Network Best Practices in Engineering, O&M and Design

Presented by
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Background – 2013 best practices survey

The survey used publically available information with selected follow up phone calls

- To leverage the publically available information, selected telephone interviews where held resulting in the sharing of internal white papers, historical funding levels, work practices and outage history

- The goal was to better understand
  - what is a typical network design, loading and investment – and why some deviate from that
  - why some utilities have very few media worthy outage events and others have many
  - for selected utilities, what is driving the increased capital and O&M spending
  - which utilities are best leveraging technology to gain system insights, capture the knowledge of those retiring, and reduce the likelihood of media worthy outage events
  - for those utilities that experienced media worthy events, how did they prepare and respond to regulatory and internal questioning

What we confirmed is that there is not one utility that does everything right, but rather several utilities that do specific things very well, depending on their individual system performance, configuration and operating philosophy

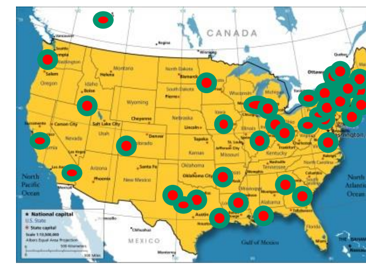
Agenda in a nutshell

- Why the survey?

  In response to recent manhole/vault events, a pair of clients engaged O’Neill Management Consulting to conduct an assessment of their underground secondary networks.

- Who was surveyed?

  Data was collected from 25 utilities, including over 60 cities with underground secondary networks. Some was public data, others sent responses to a questionnaire, and others were interviewed by phone. In addition, the consultants had directly observed many of the networks studied, when they did assignments for their 10 clients and/or former employers .



- What was studied?

  Best practices in underground secondary network design, operations and maintenance, and asset management , including funding and performance.

The survey was likely the most comprehensive and complete survey of best practices in underground secondary networks in years

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While failures are inevitable, their frequency and impact can be managed

Since networks are so reliable, media-worthy events can lead to difficult questions

METRO

Manhole explosions rock Upper East Side

By Antonio Antenucci and Natasha Velez

January 24, 2014 | 3:03pm

Three underground manhole explosions rocked an Upper East Side block Friday morning, scorching a Mercedes.

Photo: William Farrington

"I'm just worried for damage," Amrinder Kang,27, said as he surveyed his white Mercedes, which had been parked on 89th near Lexington Avenue when it was blasted by heat from one explosion. "It seems to have melted the front of the car. It's just unlucky. I woke up early to go to work now I'm stuck doing this, now I have to pay the deductible, it just sucks."

Boston Back Bay blackout & manhole fires

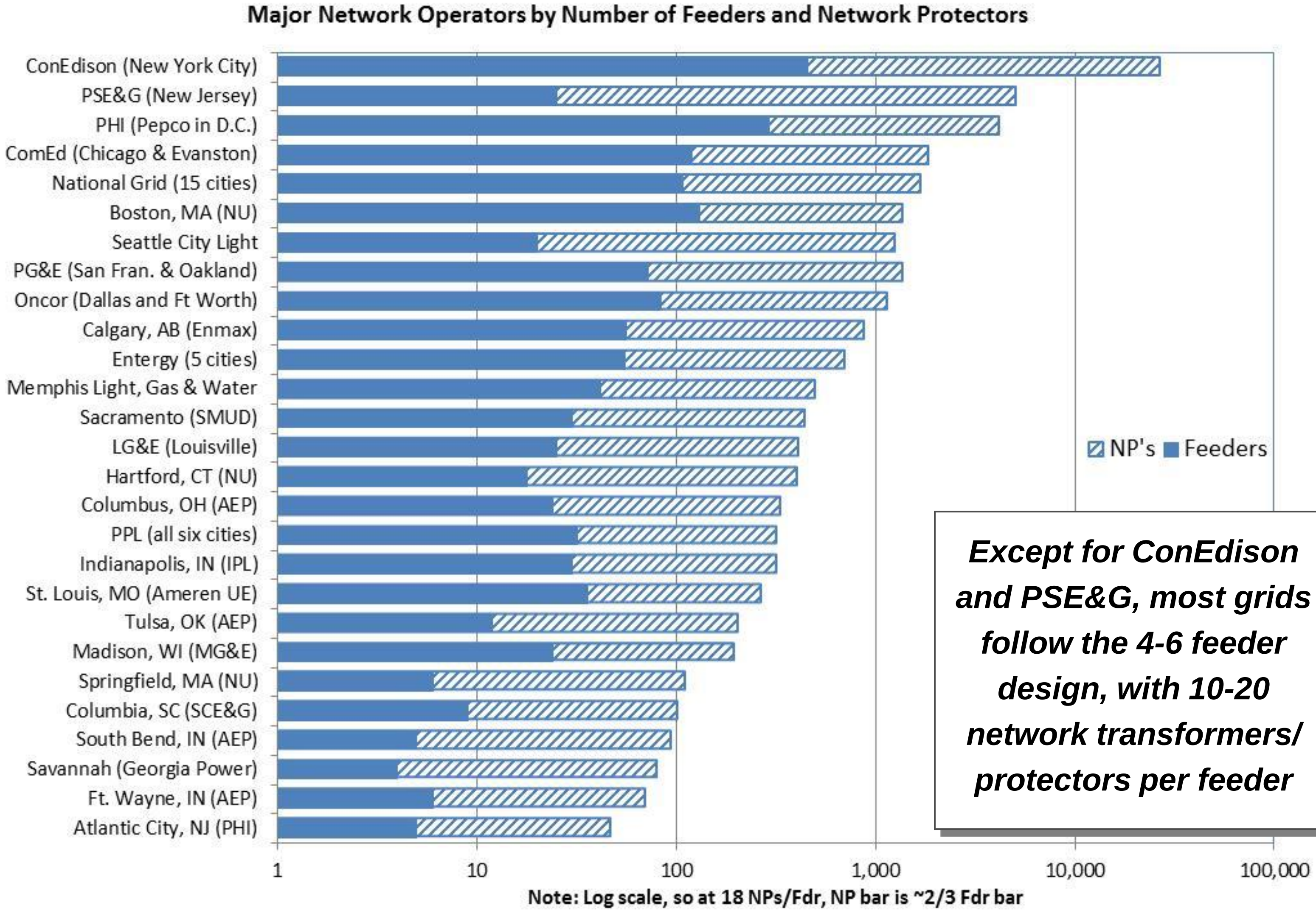
Manhole explosions reported on Huntington Avenue as NStar announces power restoration to most of city

At least two manhole explosions were reported on Huntington Avenue this afternoon near Belvidere Street at the same time as NStar was announcing progress in restoring power after the smoky fire Tuesday night that knocked power out in a broad swath of the city. The explosions were reported shortly before 4 p.m. on the street near the Christian Science Center. The cause was not known. No injuries were reported, said Boston Fire Department spokesman Steve MacDonald. No further information on the incident was immediately available.

As we approach the spring snow melt season (or rainy season elsewhere), we can expect to see an uptick in outage events

While system sizes vary, the fundamentals remain the same

With larger operators tending to have more grids/groups of the same basic size each



Except for ConEdison and PSE&G, most grids follow the 4-6 feeder design, with 10-20 network transformers/ protectors per feeder

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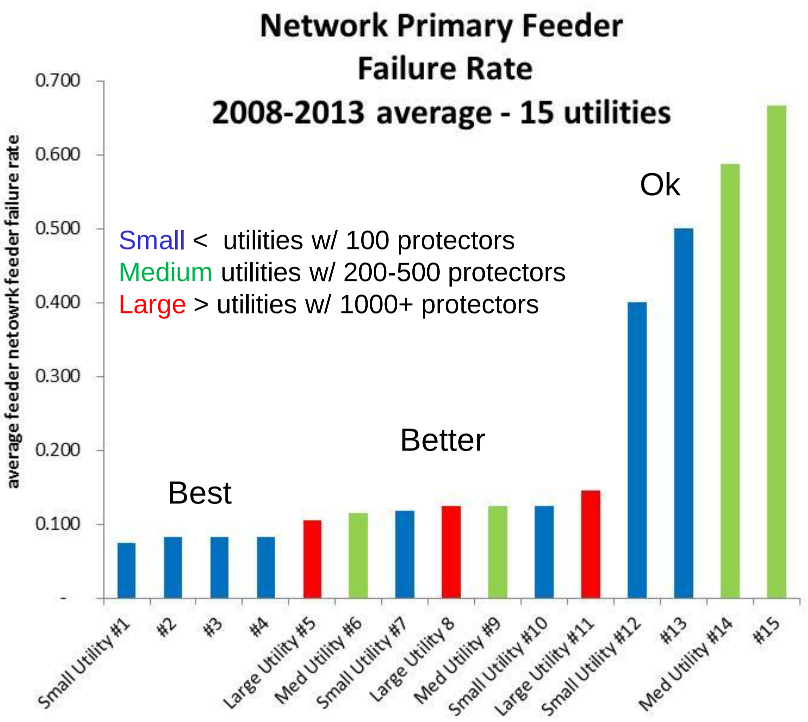
As expected, network grids are highly reliable

from our discussions with 15 plus utilities, using 6 years of primary outage history

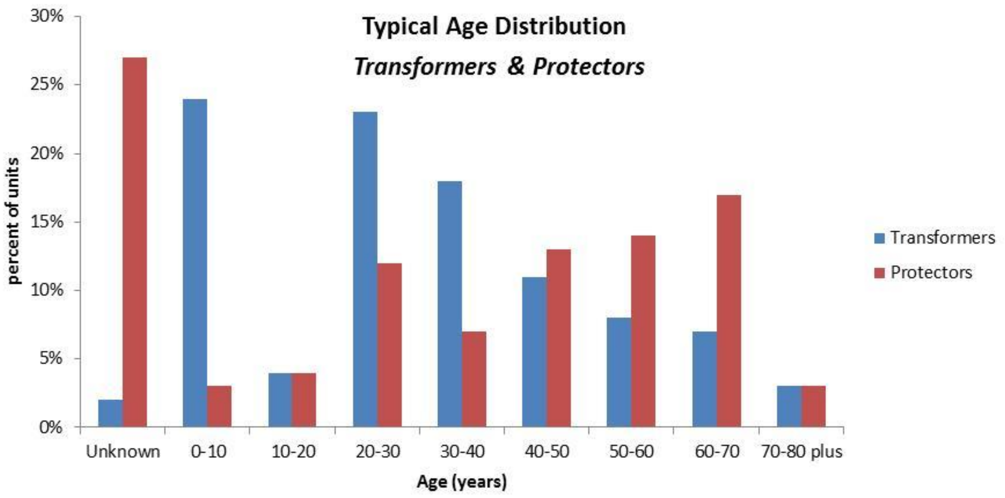
Performance of primary feeders in a typical grid (faults/grid/year)			
In a word	Failure rate	Example: 120 feeder grid	Example: 30 feeder grid
Ok	0.500	60	15
Better	0.125	15	4
Best	0.083	10	3



These failure rates are common, regardless of the size of the network, although smaller, lightly loaded networks tend to perform better

We examined key attributes of each system and grid

- **Secondary cable:** mixture of EPR, XLPE-TR, PILC and rubber butyl, with mains sized from 200 to 500 MCM copper, with the average new cable installed being 500 MCM copper. Most respondents install 600V-rated cable, with one installing 1000V-rated.
- **Primary cable:** mixture of PILC and poly, sized #2 up to 1000 MCM copper. Some use of thin wall poly to fit into tighter 3.5 inch tile ducts. One utility installed some large aluminum primary to save costs on a major rebuild.

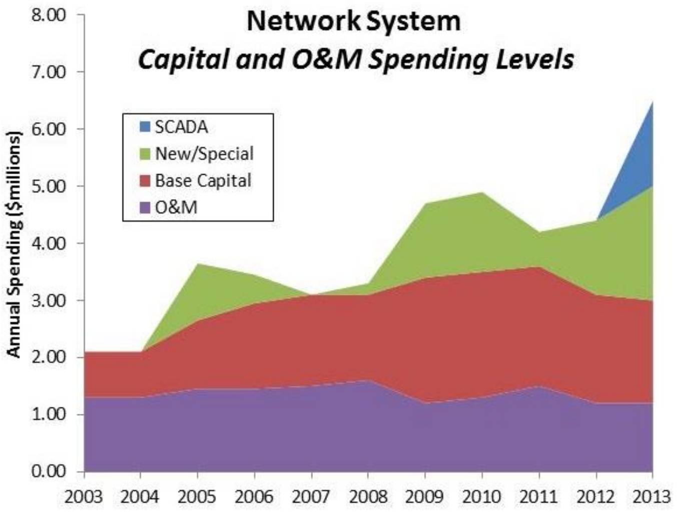


- **Transformers and Protectors:** Most have transformers with an average age younger than the protectors, due to a tendency to replace just the transformer but not the protector (saving time in disconnecting the secondary leads), or also due to historical PCB replacement programs, 4kV conversions, and load growth (where the protector is still within design specs).

Top-tier utilities are replacing equipment on a detailed root cause analysis by vintage (age), type and manufacturer

We compared system investment and program funding levels

- **SCADA Monitoring:** Half have done or are in the process of implementing a full scale SCADA program. Those that have had SCADA for 10 plus years are now moving to monitoring secondary grid load points. Those five or less years (or in the progress of installing a system), measure to the network protector.
- **PILC Replacement program**: all have some form of a PILC replacement program. Those with limited PILC have a structured, multi-year program, while those with large populations focus more on a performance-based replacement program. This is predominantly a primary cable replacement program, although several of the utilities have also included targeted replacement of secondary PILC. Noteworthy is one utility that upgraded to poly cable all their secondary cable in the late 1980's and has not experienced any significant events.
- **Protector replacements** averaged at least 1% of the asset population a year, mostly due to failures rather than load growth. Some replaced as much as 3 to 4%, especially those utilities with a regulatory accelerated recovery program.
- **Transformers replacements** were comparable with the protector replacements at about 1 to 2% of total asset base. For those utilities with a regulatory accelerated recovery program, the percent increased to about 2 to 3%.



Illustrative of a 350-protector utility experiencing selective load growth in targeted development areas

We are seeing a downtick in base line capital spending, but increased spending on targeted programs such as PILC replacement and SCADA

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We compared work practices in inspection and maintenance

- **Collection of information:** Most do inspections by paper and then enter it into an electronic system (into their work management systems).
- **Inspection cycles:** for vaults ranged from 6 months to bi-annually, while manholes are either not routinely inspected or driven by regulatory commitments as frequently as every six months. Protector comprehensive inspections ranged from annually to 5 years; all include testing relays and operations with test box.
- **Transformer tests** include taking insulating fluid samples and doing dielectric tests, with several piloting DGA (at least once to get a base line).
- **Limiters**: respondents were split between some who use limiters on secondary mains within the grid and those that do not, although all install them on service entrances.
- **Fault Locating:** The typical fault finding (start to finish, working continually) ranged from a low of 12 hours to an average high of 24 plus hours. For high impedance faults, which are typically more difficult to find, it is not uncommon to take 24-36 plus hours.

There were some interesting differences in work practices, some of which may be worth exploring for migration to best practice

We compared staffing in the field and in headquarters support

- **Field Staffing**
  - Utilities that had a large secondary network (300+ units) in one city tended to have a dedicated field force for the underground secondary network.
  - Often these crews are cross-trained to be able to do substation or radial underground work as well when needed, but are kept busy doing network work.
  - For utilities with some large networks and some small, it can be challenging to respond well to emergencies, as crews may have to travel between cities and may be restricted in other ways.

- **Support Staffing**
  - Planning and engineering support staff tended to be multi-functional, but within each organization there were staff that were recognized as the subject matter experts and who had responsibility for the network planning and support, including some specialists who spent almost all of their time on that activity.

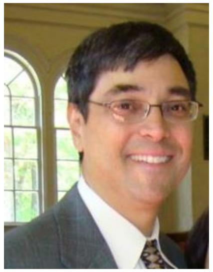
The pendulum swings back and forth between using resources dedicated to underground networks versus cross-trained for other tasks

In summary, the survey brought very useful insights

And lays the groundwork for further collaborative work on best practices

- In most cases, network grids are lightly loaded and highly reliable.
- While some utilities have considered getting out of the network business,(say via converting to a loop design), most will not do so due to limited vault space, existing customer expectations of high reliability, and the significant cost and street construction required.
- Spending (investment) in the network systems have seen increases in the past five years, specifically due to targeted programs such as PILC replacement (primary and secondary) and SCADA monitoring.
- Staff skill levels, both in the Engineering and Operations ranks, continue to be an ongoing challenge.
- While most are very adept at emergency response and restoration, most do not have a detailed up to date network plan, outlining strategies for equipment emergency ratings, selected load shedding, and total network shutdown and restoration steps.
- While much data is collected during inspections and fault locating, it is rarely kept in a format that facilitates trend analysis for system condition and operational insights.

Dan



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Underground secondary network remain a focus of study in order for utilities to ensure safe, reliable, and affordable electric service