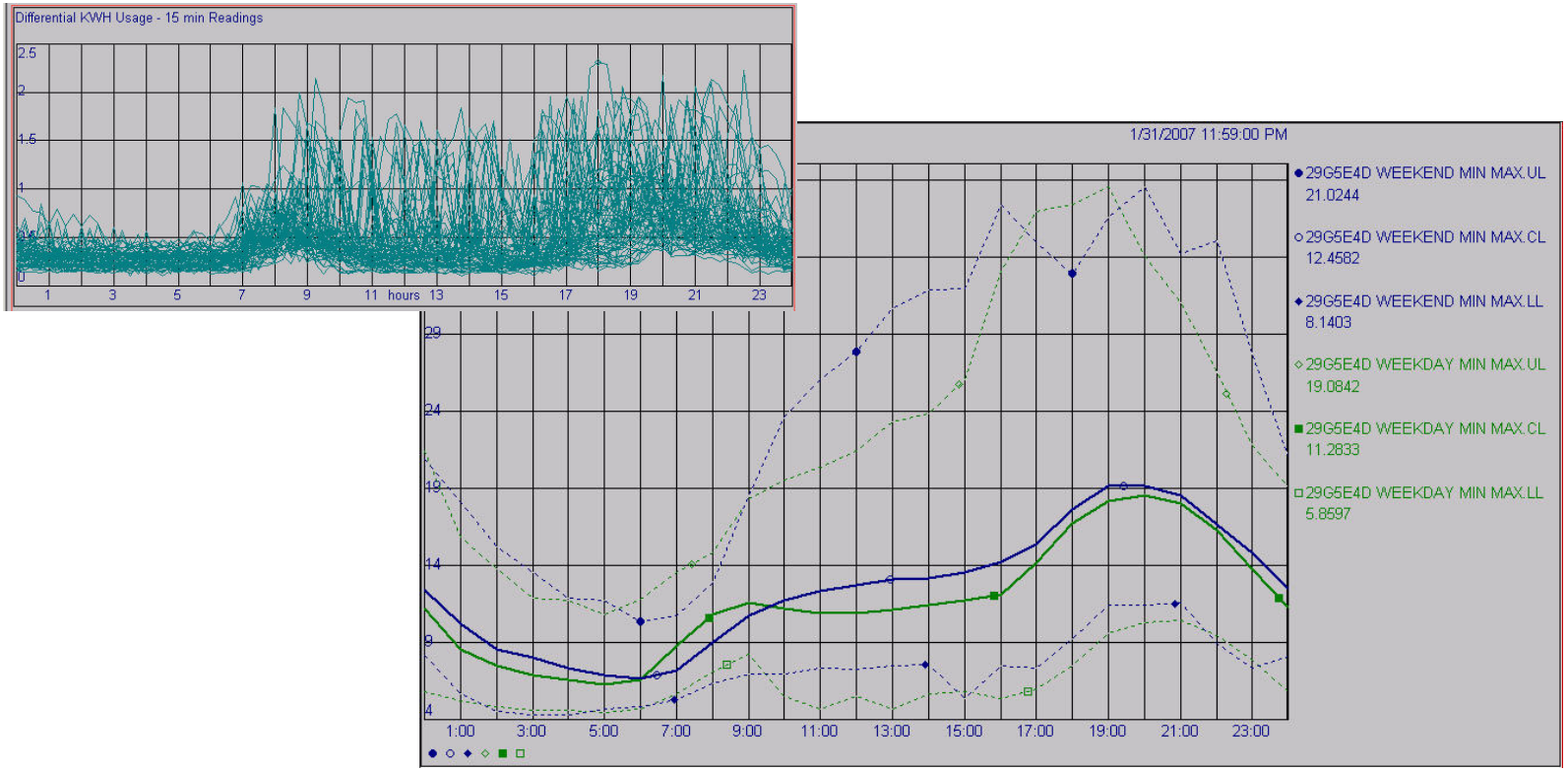
Transformer Load Profiles

- Once a daily transformer load shape is identified, it can be used to develop overall "normal" operating parameters for each device
- If the loading suddenly exceeds the normal operating envelop, an investigation can be initiated to understand why the change in load shape
  - In many cases, the equipment may need to be upsized or load relief activities must be performed



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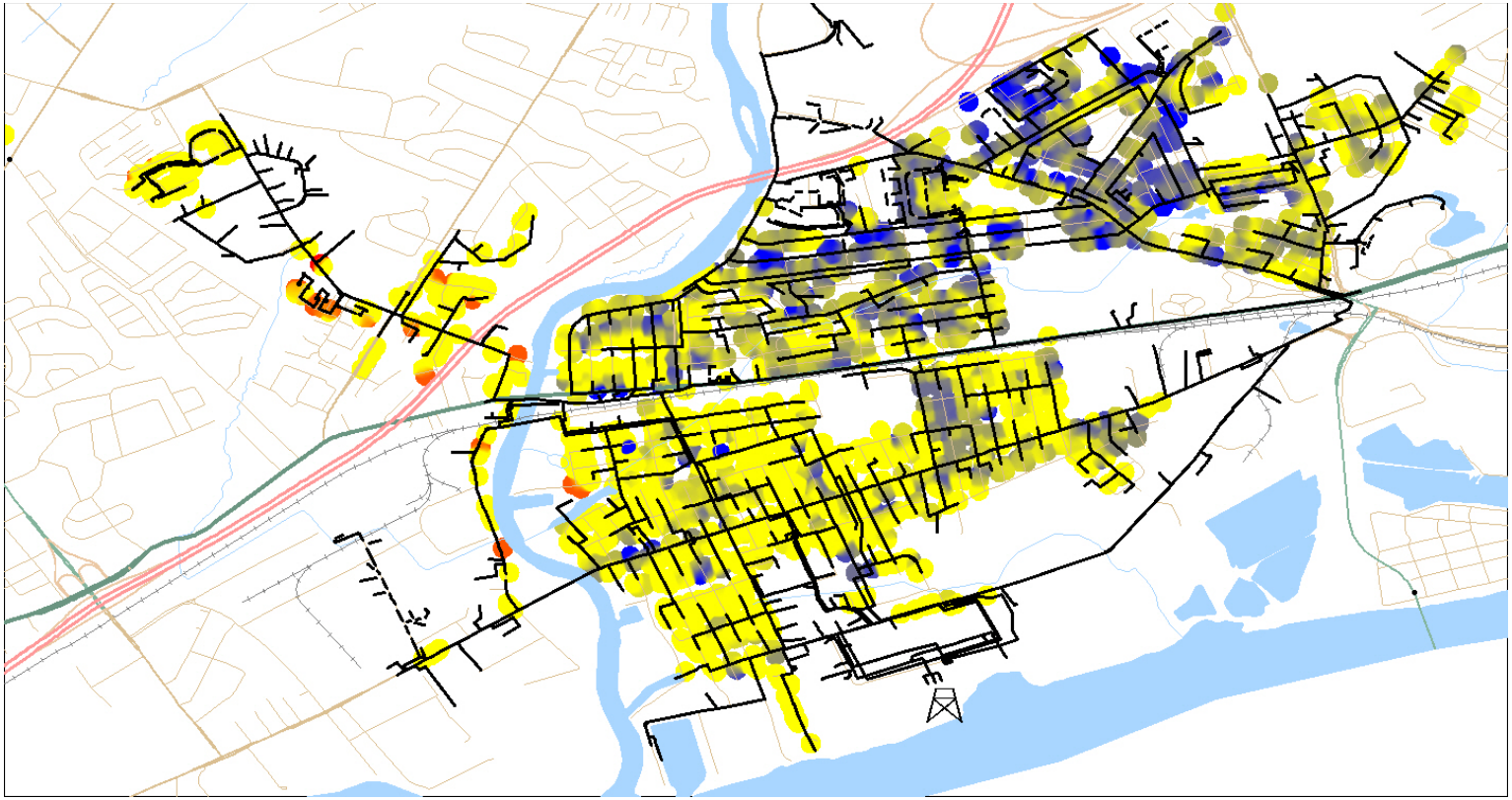
Voltage Analysis – Feeder Voltage Profiles



While the voltage profile is within the Tariff guidelines, voltages range from red/orange = >240v to blue/gray = < 240v

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Voltage Management

The Conservation Voltage Reduction Program is to realize energy savings and peak demand reduction from eligible customers in PECO's territory during the top 100 peak hours

This program incorporates voltage regulation techniques on distribution feeders that result in lower (but within regulatory requirements) service voltage levels, thereby reducing associated energy consumption and demand

Techniques deployed to achieve reductions:

- A 1% voltage reduction at the substation bus from historical levels
- The voltage set points for 13.2KV and 34KV distribution substations with automatic voltage controls (AVCs) and load tap changers (LTCs) will be recalibrated to deliver a 1% lower voltage

In the event the lower bus voltage impacts customer voltages, a mitigation strategy was deployed to improve customer voltages through the installation of capacitor banks, pole top or URD transformers and larger primary or secondary wires

Conclusion

- With sufficient planning, Smart Grids can be designed with the needed reliability and redundancy to ensure the delivery of a multitude of benefits
- Benefits such as those reviewed are real, for PECO they include:
  - Outage Management
  - Distribution Automation and Analytics
  - Voltage Mangement

Thank You

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