Distribution Storm Hardening

by

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Power Line Design is Fun!
Power Line Design is Hard!
Power Line Design (Scope) is Evolving!

• DOE Hardening and Resiliency Report (August 2010)
  – Recognized increasing age of T&D assets
  – Concerns on increased coverage, i.e. risk, as population grows
• Pennsylvania PUC recognized storm hardening as a key to electric reliability in 2017 annual report
• Florida Public Service Commission (PSC) recognized the successful contributions of storm hardening in 2018
• California Public Utility Commission (CPUC) hosted inaugural Wildfire Technology Innovation Summit in 2019
Presentation Introduction

• We are all critical contributors
  – Safety
  – Quality
  – Efficiency
  – Sustainability

• An emerging threat requires a critical response to ensure:
  – Reliability
  – Resiliency
Storm Hardening Introduction

- Fourth National Climate Assessment (Nov. 2018 @ GlobalChange.gov)
  - More frequent and intense extreme weather events
  - Infrastructure currently designed for historical climate conditions
  - Recommend forward-looking design, planning, and maintenance
  - Revise engineering approaches to reduce:
    - Exposure
    - Vulnerability
    - Risk
      - Physical
      - Financial
Storm Hardening Statistics

Hurricanes and wildfires are getting worse.

Above-average-strength Atlantic hurricane seasons,\(^1\)
number per decade

Since 1958, the frequency and intensity of serious Atlantic hurricanes has risen

Area burned by wildfires in the US, millions of acres per decade

The 2015 fire season burned the highest acreage in US history: 10.1 million
What is Storm Hardening?

• Infrastructure engineering improvements to withstand:
  – Extreme Wind
  – Extreme Flooding
  – Unplanned Attachments
  – Unknown Obstructions (vegetation)

• Extreme events include:
  – Hurricanes
  – Tornados
  – Wildfires
What is Typical Storm Hardening?

- Hardening measurements include:
  - Smarter technology
  - More resilient materials
  - Improved engineering approaches
  - Improved maintenance approaches

- No one-size-fits-all approach:
  - Strategic undergrounding
  - Critical microgrids
  - Equipment-only upgrades
Can we “harden” traditional engineering approaches?

- The bare minimum isn’t good enough
  - Model for realistic operating temperatures
  - Model for known local winds, not code-required minimums

- To assume or not to assume…
  - What is the likelihood of a future comm. underbuild?
  - Should this corner pole be considered a terminal deadend?
  - Should I look deeper into this long vs. short span configuration?
  - Is it worth the effort to add an interset pole?
  - Is 10%+2’ embedment still a valid “rule”?
PLS-CADD Analysis of Wildfire or Storm Risk

• Data inputs required:
  – Recently collected survey data
  – Surveyed conditions (weather & wind)
• User inputs required:
  – Code and/or utility required clearances
  – Weather case(s)
• PLS-CADD outputs:
  – Vegetation reports: grow-in & falling tree violations
  – Plan & Profile (P&P) with highlighted risk areas
  – KMZ with work sites
FIGURE 5-2: RADIAL CLEARANCE REQUIREMENT TO VEGETATION

where:

- \( \phi \) = conductor swing out angle in degrees under all rated operating conditions
- \( S_F \) = conductor final sag at all rated operating conditions
- \( x_v \) = radial clearance (include altitude correction if necessary)
- \( \ell_i \) = insulator string length (\( \ell_i = 0 \) for post insulators or restrained suspension insulators)
- \( y_v \) = horizontal clearance at the time of vegetation management work
- \( \delta \) = structure deflection at all rated operating conditions
[PLS-CADD model showing grow-in violations in red and falling tree violations in pink]
[PLS-CADD plan & profile drawing showing grow-in and falling tree violations]
See PLS white paper @ https://www.powline.com/technotes/Wildfire_Risk_Assessment_Using_PLS-CADD.pdf
What is considered a slope?
- Ratio greater than ~3:1 (horizontal to vertical)
- Ditch that exceeds critical discount depth

What are slope installation risks?
- Poor soil compaction
- Continued soil erosion

How can we mitigate slope installs?
- Pick a different spot!
- Additional embedment (soil discount)
## PLS-CADD Automation Example – Slope Embedment

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<tr>
<th>Structure Number</th>
<th>Max Z Delta at 5’</th>
<th>Additional Embedment Required</th>
<th>Structure Height or Pole Length (ft)</th>
<th>Actual Embedded Depth (ft)</th>
<th>Modeled Embedded Depth (ft)</th>
<th>Calculated Embedded Depth (ft)</th>
<th>Min. Bury Depth before Add'l Butt Coating Req. (ft)</th>
<th>Standard Butt Coating (ft)</th>
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PLS-CADD Analysis of Replacement Impacts

- System hardening is an everyday occurrence
  - Single pole replacements
  - Single span reconductors
- Can’t assume it’s okay to simply:
  - Match existing adjacent span tensions
  - Match corresponding existing guying
- BEST PRACTICE
  - Model adjacent “+1” poles as M4 structure, along with “+2” spans
  - G.O. 95 Rule 44.2: analyze “+1” impact with updated intrusive data
Be wary and try to mitigate extreme span imbalances
- Long spans (over 500’)
- 2:1 span ratios e.g. 300’ vs. 150’ spans at the same pole

Issues created
- Cascading deflection & failures
- Soil ratcheting

Mitigation measures
- Interset poles
- Add guying for long span
- Double tangent crossarms and/or greater embedment
PLS-CADD Analysis of Critical Crossings

• Typical critical crossings
  – Highways
  – Environmentally sensitive areas
  – Always-on customers

• Hardening approach: terminal deadend (see GO95 Rule 47.3)
  – Increases resiliency & reduces maintenance risks or delays
  – Consider increasing conductor size for difficult spans at a minimum

• Main benefits
  – Limits cascading failure potential
  – Simpler replacement, as terminal DE is designed for stringing
Typical code-compliant stringing approach based on
- Safety factors
- Percentages at load condition

Consider evaluating beyond percentages
- Particularly with lighter but stronger conductors
- CIGRE Technical Brochure #273
  - Consider catenary constants to reduce aeolian vibrations

Sanity check → are stringing tensions realistic? Ask the crew!
PLS-CADD XML Automation

- XML provides obvious benefits
  - Simple material counts
  - Tabulate analyses results

- Consider XML automated calculation tools to support
  - Internal QA/QC (embedments, materials, etc.)
  - Unique construction requests, such as anchor plate slot trench
  - Confirm a unique and multi-tiered engineering standard, such as crossarm and pin loading requirements
  - Create automated and customized pole loading reports
Hardening from Start to Finish

- A hardened design needs a hardened as-built
- Take advantage of a well-engineered design by simply:
  - Importing as-built LiDAR into IFC PLS-CADD model
  - Update structure groups if allowed, i.e. “new” vs. “existing”
  - Determine if additional construction tolerances are allowed
    - GO95 example: Table 6 min. pole embedments
    - Consider XML pole loading summary reviews
  - We are the last line of defense!
    - Final chance to protect your company, client, license, etc.
Live Demo Time!
Thanks for your time! Any questions?