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We Deliver.

COR-TEN KL0 Tower Issues and Mitigation Program

Erika Antunes
Engineer II
T&S Asset Strategy

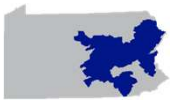
Slide 1

KL0 Remove from title

Lagunilla, Kyra Elizabeth, 2024-09-30T12:06:52.383

PPL Overview

KL0

	CUSTOMERS	SERVICE AREA	SERVICES
Pennsylvania PPL Electric Utilities 	**1.4M** Electric	**10,000mi²**	• Electric Distribution • Electric Transmission
Kentucky LG&E and KU 	**1.0M** Electric **0.3M** Gas	**9,400mi²**	• Electric Distribution • Electric Transmission • Gas Distribution • Gas Transmission • Regulated Generation
Rhode Island Rhode Island Energy 	**0.5M** Electric **0.3M** Gas	**1,200mi²**	• Electric Distribution • Electric Transmission • Gas Distribution

■ Represents service territory

413 mi
500kV

1249 mi
230kV

278 mi
138/115kV

3379 mi
69kV

5318 mi
Total Transmission Line Mileage

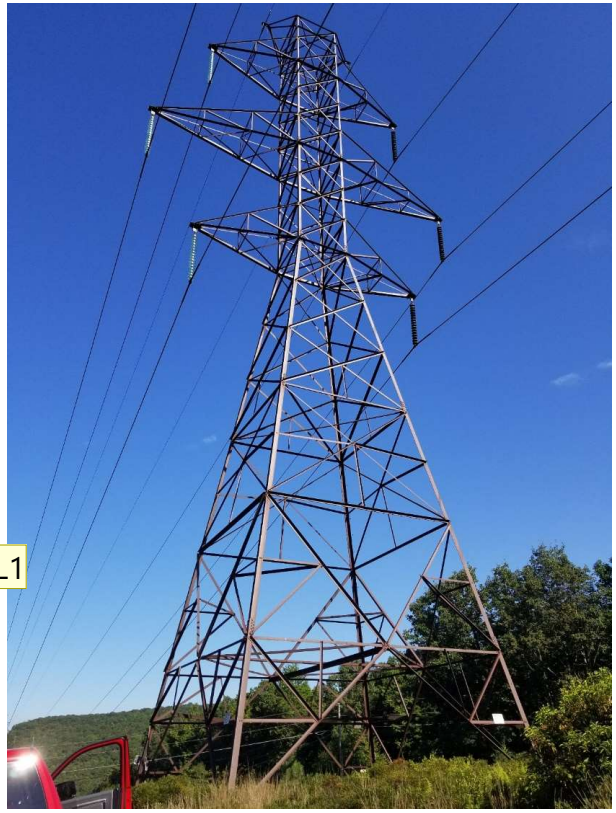
Slide 2

KL0 Consider adding summary of transmission miles by voltage class, either on the slide or verbally
Lagunilla, Kyra Elizabeth, 2024-09-30T12:09:33.091

Intro to COR-TEN Lattice Towers

KL0

- COR-TEN steel depends on weathering cycle to develop protective surface coating (patina) that provides resistance to atmospheric corrosion
- COR-TEN Lattice Towers installed between the 1960s and 1970s
  - Believed to reduce future maintenance due to corrosion-resistant nature of weathering steel
- In lattice construction, moisture trapped in joints does not allow for complete wetting and drying cycle that leads to pack-out rust
  - Results in section loss, deformation of steel members and connecting hardware, sheared bolts, members disconnecting, loss of structural integrity and eventually structural failure
- Issues seen in other infrastructure where two pieces of COR-TEN steel overlap at joints, i.e. bridges
- No manufacturer's warranty currently exists for remediation
- COR-TEN Towers have since been removed from PPL's design standards



KL1

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Slide 3

KL0 Not quite sure where this fits but would be helpful to note that COR-TEN was removed from our standards
Lagunilla, Kyra Elizabeth, 2024-09-30T12:45:34.085

KL1 Consider comparing to weathering steel monopoles and how we don't see these issues
Lagunilla, Kyra Elizabeth, 2024-09-30T12:46:31.150

PPL EU COR-TEN Tower Timeline

KLO

1960/70s — Installation of 1,284 COR-TEN Towers on PPL EU System

Q4 2016 — Third Party Inspections and Remediations on COR-TEN Towers

Q1 2020 — Third Party Inspections on COR-TEN Towers

Q2 2020 — Finalization of PPL EU COR-TEN Strategy & Start of Project Planning

2021+ — Additional Third Party Inspections for each Project

2021-35 — Execution of COR-TEN Replacement Program

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Slide 4

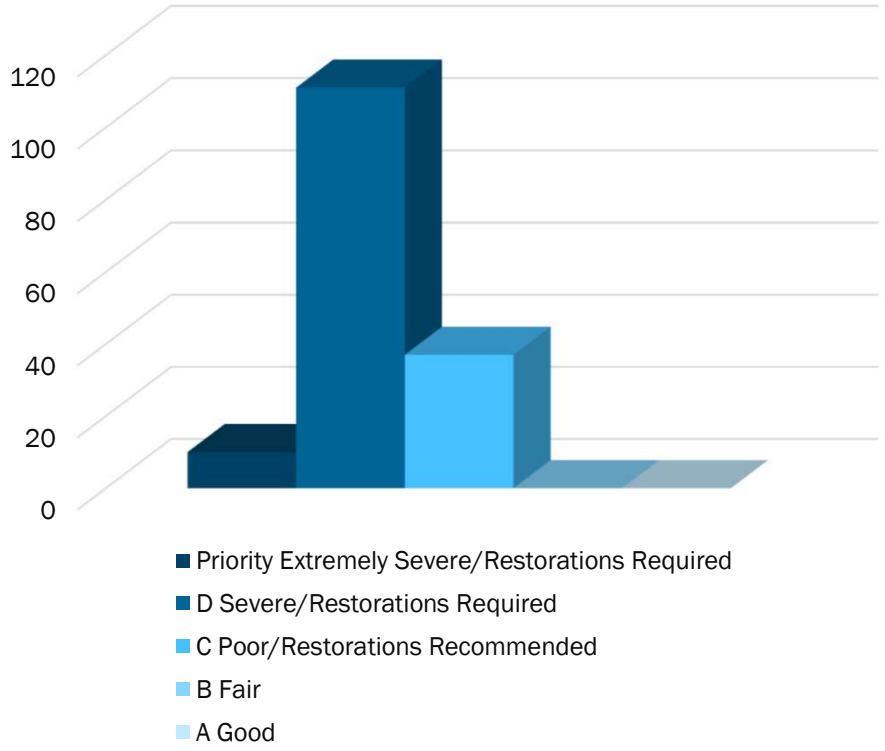
KL0 Consider starting timeline in 1960s and swapping slide 3 and 4.

I know you mentioned it flows better during the presentation so just a thought, totally your call!
Lagunilla, Kyra Elizabeth, 2024-09-30T12:13:32.751

2016 Third Party Inspection #1 Results

KL0

- Goal:
  - Understand issues of COR-TEN and remediation efforts
- Field-Based Assessment:
  - Groundline Inspection of 158 COR-TEN Towers
  - Measurement of pack-out rust taken at each joint
  - Visual observation of thinning, pitting, or edge loss
  - Provide an overall tower rating for each tower inspected
- Results:
  - Every joint & connection accumulated some level of pack-out
  - Roughly 600 members & joints across 158 towers needed to be restored
  - The majority of the members & joints are within 15' of the ground



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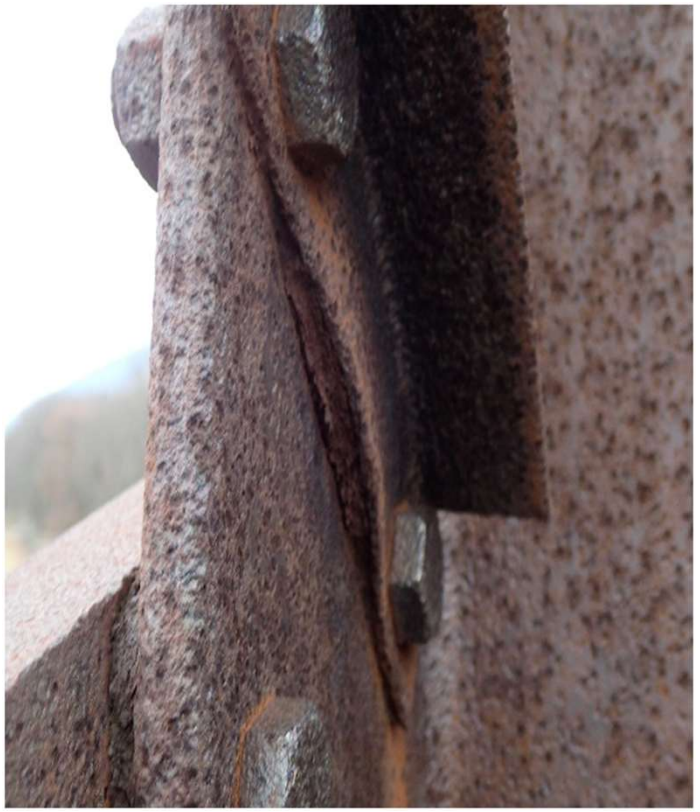
Slide 5

KL0 Add 2016 here for consistency with the timeline
Lagunilla, Kyra Elizabeth, 2024-09-30T12:16:26.090

Minor Pack-Out Rust Observed



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Significant Pack-Out Rust Observed

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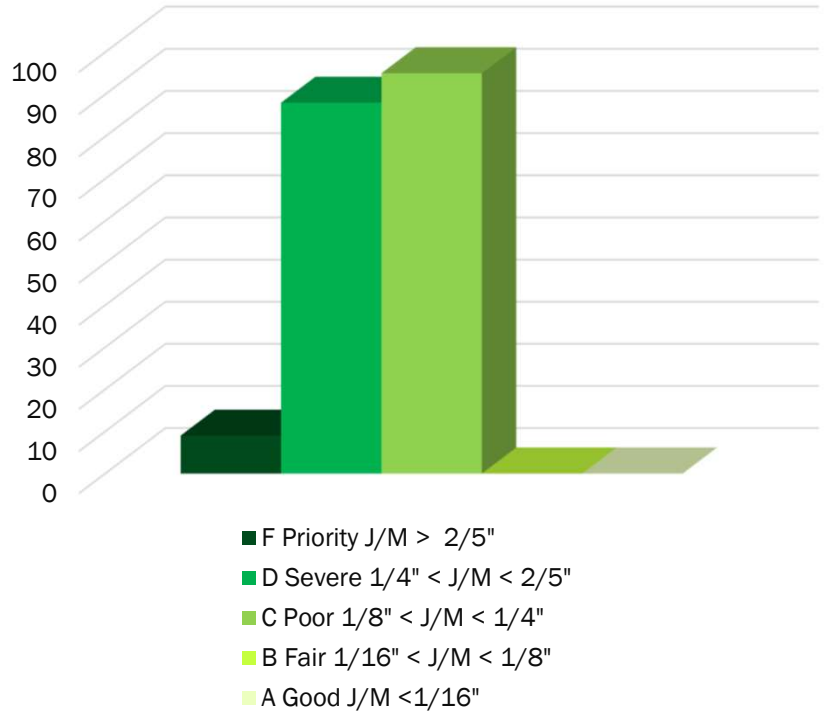
2020 Third Party Inspection #2 Results

KL0

- Goal:
  - Acquire detailed measurements to evaluate condition further
- Field-Based Assessment:
  - Climbing inspection of 192 COR-TEN Towers
  - Measurements of pack-out rust taken at each joint
  - Measurements of section loss taken at each member
  - Visual observation of damage at each attachment point
  - Provide an overall tower rating for each tower inspected
- Results:
  - Over 90% joints showed visible pack-out rust in connections
  - The protective patina was not set up properly at numerous members, resulting in section loss across the entire structure
  - Structural damage was found on several members



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Slide 8

KL0 Similar comment - would be helpful to restate the year here
Lagunilla, Kyra Elizabeth, 2024-09-30T12:18:28.989

Pack-Out & Pitting Observed

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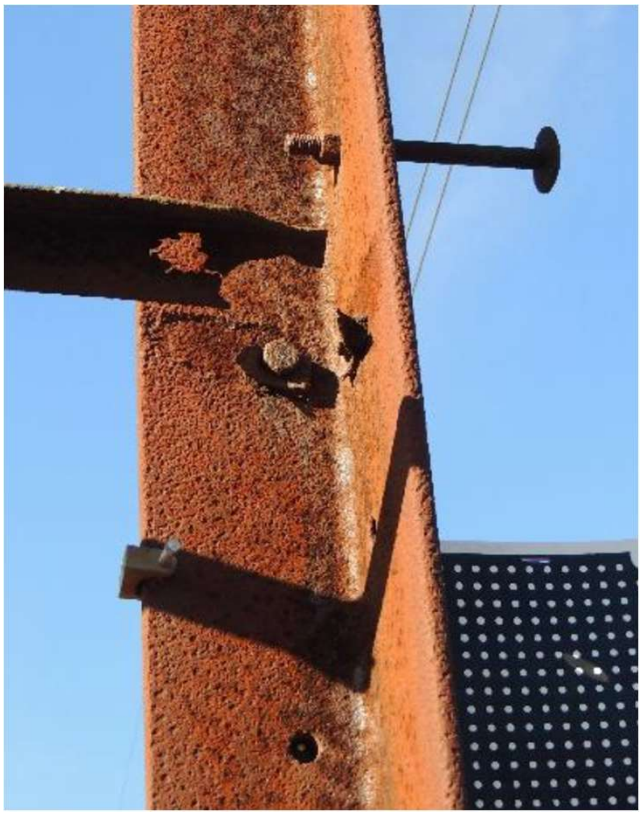
Ruptured Members Observed



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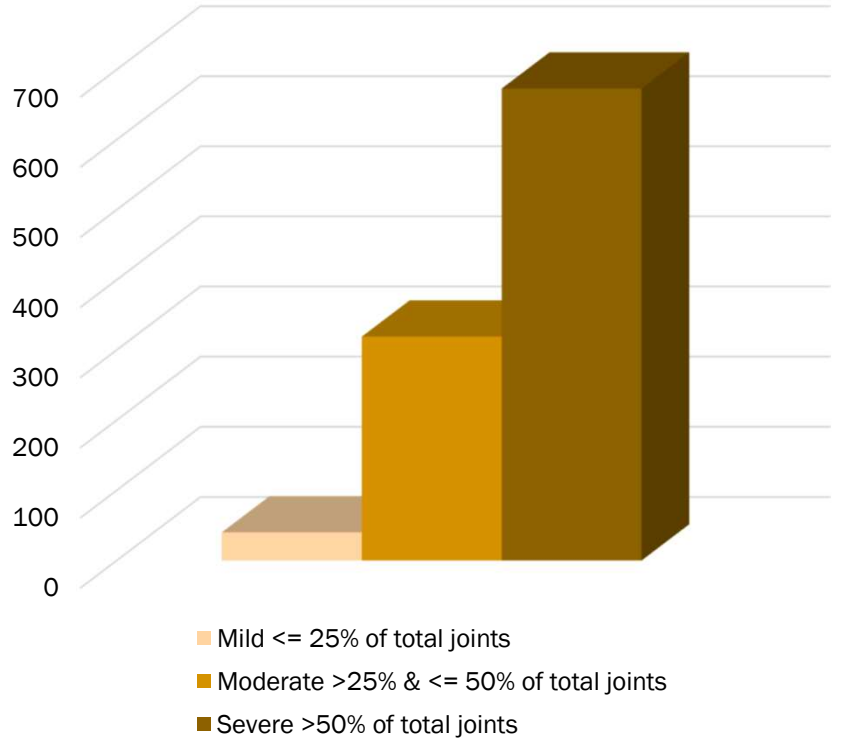
2021+ Third Party Inspection #3 Results

KL0

- Goal:
  - Acquire high-level data for specific line projects to confirm condition
- Field-Based Visual Assessment:
  - Climbing inspection of 1,032 COR-TEN towers
  - Visual observation of number of joints experiencing pack-out rust
  - Provide an overall tower rating for each tower inspected
- Results:
  - Over 96% of inspected towers had over 25% of the joints experiencing pack-out rust
  - Additionally, over 65% of inspected towers had over half of the joints experiencing pack-out rust



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Slide 11

KL0 Nice job summarizing the inspection results.

When presenting, recommend trying to make it clear what the differences are between the inspections (climbing vs groundline, measurements vs visual only, etc)

Lagunilla, Kyra Elizabeth, 2024-09-30T12:24:28.508

Pack-Out Observed by RTR

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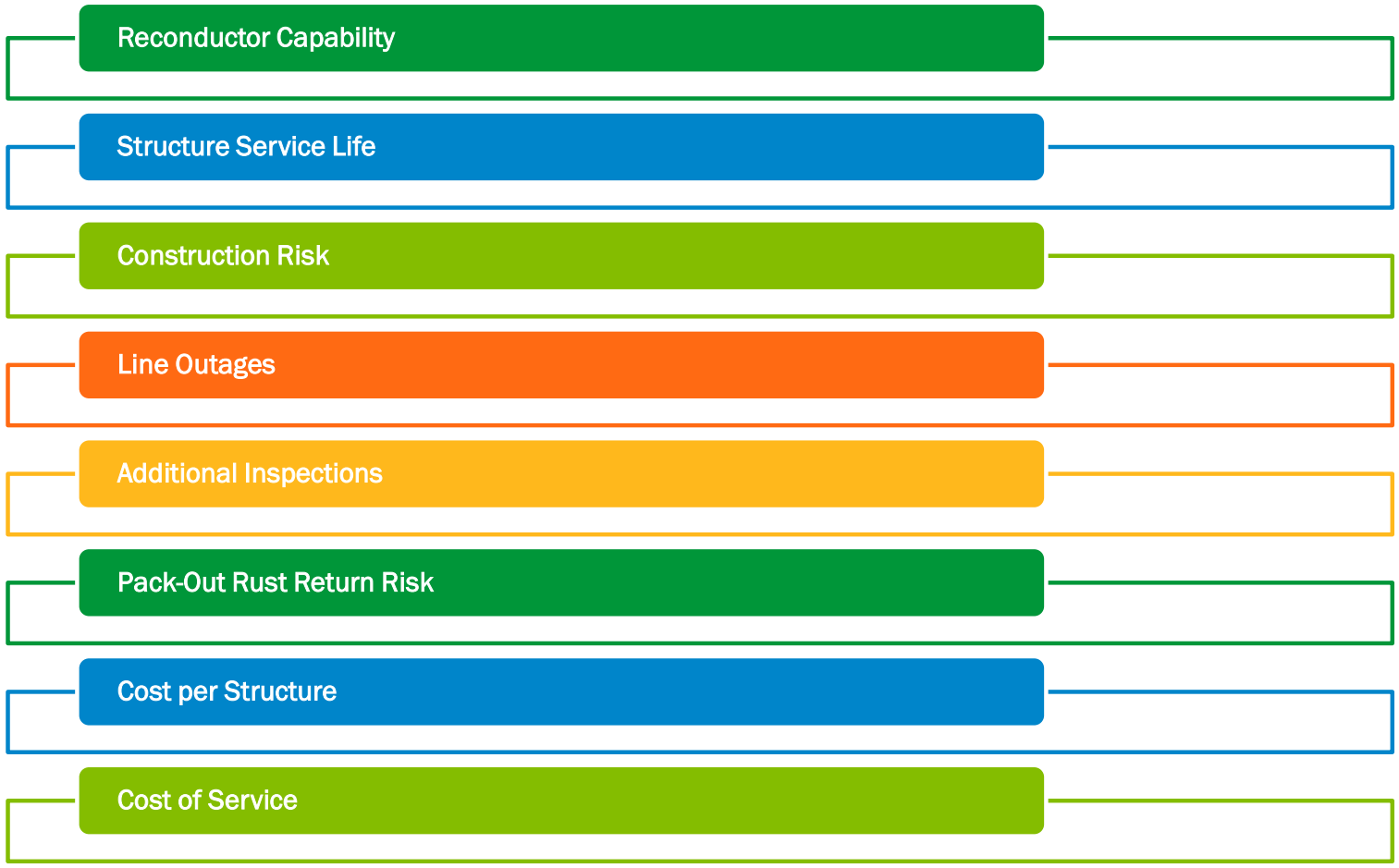
KL0

PPL EU COR-TEN Solution Evaluation



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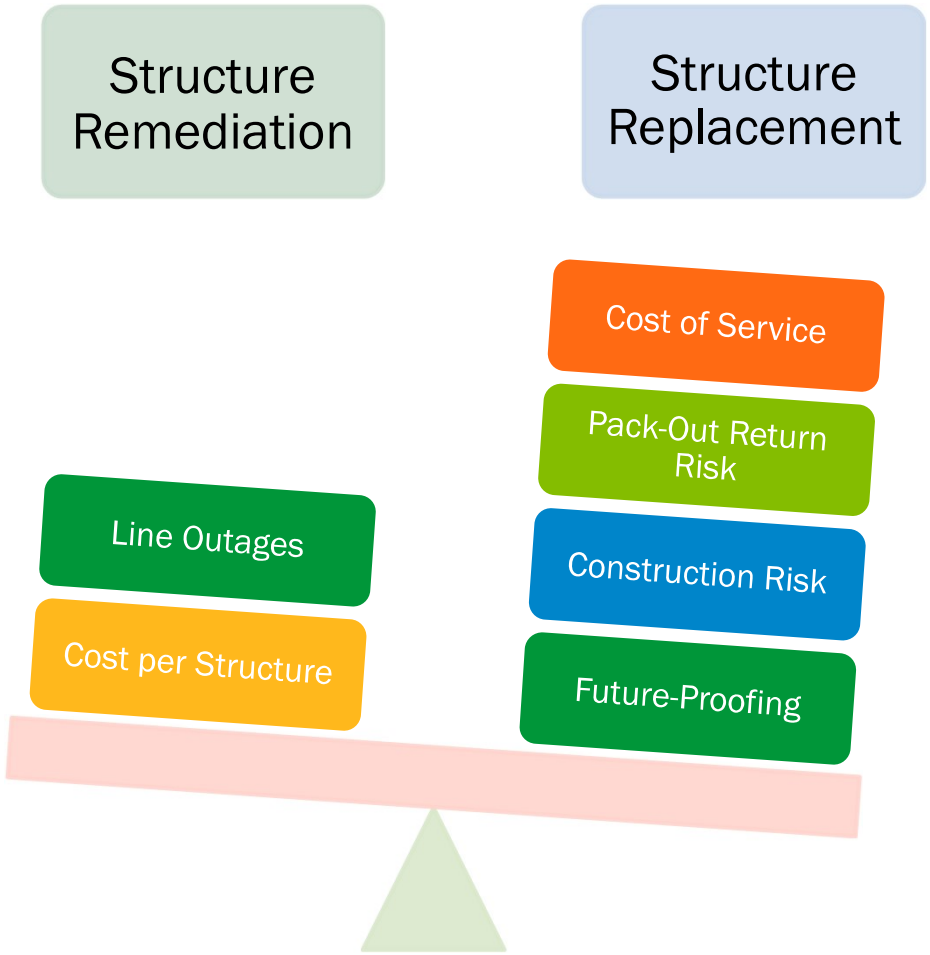
Slide 13

KL0 This slide is a little hard to read. Can you keep the categories and just speak to the associated questions?
Lagunilla, Kyra Elizabeth, 2024-09-30T12:26:26.682

KL0

Structure Remediation vs Replacement

KL1



Structure Replacement Assessment Results:

- **Cons**
  - Outages longer in duration
  - Higher upfront cost
- **Pros**
  - Lower cost to maintain
  - No risk of severe pack-out return
  - No risk of performing ineffective remediations
  - Longer in-service life after replacement
  - Ability to reconductor now or in the future

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Slide 14

KL0 Clarify the pro/con list is for replacement.
Lagunilla, Kyra Elizabeth, 2024-09-30T12:29:37.174

KL1 Consider including example of a line analysis with rough COS comparison for remediation vs replacement
Lagunilla, Kyra Elizabeth, 2024-09-30T12:48:44.762

Example: Alternative Evaluation

Asset Details	Project Scope	Upfront	45 Year	75 Year	Additional Notes
Transmission Line Name: Harwood-East Palmerton, Harwood-Siegfried, & Siegfried-Harwood **Voltage:** 230kV **Line Installation Date:** 1970 **Length:** 40.2 miles **COR-TEN Tower Count:** 178 Towers	Remediate Structures on the 230kV Transmission Lines	$45.7M	$598.1M	$1,208.3M	• 3-6 Inspection Cycle • Rebuild line in 30 years • Ongoing O&M costs • Observation of pack-out rust issues after coating is applied
	Full Rebuild of the 230kV Transmission Lines	$182.8M	$568.7M	$691.5M	• 6-12 Inspection Cycle • O&M costs begin after 30 years • Eliminates COR-TEN steel • No need for major asset replacements during timeframe

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KL0

PPL EU COR-TEN Strategy Goals

Goal #1

Remove all COR-TEN lattice towers from the system

Goal #2

Maintain the reliability of BES system

Goal #3

Eliminate increased maintenance costs

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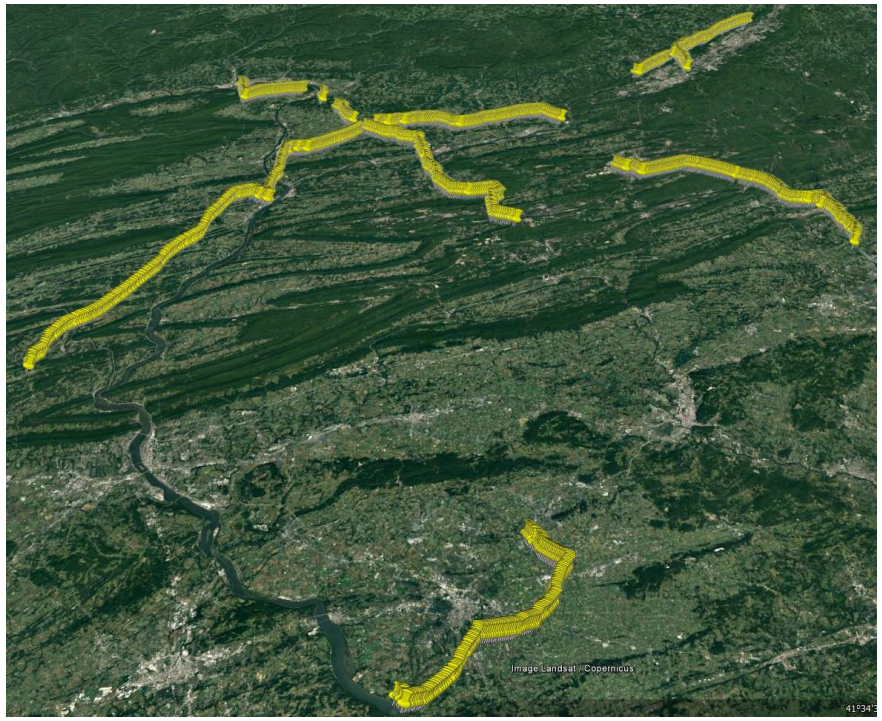
Slide 16

KL0 Maybe swap this slide with slide 15?
Lagunilla, Kyra Elizabeth, 2024-09-30T12:37:40.091

Data Analytics Model

- Prioritization needed for efficient Project Planning
- T&S Asset Strategy and Data Analytics developed a COR-TEN Risk Model to prioritize COR-TEN lattice structure replacements.
- Data utilized included:
  - Internal
    - Tower Height
    - Voltage Level
    - Installation Date
    - Framing Type
  - External
    - Pack-out & Section Loss Measurements
    - Vegetation at Tower Base
    - Structure Elevation
    - Water Storage
    - Service Environment



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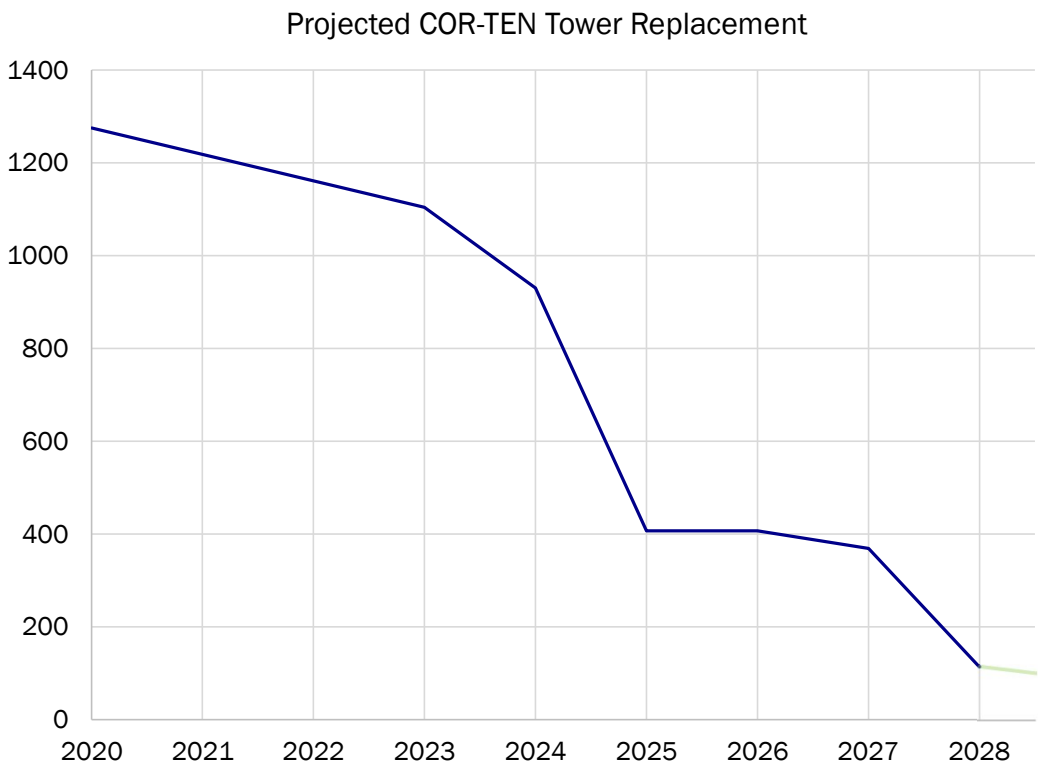
Results of COR-TEN Program



Goal 1: ☑

- 306 COR-TEN towers removed total
  - Includes 126 removals completed YTD
- Removal of remaining 865 230kV COR-TEN towers completed between 2024-2028 through rebuilds
  - Project to address remaining 113 COR-TEN Towers on 500kV being developed

Goal 2: ☑

- No premature COR-TEN Tower failures on the BES System

Goal 3: ☑

- Eliminate inspection and conductor testing needs over next 5 years, resulting in ~$3M maintenance cost reduction

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Slide 18

AE0 Fact check me!!!
Antunes, Erika, 2024-09-27T17:35:55.934

KL0 0 None I'm aware of *knock on wood*

Mark can confirm
Lagunilla, Kyra Elizabeth, 2024-09-30T12:41:47.705

KL1 Can we provide a rough update on how many towers have been removed so far?
Lagunilla, Kyra Elizabeth, 2024-09-30T12:42:58.331

Summary

Problem:

- COR-TEN towers at high-risk of failure due to pack-out rust accumulating at joints

Extent of Condition:

- 1,284 COR-TEN towers all experiencing significant pack-out at the joints, section loss of members, and damage to connecting hardware

Solution:

- Prioritized Structure Replacement to cost-effectively eliminate COR-TEN tower risk

Goals:

- Remove all COR-TEN towers from the system to maintain BES reliability and safety

Results:

- Successful execution and planning of all COR-TEN tower removals
- No tower failures
- Significant reduction in maintenance costs

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Thank you!
Questions?

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