URD Cable Fault Prediction Model

Christopher Gubala
ComEd
General Engineer – Reliability Analysis

2014 IEEE PES General Meeting
Utility Current Practices & Challenges of Predictive Distribution Reliability
ComEd, An Exelon Company

- 3.8 million electric customers in northern Illinois, including the City of Chicago
- Service Territory: 11,300 square miles
- Peak Load: 23,753 MW (7/20/2011)
- 2011 Rate Base: $8.6 billion
- 1.5 million poles
- 530,000 distribution transformers
- 65,000 circuit miles of primary distribution
- 54% overhead, 46% underground
- 5,800 circuit miles of transmission
- Including 2nd largest underground network in the U.S. (390 miles)
- 882 substations
- 350 transmission-connected, 532 distribution-connected
- 29,084 MW of connected generation, including:
  - 10,700 MW of connected nuclear
  - 2,327 MW of connected wind
  - Additional 14,829 MW of wind generation in the PJM queue
World Continues to Evolve & Advance.......

Reliable and Quality Power

[Images of various technologies and power lines]
Energy Infrastructure Modernization Act

On October 27, 2011, the Illinois General Assembly enacted the Energy Infrastructure Modernization Act (EIMA), setting in motion a $2.6 billion investment by ComEd to strengthen and modernize the state’s electric grid.

The Investment Plan has two primary components:

• Reliability-Related Investments—5 year program, $1.3B
  – Underground cable – mainline, URD, manholes
  – Ridgeland 69kV cable replacement
  – Training centers
  – Wood pole inspection, reinforcement/replacement
  – Storm hardening – undergrounding, spacer cable

• Smart Grid-Related Investments – 10 year program, $1.3B
  – Distribution Automation
  – Smart Substations
  – Smart Meters
Reliability Related Investments

**Underground Cable**
- 5-year, $1.0B program
- Remediate 4,300 miles of underground residential cable
- Assessment and refurbishment of 32,000 manholes
- Replacement of 660 miles of mainline cable
- Testing of 925 circuit sections
- Replacement of 10 miles of high voltage (69kV) cable

**Storm Hardening**
- 5-year, $201M program
- Designed to further reduce the susceptibility of circuits to storm related damage
- Engineered solutions include but not limited to, overhead to underground conversion, installation of tree-resistant conductors, and additional vegetation management
- Testing of 925 circuit sections
- Replacement of 10 miles of high voltage (69kV) cable

**Wood Poles**
- 5-year, $75M program
- Inspection of 733,000 wood poles to determine need for replacement or reinforcement
- Replace or reinforce an estimated 19,000 poles

$10M Program: Construction of two new facilities – one in Chicago and one in Rockford – to provide electric and customer operations training
Smart Grid Related Investments

**Smart Meters**
- 10-year, $950M program
- Replace all retail meters with smart meters (approx. 4M)
- Deploy Silver Spring Networks Advanced Metering Infrastructure (AMI)
- Two-way communications
- Supports other customer services and Smart Grid applications

**Distribution Automation**
- 5-year, $244M program
- Expand self-healing grid technology with automatic sectionalizing devices and advanced control systems
- Install 2,500 12kV devices and 100 34kV devices
- Upgrade software for 800 devices to enhance protection schemes
- Convert radio network from Utilinet to Silver Springs Network (8,000 radios)

**Intelligent Substations**
- 5-year, $77M program
- Modernize 10 substations
- Asset health monitoring software
- Upgrade electro-mechanical relays to microprocessor-based
- Upgrade older air magnetic breakers to modern vacuum breakers
- Install transformer monitoring
- Install monitoring on station batteries and 138kV breakers

Cyber Secure Communications: Secure, tiered, robust communications architecture aligned with industry best practices and national security standards with capacity to meet the current and future requirements of the Smart Grid
URD Cable vs. Faults

- ~21,000 miles URD cable on the System
  - ~8,700 miles or 41% Bare Concentric Neutral URD Cable; purchased between 1966-1985
  - ~12,300 miles or 59% Jacketed Concentric Neutral URD Cable; purchased from 1986 to current
- ComEd’s URD failures cluster around aging bare concentric cable which was installed/purchased during the period 1966 to 1985 (~8,700 miles)
  - 92% of historical faults was on cable installed before 1986
URD Fault Predicative Model

Through Regression Analysis, our URD Fault Predicative Model incorporates weather factors at O’Hare Airport on a monthly basis:

- Sum of Cooling Degree Days
- Sum of Cooling Degree Days (T-1)
- Sum of Precipitation
- # of days that reach ≥ 90°F
- # of days that reach ≥ 95°F
- Sum of Lightning strokes

Area of opportunity is to include Daily Extremes:

- 2013 Flooding & Rain Events
- 2014 Snow Melting Events
2013 Daily Graph: URD Faults vs. Precipitation/CDDs

- URD faults increase when there’s more than \( \frac{3}{4} \)” of rain (2013: 16 days vs. Mean: 14 days). URD faults also increase the day following these days (2013: +14 days vs. Mean: +11 days)
  - 5 days above the average (2013: 30 days vs. Historic Mean: 25 days)

- The flooding event (5.55”) on April 17\(^{th}\) – 19\(^{th}\) (3 Days) accounted for 106 faults
  - Historically, on average 10 URD faults/day in April; during the flood event URD faults were 76 faults unfavorable (Actual: 106 faults vs. Predicated: 30 faults)

- The rain event (1.78”) on January 29\(^{th}\) – 30\(^{th}\) (2 Days) accounted for 59 faults
  - Historically, on average 8 URD faults/day in January; during the rain event URD faults were 43 faults unfavorable (Actual: 59 faults vs. Predicated: 16 faults)

- 2013 Weather Normalization (Flood & Rain Adjusted) = 5,899
  - 6,018 Actual – 76 – 43 = 5,899 Weather Normalized
2014 Daily Graph: URD Faults vs. Snow Melt

- Through March, O’Hare’s snow total of 80.6” was the 3rd snowiest season (July 1st-June 30th) going back to the 1884-1885 season, 1978-79 was snowiest with 89.7” of snow.
  - Midway’s snow fall total of 86.8” was the 2nd snowiest season.
  - Per the National Weather Service, 2014 winter, December 2013 to March 2014, was the coldest in Chicago history going back to 1872 with an average temperature of 22.0°. The previous record for the coldest December to March period was 1903-1904 at 22.3°
- Over 60” of snow melted in three major events this year (Jan 10th – 11th, Feb 20th – 21st, Mar 10th – 11th)
  - These events include the day of the snow melt and the day proceeding (6 days) accounting for 147 URD faults which were 95 faults unfavorable (Actual: 147 faults vs. Projected: 52 faults)
Conclusion

• Our URD Fault Weather Model does well by incorporating weather factors on a monthly basis from a centrally located point (O’Hare Airport)
  – 2012 and 2013 URD Faults were within ± 5% of the projection

• Extreme Weather in all types have impacted our Service Area the past couple of years and Daily Extremes can be offset when grouping weather totals by month

• We currently analyze Extreme Daily Outliers on a case-by-case basis and are looking into other data sets which can aid in incorporating these Extremes
  – River Levels which correlate to Ground Saturation via Snow Melt
  – Daily Model vs. Monthly Model
Questions?

Thank You