

Pipeline Impacts of Increased Electrical Transmission Loads (Reconductoring)

AMPP

September 9, 2026



Agenda

- Introduction to Reconductoring/AC Load increases
- Why is Induced AC a concern
- What does the Pipeline Industry need?

TCI Status

- Documentation
 - Developed Industry Notice
 - Developed Powerpoint Presentation
- Communication
 - AMPP Outreach to NAPSAR (State Regulators)
 - AMPP/API/INGAA/AGA Outreach to:
 - PHMSA (Paul Roberti, Ben Kochman, Linda Daugherty, Rod Seeley)
 - Membership
 - FERC/DOE
 - Looking for ways to communicate with other groups:
 - IEEE
 - Electric Transmission Operators
 - Independent System Operators (ISO, RTOs)
 - MISO, ERCOT, CAISO, etc.

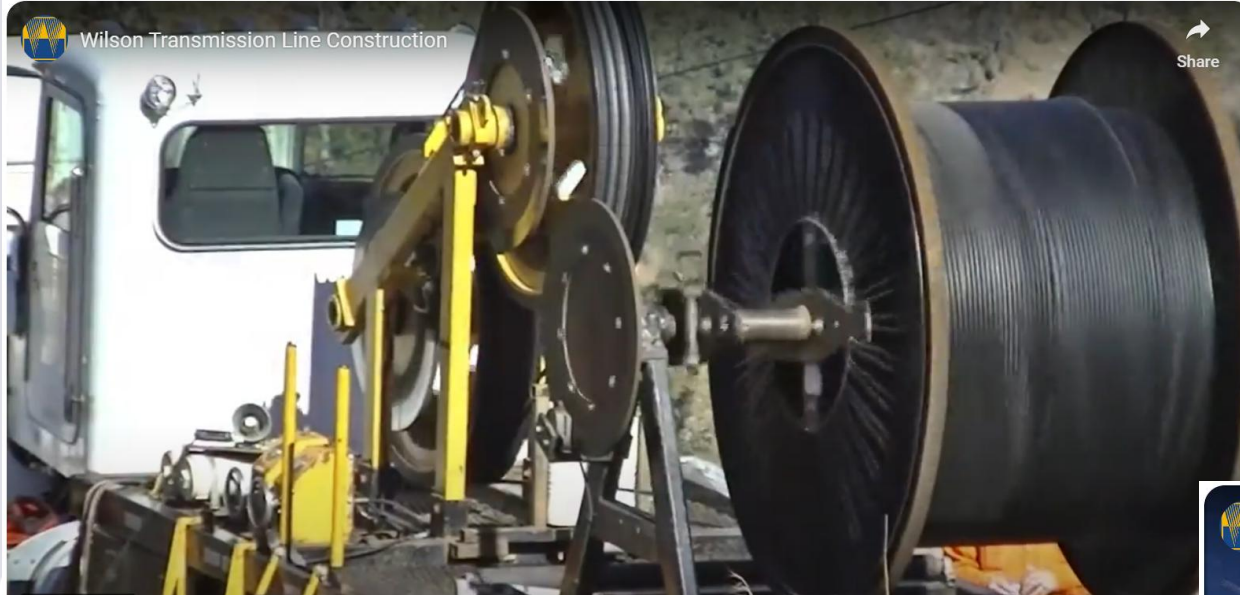
TCI Desired Outcome

- Dialogue between federal agencies (Pipeline and Hazardous Materials Safety Administration (PHMSA), Federal Energy Regulatory Commission (FERC) and Department of Energy (DOE)), state agencies, local power companies and pipeline operators to discuss safety impacts of AC interference to public, environmental, and pipeline infrastructure; providing advanced notification, and information sharing between industries.
- Education across industries of the safety and integrity concerns related to AC interference on steel pipelines.
- Encourage a partnership between pipeline operators and electric transmission companies to discuss the aforementioned concerns, to facilitate proactive communication and necessary data sharing to evaluate the potential impacts on pipelines.

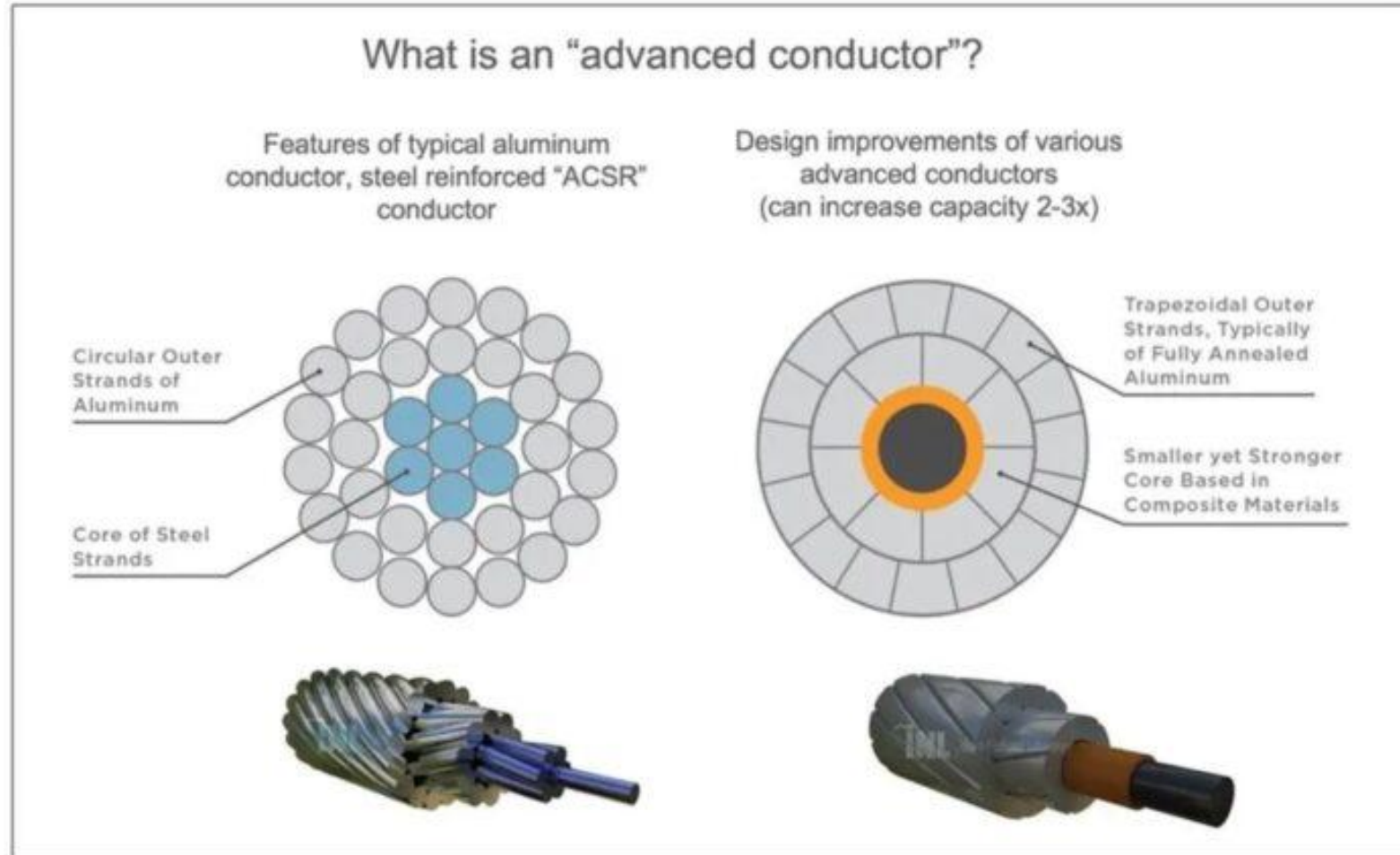
What is Reconductoring

- Reconductoring is simply the replacement of the wires / conductors on an AC Transmission Tower.
- Reconductoring is performed as required to address conductor fatigue and maintain reliability.
- Reconductoring utilizes existing infrastructure and has minimal impact on landowners along the ROW and no excavation.
- A US Gas Transmission Operator recent reported a reconductoring project in a collocated ROW where the electric utility replaced all overhead conductors for approximately 120 ROW miles in a 30-day period.

What is Reconductoring



Reconductoring with Advanced Conductors



Drivers for Increased Reconductoring with Advanced Conductors

- Increased electric demand across the US due to data centers.
- Increased electric demand across the US due to electric vehicles.
 - US mandate for ~70% of all new vehicles be EV / Hybrid by 2032
 - California mandate – 100% EV by 2035
- Reconductoring is ~120% of the cost of new transmission towers with conventional conductors; however, such projects typically take 10 - 15 yrs.
- “Clearing the backlog of nearly 12,000 solar, wind, and storage projects waiting to connect to the grid is essential to deploying clean electricity to more Americans,” said **U.S. Secretary of Energy Jennifer M. Granholm**.

Reconductoring – In the News

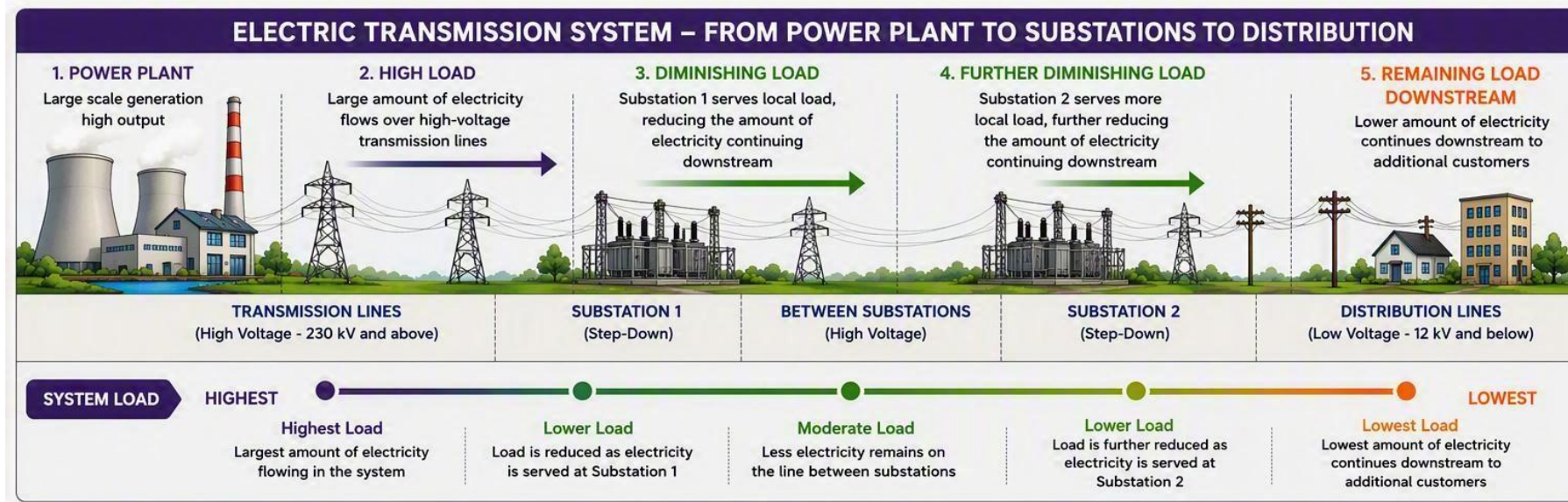
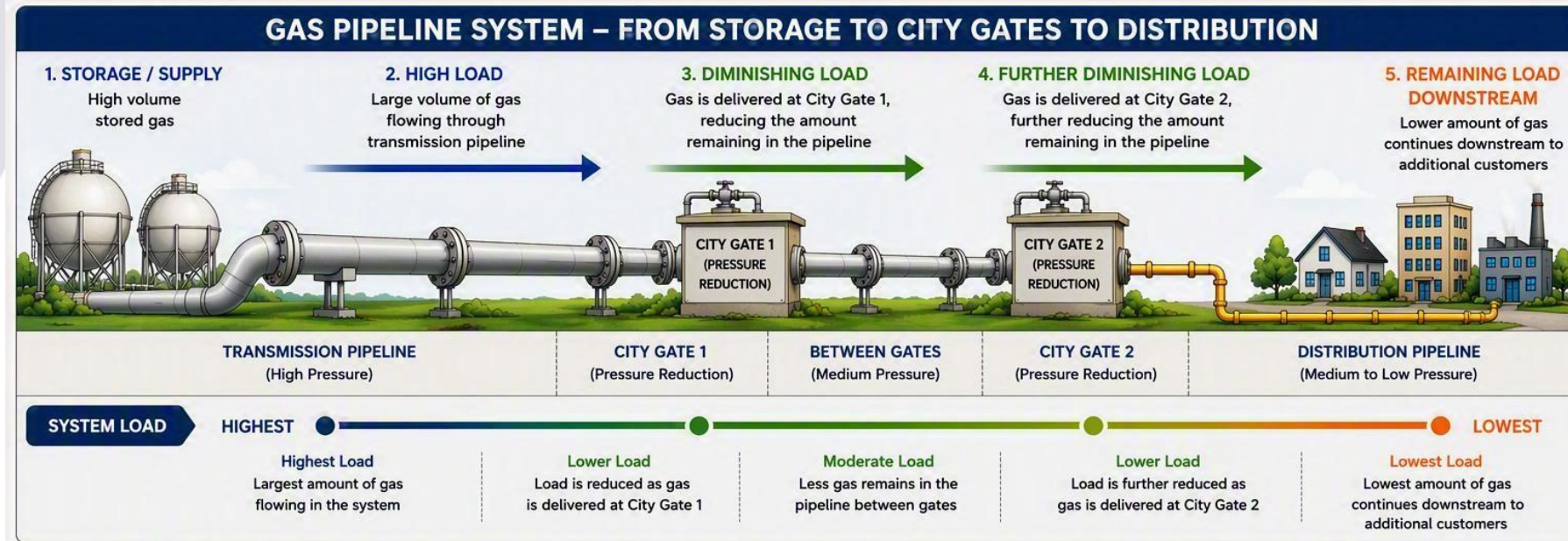
DOE Awards \$600 Million Grant to Improve California's Electricity Grid and Build Clean Energy Projects

Aug. 12, 2024

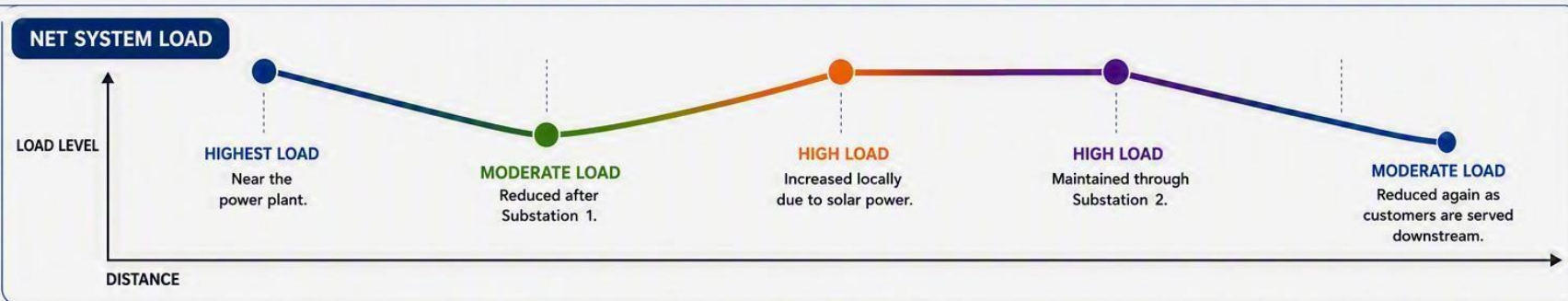
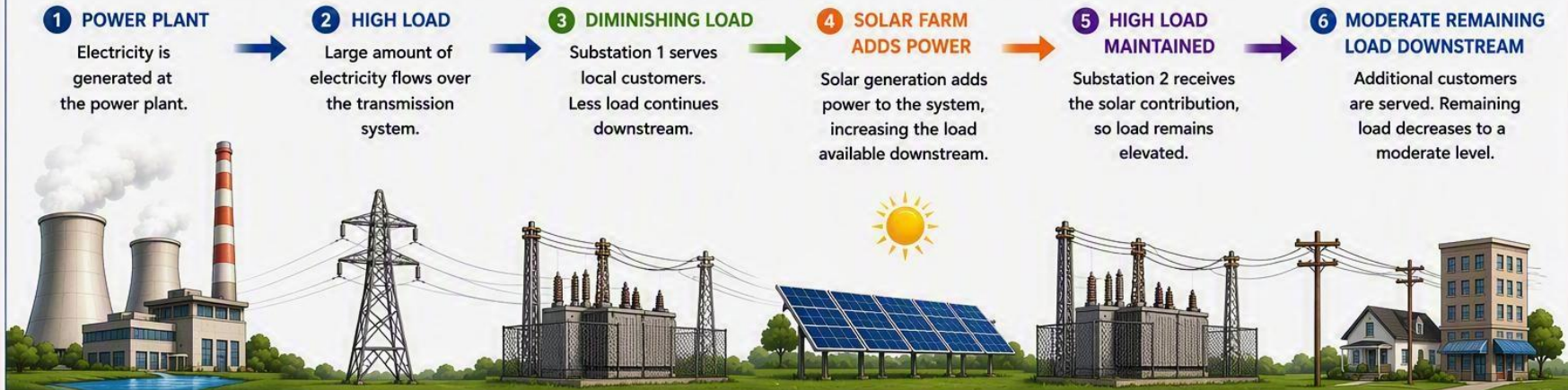
The U.S. Senators Alex Padilla and Laphonza Butler (both D-Calif.) and Speaker Emerita Nancy Pelosi (D-Calif.-11) have announced the Department of Energy's (DOE) grant of \$600 million in federal funding to upgrade 100 miles of transmission lines in California and improve the state's grid reliability and deliver clean, affordable electricity.

The funding is part of the \$10.5 billion Grid Resilience and Innovation Partnership (GRIP) program established by the Bipartisan Infrastructure Law.

- Enhance more than 100 miles of transmission lines with advanced conductor technologies that will help connect more clean energy resources than the existing grid accommodates currently.

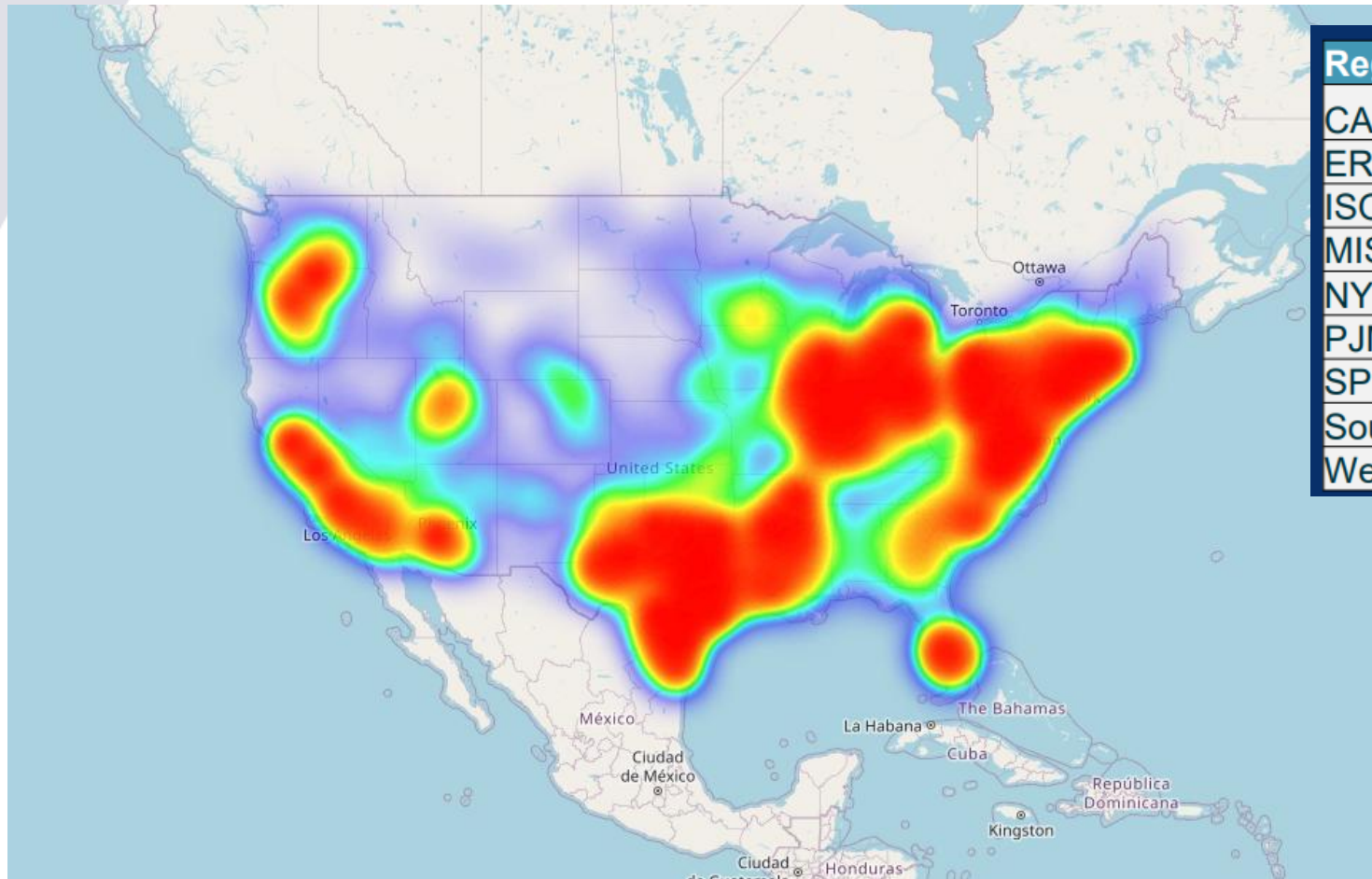


ELECTRIC TRANSMISSION SYSTEM – LOAD CHANGES ALONG THE WAY



In the electric system, load (the amount of electricity flowing) generally decreases as substations serve customers. A solar farm located between substations adds power locally, increasing the load available downstream and maintaining higher load levels through the next substation before gradually decreasing again.

Interconnection queues



Region	<i>n</i> (active)	Capacity (GW)
CAISO	638	272.8
ERCOT	1,447	346.1
ISO-NE	399	45.6
MISO	2,213	447.5
NYISO	402	78.5
PJM	1,942	211.5
SPP	643	142.4
Southeast (non-ISO)	1,002	162.5
West (non-ISO)	1,617	583.5

WHY THIS MATTERS

Increased risk with no visible changes

Increased electrical loads can increase AC Interference on nearby pipelines
With no obvious new construction

1 Shock hazard

Touch voltage can endanger field personnel.

2 AC corrosion

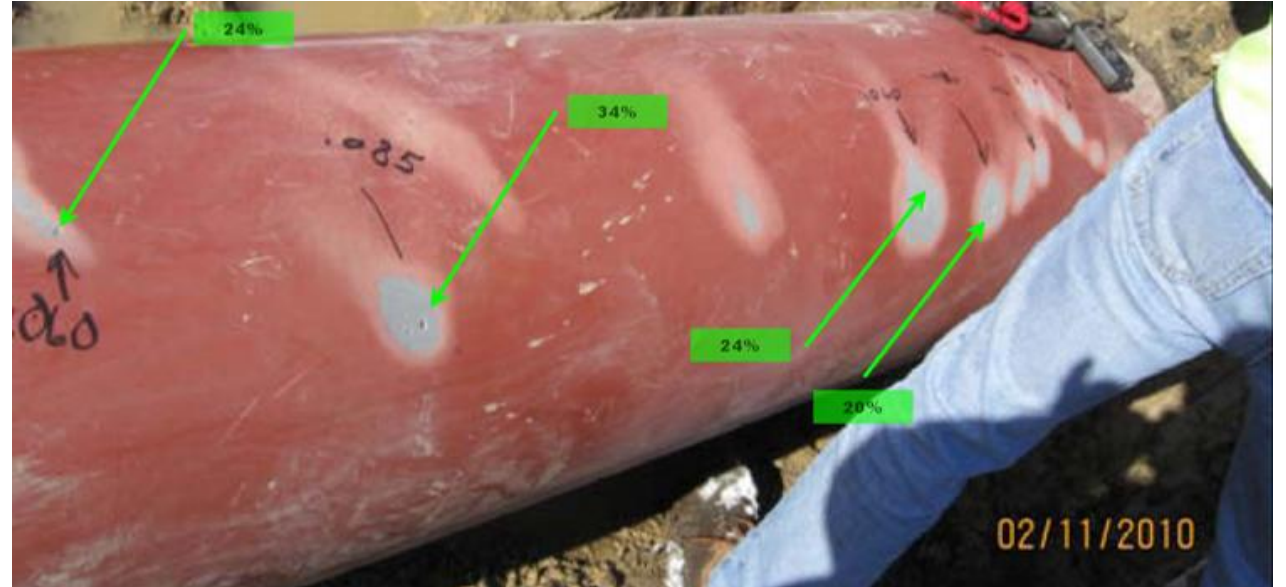
Accelerated corrosion rates – leaks before detection.

3 Fault current

Fault arcs – high risk threats to personnel and pipelines.

4 Less warning

Reconductoring can increase threat with no warning.



Potential Impacts to Pipeline Systems

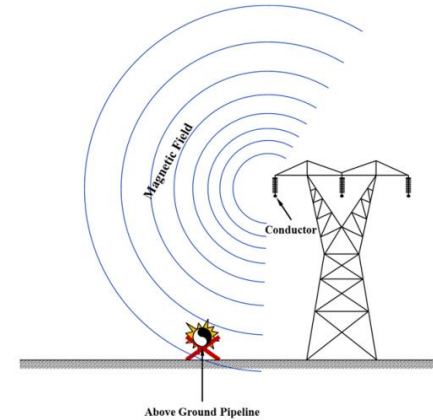
For a detailed technical discussion, please reference the 2015 INGAA Foundation report, [Criteria for Pipelines Co-Existing with Electric Power Lines \(DNV / Finneran\)](#).

EXECUTIVE SUMMARY

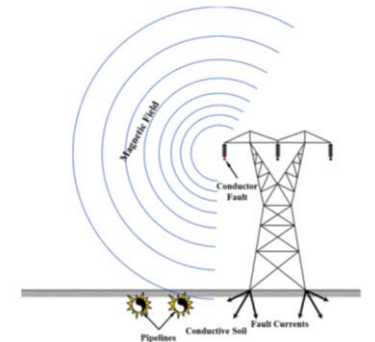
The primary objective of this report is to present the technical background, and provide best practice guidelines and summary criteria for pipelines collocated with high voltage AC power lines. The report addresses interference effects with respect to corrosion and safety hazards, and fault threats. The guidelines presented address mitigation and monitoring, encroachment and construction, risk severity classification, and recommendations for further industry development.

This report addresses the technical background to high voltage interference with respect to collocated and crossing pipelines, and presents basic procedures for dealing with interference scenarios. The provisions of this document are recommended to be used under the direction of competent persons, who are qualified in the practice of corrosion control on metallic structures, with specific suitable experience related to AC and/or DC interference and mitigation. This document is intended for use in conjunction with the reference materials cited herein.

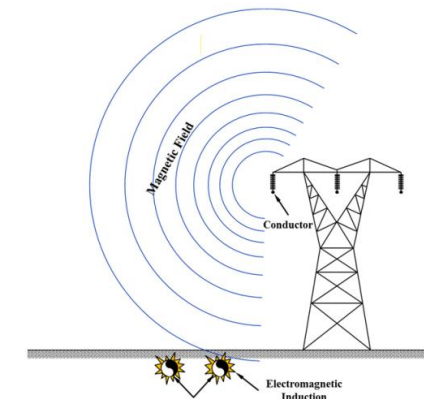
Collocated pipelines, sharing, paralleling, or crossing high voltage power line rights-of-way (ROW), may be subject to electrical interference from electrostatic coupling, electromagnetic inductive, and conductive effects. If the interference effects are high enough, they may pose a safety hazard to personnel or the public, or may compromise the integrity of the pipeline. Because of increased opposition to pipeline and power line siting, many future projects propose collocating high voltage alternating current (HVAC) and high voltage direct current (HVDC) power lines and pipelines in shared corridors, worsening the threat.



Capacitive Coupling



Faults - Inductive and Conductive Interference



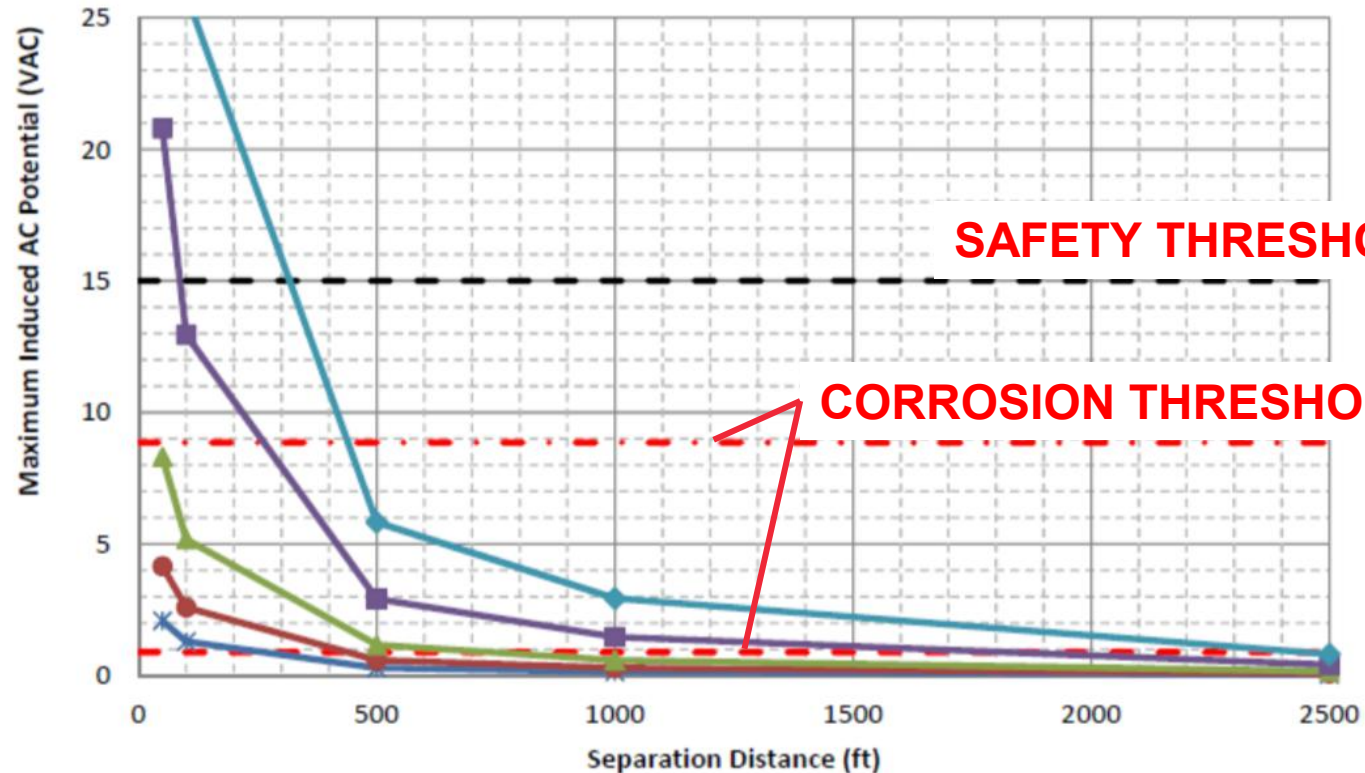
Steady State - Inductive Interference

Inductive Interference Threats

Maximum Induced AC Potential vs. Separation Distance

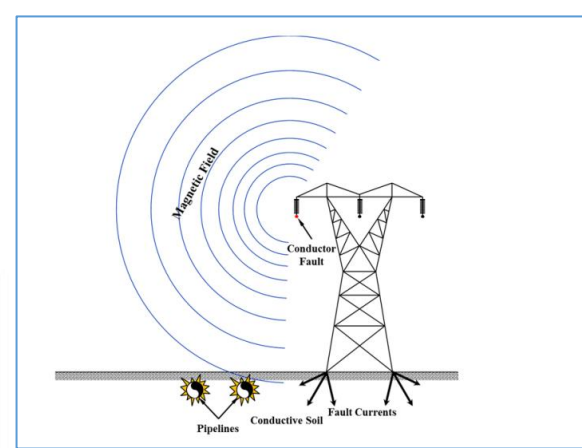
2500 ft Parallel Segment

- 20 Amps/m² @ 1,000 ohm-cm
- 20 Amps/m² @ 10,000 ohm-cm
- NACE 15 Volt Threshold
- 250 Amps
- 1000 Amps
- 5000 Amps
- 500 Amps
- 2500 Amps

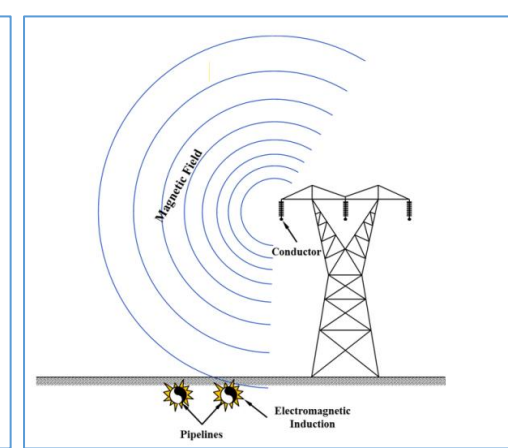


SAFETY THRESHOLD

CORROSION THRESHOLDS



Faults - Inductive and Conductive Interference

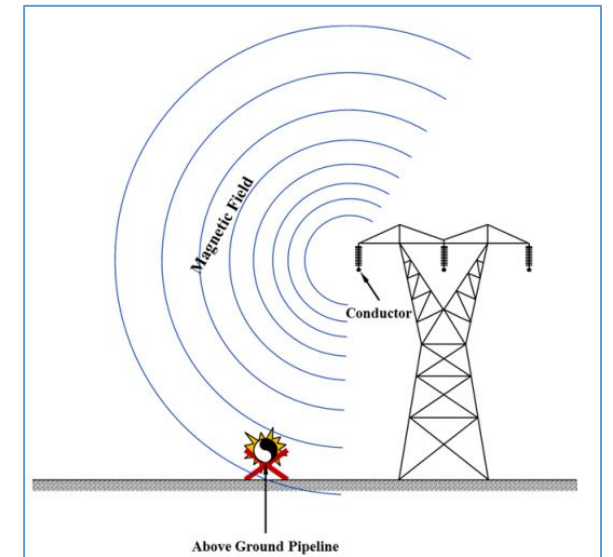


Steady State - Inductive Interference



Figure 12. Effects of separation distance on induced AC potential. Current density limits presented for a theoretical 1cm² holiday.

Capacitive Coupling



Capacitive Coupling

CASE STUDY · 2022-2023

Phillips 66 AC mitigation project shows how grid changes can create pipeline AC risk without a new crossing

Increased electrical loading changed AC exposure on an existing pipeline corridor.

Phillips 66 AC Mitigation Project On Active NGL Pipeline 2022-2023

Chad Stuart · Gulf Coast Region Corrosion Supervisor

AC CORROSION RISK

From elevated
pipe-to-soil potentials
to mitigated AC exposure

Loading changed—not the crossing

ACTIVE NGL PIPELINE

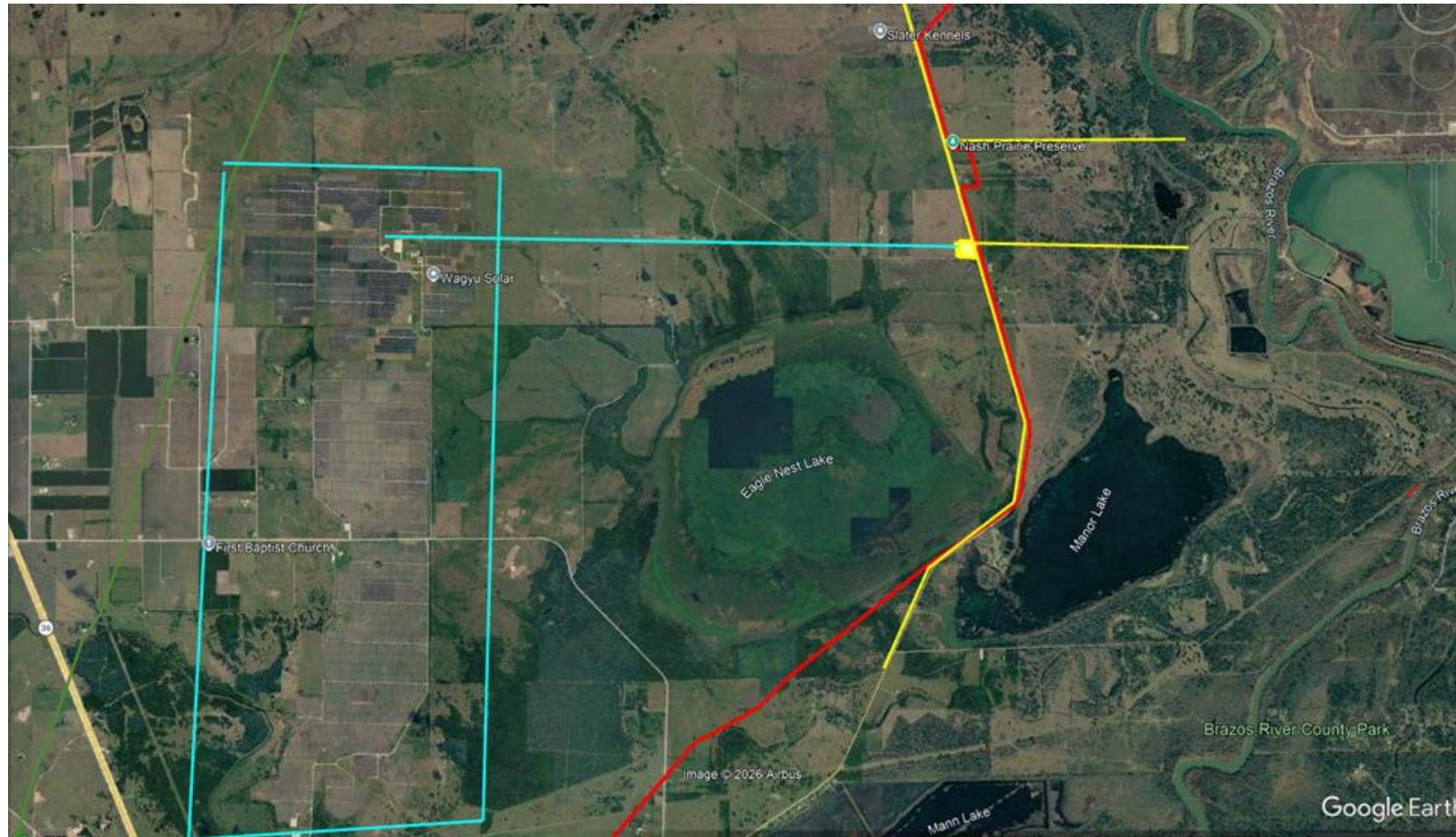
18-inch

FBE-coated pipeline installed in 2015

WHAT CHANGED

A new 365 kV line tied into the existing substation to support a solar farm.

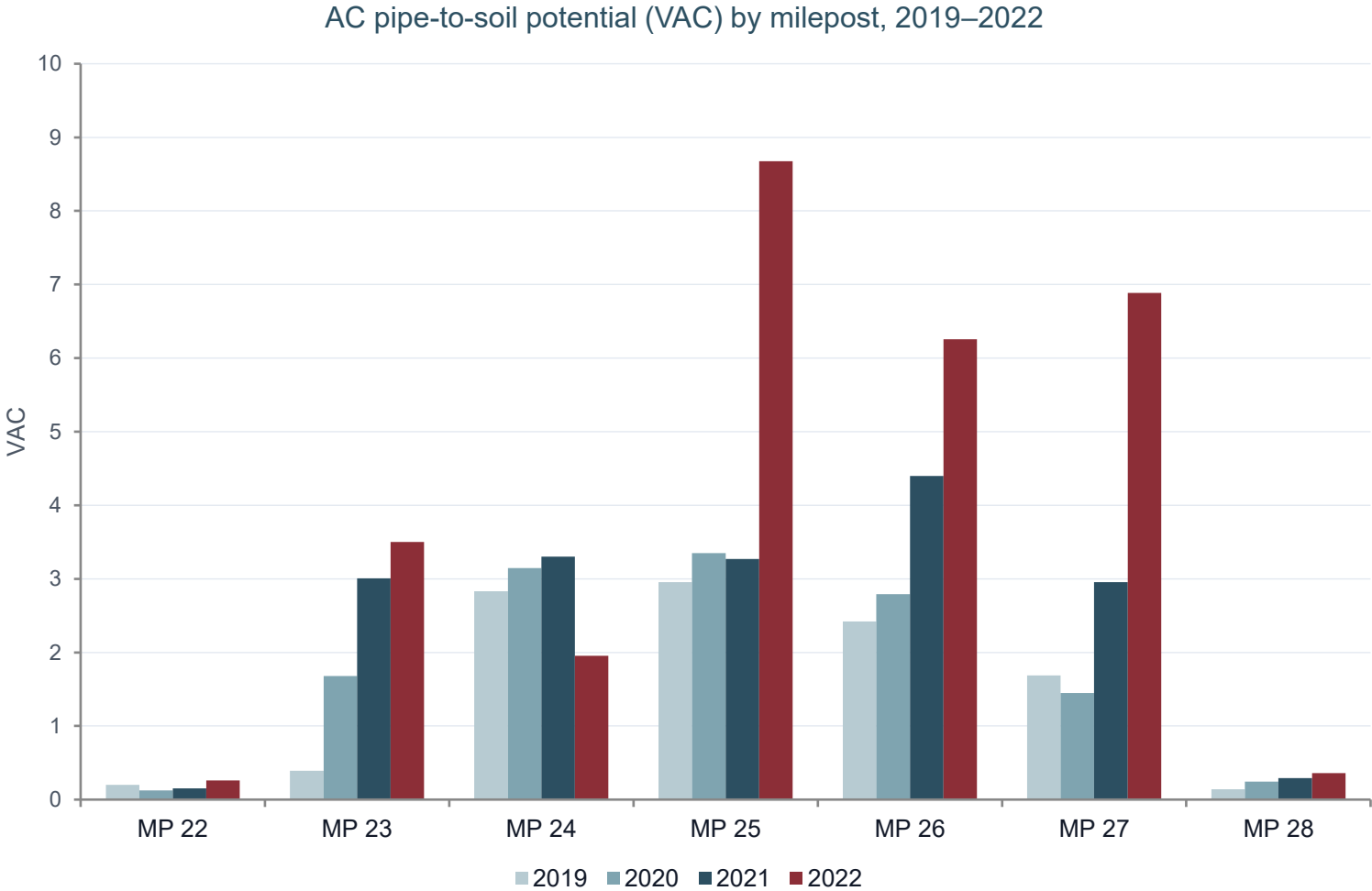
Power transfer increased on existing assets; the physical corridor appeared unchanged.



LEGEND

- P66 pipeline
- Existing electrical / substation
- New 365 kV tie-in
- New Solar Farm

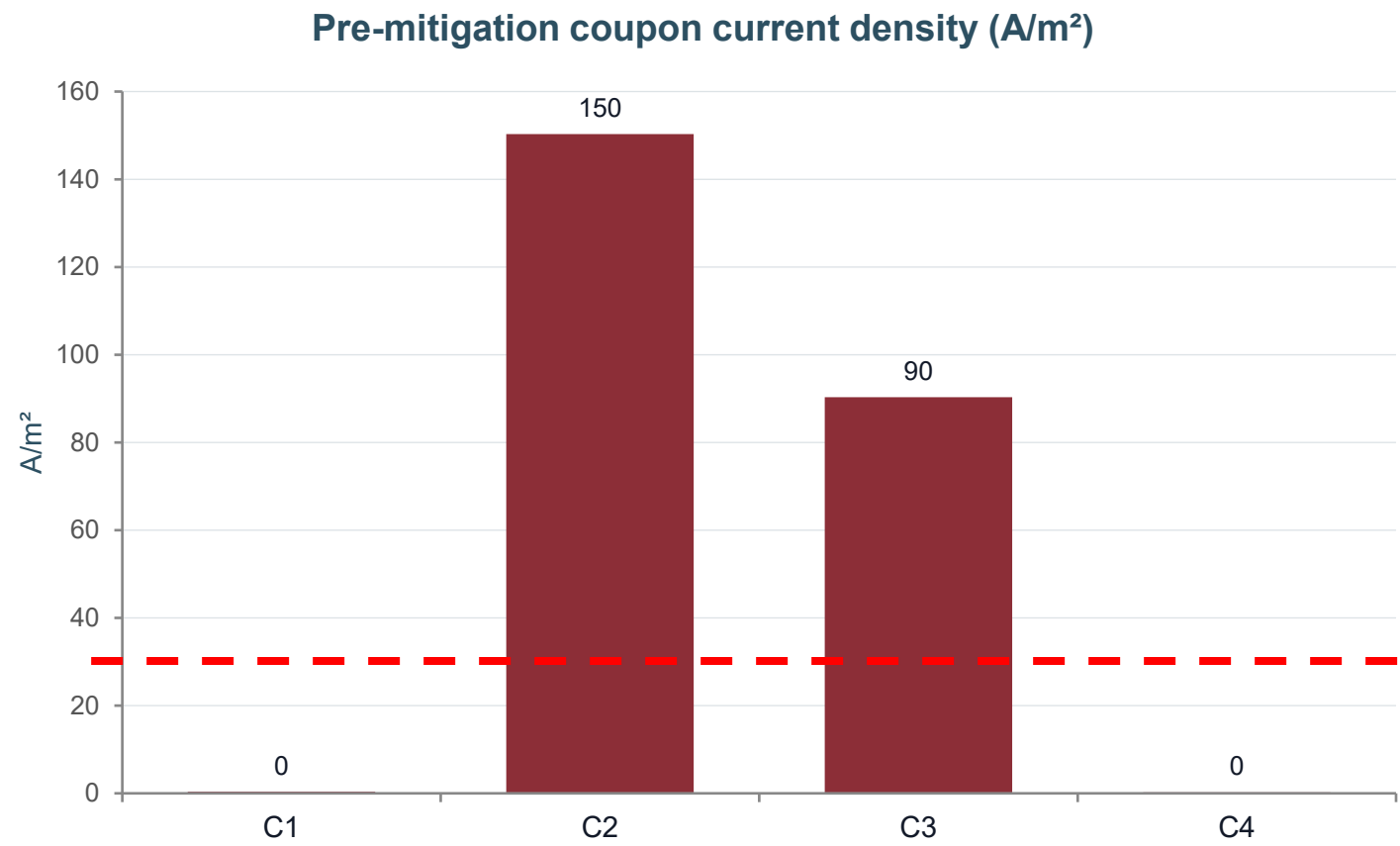
The 2022 annual survey found a concentrated jump at MP25–27 ~2-3x spike from prior years



Milepost	2019	2020	2021	2022
MP 22	0.20	0.13	0.15	0.26
MP 23	0.39	1.68	3.01	3.50
MP 24	2.83	3.15	3.30	1.96
MP 25	2.96	3.35	3.27	8.68
MP 26	2.4	2.79	4.40	6.26
MP 27	1.69	1.45	2.95	6.88
MP 28	0.14	0.24	0.29	0.36

Concentrated near the substation / power-line corridor: largest 2022 jumps occurred around MP 25–27.

Coupon testing confirmed high corrosion threat Requiring mitigation



Coupon Readings (Pre mitigation)

Coupon	A/m²	VAC
Coupon 1	0.4	1.4
Coupon 2	150.3	6.4
Coupon 3	90.3	5.4
Coupon 4	0.2	8.8

NACE Threshold $i_{AC} \leq 30 \text{ A/m}^2$

This study is a practical example of how load increases and reconductoring-related changes can alter AC exposure

01

Power transfer drives induced AC

Increased power transfer on existing transmission assets can raise induced AC on nearby pipelines — no new crossing required.

02

Corridor can look unchanged

The pipeline operator may see a changed corrosion environment even when the physical corridor appears unchanged on the right-of-way.

03

Why notification matters

The pipeline supports the case for better communication when utilities increase line loading, add generation, reconfigure substations, or make reconductoring-related upgrades.

Bottom line — load and configuration changes on existing assets can shift AC exposure on adjacent pipelines.

AC corrosion caused a leak before the next inspection

Mitigation was already in place.

With increased loads -
AC corrosion accelerated enough to produce
a leak before the next required pipeline
inspection.

RELATED IMPACTS

- Leaks risk rupture and ignition,
- Shutdowns interrupt critical fuel supply
 - Airports & gas stations
 - Hospitals & power plants



LEAK

Accelerated corrosion + delayed awareness

WHY THIS MATTERS

Without notification, operators are forced into a reactive risk posture

REACTIVE STATE

Discover, then respond.

Mitigation begins only after the AC corrosion hazard has already been identified — Often times only after corrosion symptoms appear.

1

Change without notice

Utilities increase load, add generation, reconfigure substations, or reconductor without notifying the pipeline operator.

2

Risk profile shifts unseen

The pipeline's AC exposure changes, but the operator has no signal that the risk profile has moved.

3

Late discovery

Elevated AC interference is found only through annual surveys, field testing, or visible corrosion symptoms.

4

Escalating consequences

Risk can escalate unchecked — with potential for financial loss, property damage, service disruption, and public-safety exposure.

THE PROACTIVE SHIFT

Early notification moves operators from discovery to prevention

PROACTIVE STATE

Anticipate, then act.

Notification creates time to assess changing AC exposure, deploy targeted testing, and plan mitigation before corrosion risk escalates.

1

Notify before change

Utilities alert the pipeline operator before increasing load, adding generation, reconfiguring substations, or reconductoring.

2

Anticipate AC exposure

Operators can evaluate how the planned change may alter the pipeline's AC risk profile before the impact appears in the field.

3

Act early

Early notice enables targeted AC testing, coupon installation, modeling, and mitigation planning before risk escalates.

4

Protect people and assets

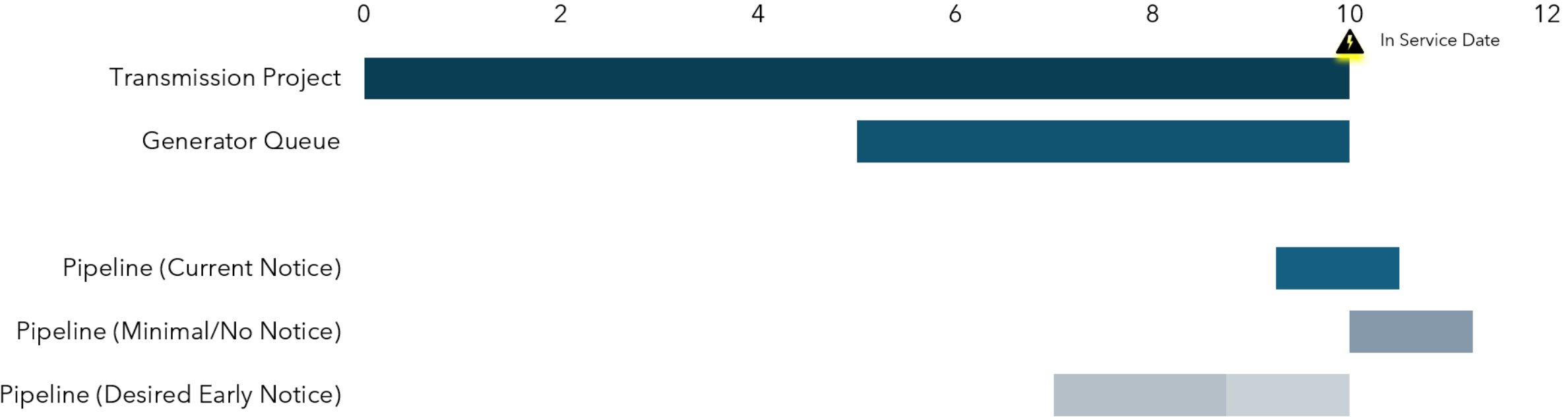
Proactive coordination better protects the public, nearby property, the pipeline system, and operator resources.

Bottom line: Notification is not just a coordination courtesy —
It is an important public-safety control.

What the pipeline industry needs:

- Short Term: Communication of planned projects that will increase electrical load.
 - A minimum of 12-18 months prior to installation.
 - Specific data regarding load increases, physical geometry information and proposed operational parameters.
- Long Term: Tools/Methods that will assist electric and pipeline operators to identify projects of interest and facilitate communication.

Misalignment Between Infrastructure Development Timelines and Pipeline Notification (Years)



Questions / Ideas?

Supplemental Slides

HVAC Interference Studies

Information & Data Requirements

Purpose: Define what information is required to conduct a complete HVAC interference corridor study, and why each data element is needed.



Keith Parker
External Corrosion Specialist, SME
LP Pipeline Integrity Corrosion Prevention

HVAC Transmission Line Data: What Is Needed & Why

PHYSICAL / GEOMETRIC DATA

Tower Coordinates & Height

Defines the source geometry for induced-EMF and GPR calculations. Tower separation from pipeline determines coupling magnitude.

Conductor Configuration (Vertical/Horizontal/Delta)

Phase arrangement governs the cancellation pattern of induced fields. Unbalanced configurations produce higher residual coupling.

Phase Configuration & Transposition

Transposed lines cancel EMF over their length; untransposed lines accumulate induced voltage. Must be modeled correctly.

Shield Wire / Ground Wire Data

Shield wires provide partial shielding of inductive coupling and carry fault current; they must be included in the HIFREQ/CDEGS model.

Bundle Conductor Data

Bundled conductors affect the mutual impedance calculation in the Carson-Pollaczek formulation.

ELECTRICAL / OPERATIONAL DATA

Operating Voltage (kV)

Determines line-to-ground voltage; drives coating dielectric stress during fault conditions.

Average & Peak Line Loading (A)

Induced EMF scales linearly with line current. Peak loading — not average — governs worst-case steady-state interference.

Phase Imbalance Data

Phase imbalance produces residual coupling that drives pipeline voltages even when three-phase cancellation should theoretically apply.

Maximum SLG Fault Current (kA) & X/R Ratio

Single-line-to-ground faults drive the conductive GPR calculation. X/R ratio and fault clearing time determine peak stress and IEEE Std 80 touch-voltage limits.

Fault Clearing Time (cycles)

Shorter clearing times reduce the energy delivered to the pipeline during a fault event and affect permissible touch potentials.

Pipeline Data: What Is Needed & Why

DATA ITEM	WHY IT IS NEEDED
Centerline GPS / Alignment Sheets	Defines the corridor geometry; required to calculate separation distances and parallelism lengths for induced-EMF modeling.
Depth of Cover	Affects earth-return impedance in Carson-Pollaczek calculations and GPR influence zone depth calculations.
Diameter, Wall Thickness, Grade	Needed to model pipe impedance, mechanical response to coating stress voltages, and ILI anomaly correlation.
Coating Type, Age, and Condition	Coating resistance governs how induced voltage develops between discontinuities. Dielectric strength determines fault-condition stress limits (3–5 kV).
Insulating Joint / Casing Locations	Electrical discontinuities concentrate induced voltage at their positions; modeling must include these as boundary conditions.
CP Rectifier Locations & Output	CP operating conditions affect AC corrosion risk; over-protection is one of the three SP21424 prerequisites for ACIC.
Recent Test Station AC Voltage Data	Establishes the existing interference baseline; identifies hot spots before modeling begins.
ILI Anomaly History (Metal Loss)	Clusters of unexplained pitting in a corridor may already reflect AC corrosion; used to calibrate model risk output.

Soil, Field & Corridor Data: What Is Needed & Why

SOIL	
Soil Resistivity (Wenner 4-pin)	Controls earth-return impedance in induced-EMF model and governs the GPR influence zone radius. Low-resistivity soils spread fault current over larger areas; high-resistivity concentrates gradient near tower footings.
Layered Soil Model	Real soils are not uniform. CDEGS MALT/MALZ multi-layer model required for accurate GPR and spread-resistance calculations. Built from multiple Wenner traverses.
FIELD MEASUREMENTS	
AC Pipe-to-Soil Voltage (Snapshot)	Confirms the spatial distribution of induced voltage at all accessible test stations and appurtenances — replaces estimates with actual measurements.
Long-Duration AC Voltage Logging (7–30 days)	A snapshot taken during low-load conditions can underestimate peak interference by 2–4×. Long-duration logging captures diurnal, weekly, and seasonal loading peaks.
Coupon-Based AC Current Density (7–30 days)	Direct measurement of J_{AC} at simulated coating defects. The ISO 18086 / SP21424 primary criterion: $<30 \text{ A/m}^2$ (low), $30\text{--}100 \text{ A/m}^2$ (moderate), $>100 \text{ A/m}^2$ (high risk).
Coupon-Based DC Current Density	This allows for the use of the AC to DC current density ratio, as outlined in SP21424-2018, Section 6 (Criteria), specifically bullet 6.2, as well as ISO 18086:2019, Section 6 (Evaluation of AC corrosion likelihood), subsections 6.1 and 6.2, which address the AC/DC current density ratio
CP On/Instant-Off/Polarized Potentials	Determines whether cathodic protection is adequate ($\geq -850 \text{ mV CSE}$ polarized) and whether over-protection is present — a prerequisite for AC corrosion under SP21424.
CORRIDOR	
One-Call / Foreign Pipeline Inventory/Foreign Bonds	Foreign CP systems in the corridor can interact with HVAC mitigation grounding; foreign pipelines can be inadvertently affected by proposed mitigation. The presence of these bonds, often originally installed for DC interference mitigation, can allow AC to travel in non-intuitive ways and may sometimes act as unintended grounding locations

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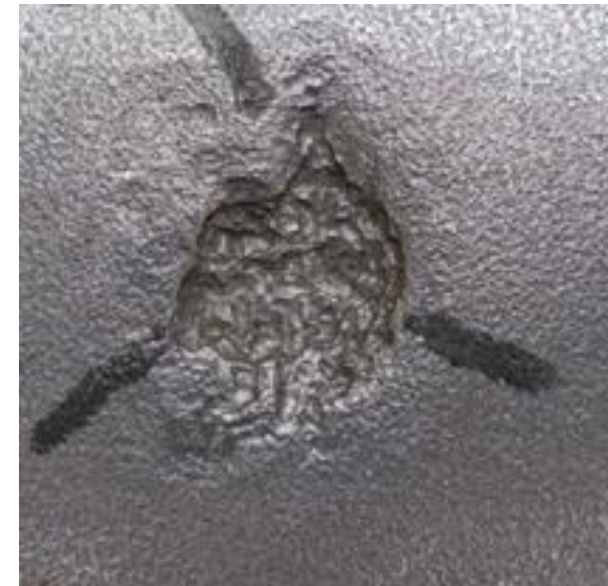
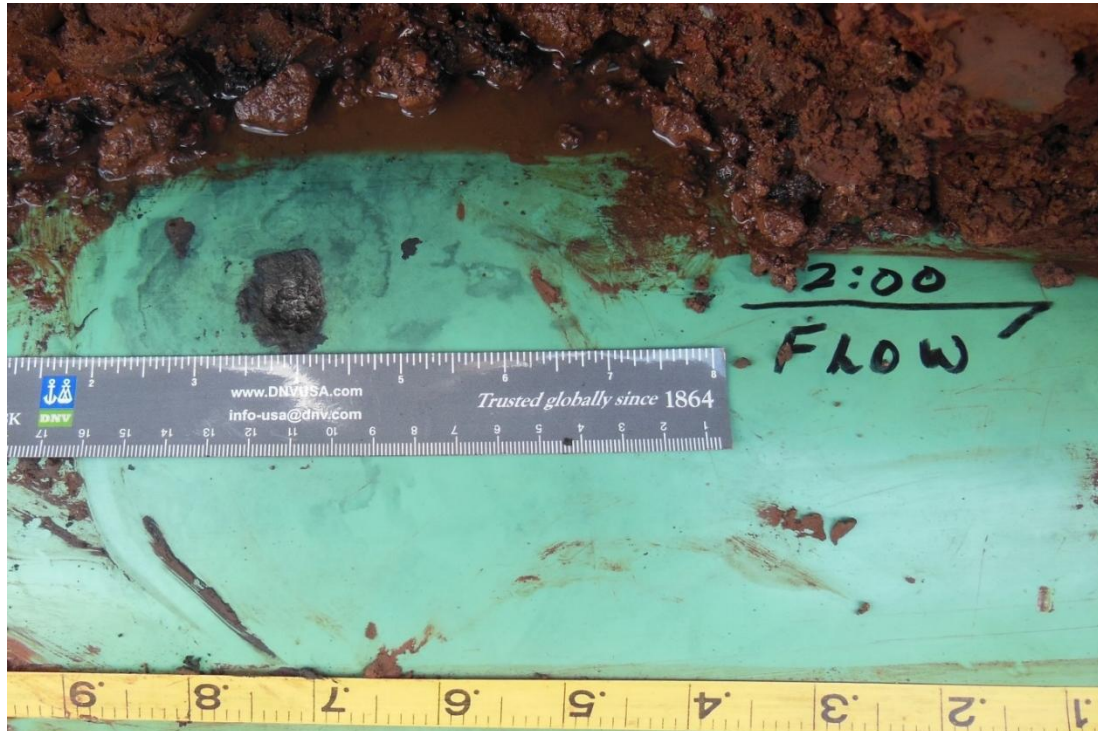


Keith Parker
External Corrosion Specialist, SME
LP Pipeline Integrity Corrosion Prevention

Feature 1 – As Excavated and After Cleaning

56% through wall

- Little to no nodule found
- Only feature in FBE segment
- 56% Through wall
- Soil Resistivity (ρ) 240-320 ohm-cm



Feature 3 – As Excavated and After Cleaning 56% through wall

- Hardened nodule and coating damage
- Coal Tar
- 56% Through wall
- ρ : 180-196 ohm-cm



Feature 4 – As Excavated and After Cleaning

79% through wall

- 3-inch hardened nodule
- Damaged coal tar coating
- 79% Through wall
- ρ : 87-144 ohm-cm

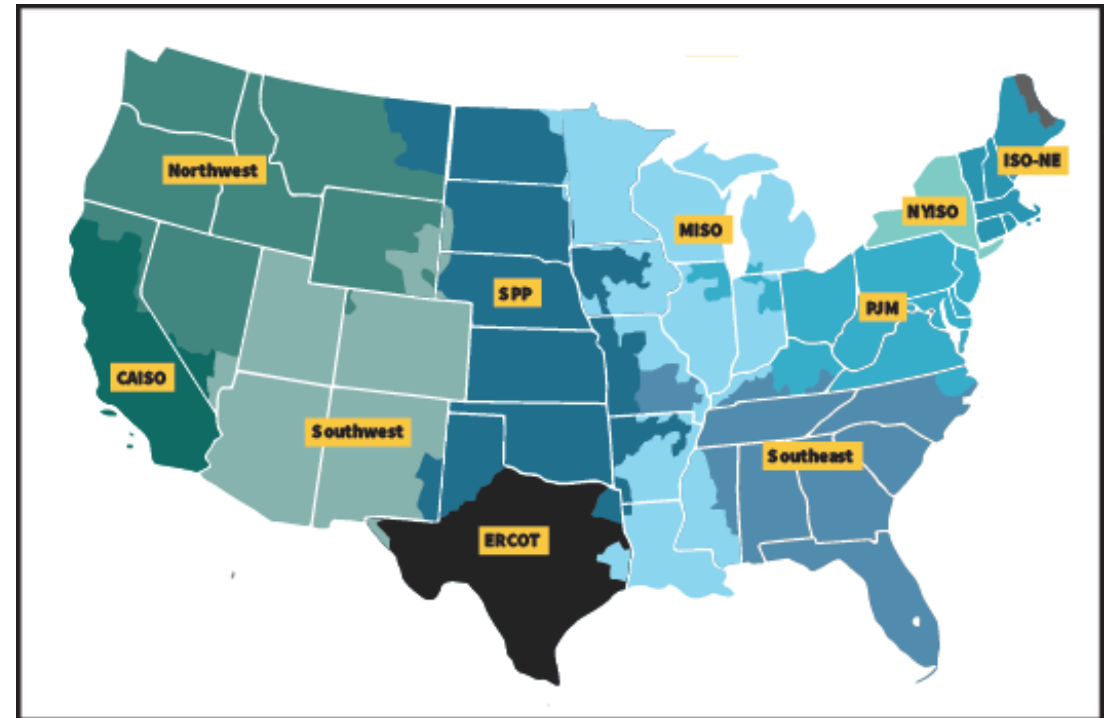


What can Operators do right now?

- Communicate/Educate about the issue.
 - Internally
 - Operations – patrols
 - Right-of-way/Property Groups
 - Strategy Groups
 - Electric
 - Externally
 - Regulators
 - Electric Transmission Companies
 - Other Operators
- Work with Joint Utilities on locations of Electric Transmission Lines

What can Operators do right now?

- Look for info on projects from the Independent System Operators (ISO) or Regional Transmission Organizations (RTO) in your areas.
 - **CAISO** (California ISO): Covers California.
 - **ERCOT** (Electric Reliability Council of Texas): Covers most of Texas.
 - **ISO-NE** (ISO New England): Covers Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.
 - **MISO** (Midcontinent Independent System Operator): Covers the Midwest and parts of Manitoba, Canada.
 - **NYISO** (New York Independent System Operator): Covers New York state.
 - **PJM** (Pennsylvania-New Jersey-Maryland Interconnection): Covers all or parts of 13 states and D.C. in the Mid-Atlantic and Midwest.
 - **SPP** (Southwest Power Pool): Covers parts of the central US, including Arkansas, Oklahoma, Kansas, and parts of neighboring states.
 - **AESO** (Alberta Electric System Operator): Operates in Alberta, Canada.
 - **IESO** (Independent Electricity System Operator): Operates in Ontario, Canada.



Appl In Service Date	County	State	Study Cycle	Study Gro	Study P	Service	POI Name	Summe	Winter	Fuel	Generating Facili	Negotiated In Service Date
2027-04-01T04:00:00+00:00	Calhoun	MI	DPP-2022	East (ITC)	Phase 1	NRIS	MAJESTIC - ONEIDA 345.0kV	255	255	Solar	Photovoltaic	
2028-04-01T04:00:00+00:00	Monroe	MI	DPP-2023	East (ITC)	Study Not	NRIS	LEMOYNE - MAJESTIC 345.0kV	200	200	Solar	Photovoltaic	
2030-03-01T05:00:00+00:00	Washtenaw	MI	DPP-2025	East (ITC)	Phase 1	NRIS	Majestic-Milan 345 kV Line	1414	1414	Gas	Combined Cycle	
2030-01-31T05:00:00+00:00	Washtenaw	MI	DPP-2026	East (ITC)		NRIS	MAJESTIC - MILAN 345.0kV	245	245	Solar	Photovoltaic	
2028-04-01T04:00:00+00:00	Eaton	MI	DPP-2026	East (ITC)		NRIS	MAJESTIC - ONEIDA 345.0kV	400	400	Battery Sto	Battery Storage	
2028-09-30T04:00:00+00:00	Washtenaw	MI				SIS	Majestic 345kV to Milan 345kV	76.5	76.5			2028-09-30T04:00:00+00:00

L RTP FACT SHEET - TRANCHE 1

MAJESTIC-COVENTRY-WAYNE RECONDUCTOR PROJECT

@ITCHoldingsCorp

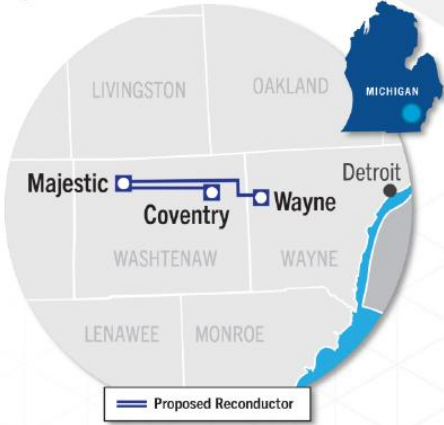
@ITCGrid

ITC Holdings Corp

PROJECT OVERVIEW

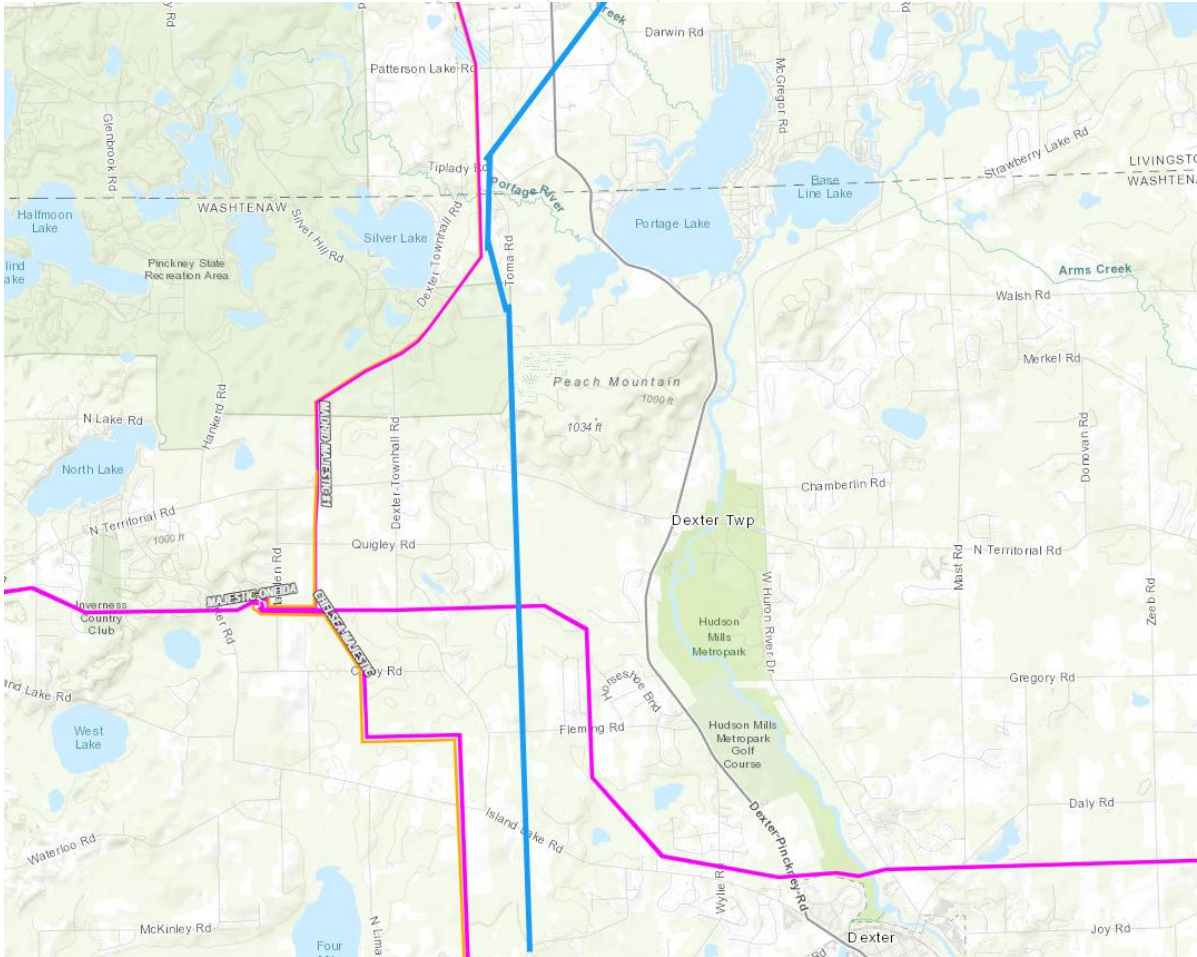
ITC Michigan is committed to serving customers and communities by providing safe, secure, reliable electricity transmission service to meet their needs. This reconductor project is part of Tranche 1 of the overall Long-Range Transmission Plan (LRTP) explained in more detail on the reverse.

In Washtenaw and Wayne counties, ITC will be making infrastructure improvements by reconductoring approximately 32 miles of transmission lines from our Majestic station to Wayne station. Construction is scheduled to begin Q2 2024 and be completed by Q4 2025.



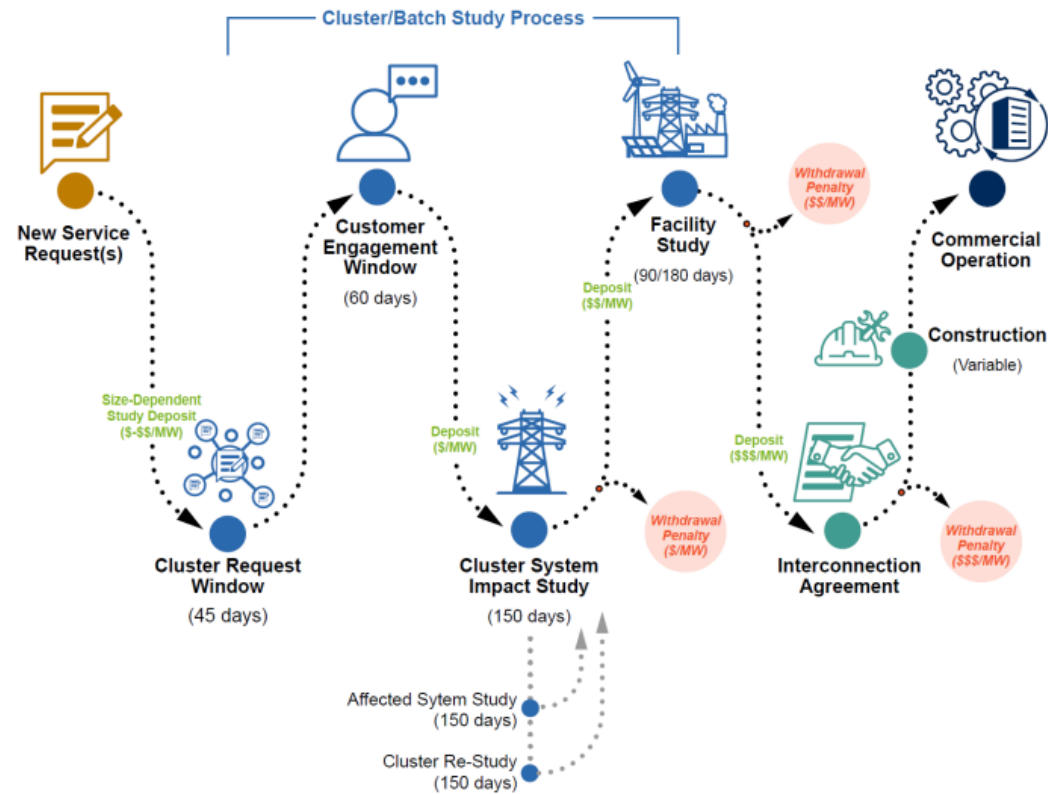
WHAT IS RECONDUCTORING AND WHY IS IT BENEFICIAL?

Reconductoring is the replacement of existing transmission line wires with upgraded wires that are better able to handle the additional capacity (demand) placed on them. On this specific project, ITC will keep existing transmission structures, thereby providing resilient and reliable electricity at substantial cost savings to the community. The completed project will also provide system efficiency and storm resiliency.



Interconnection queues

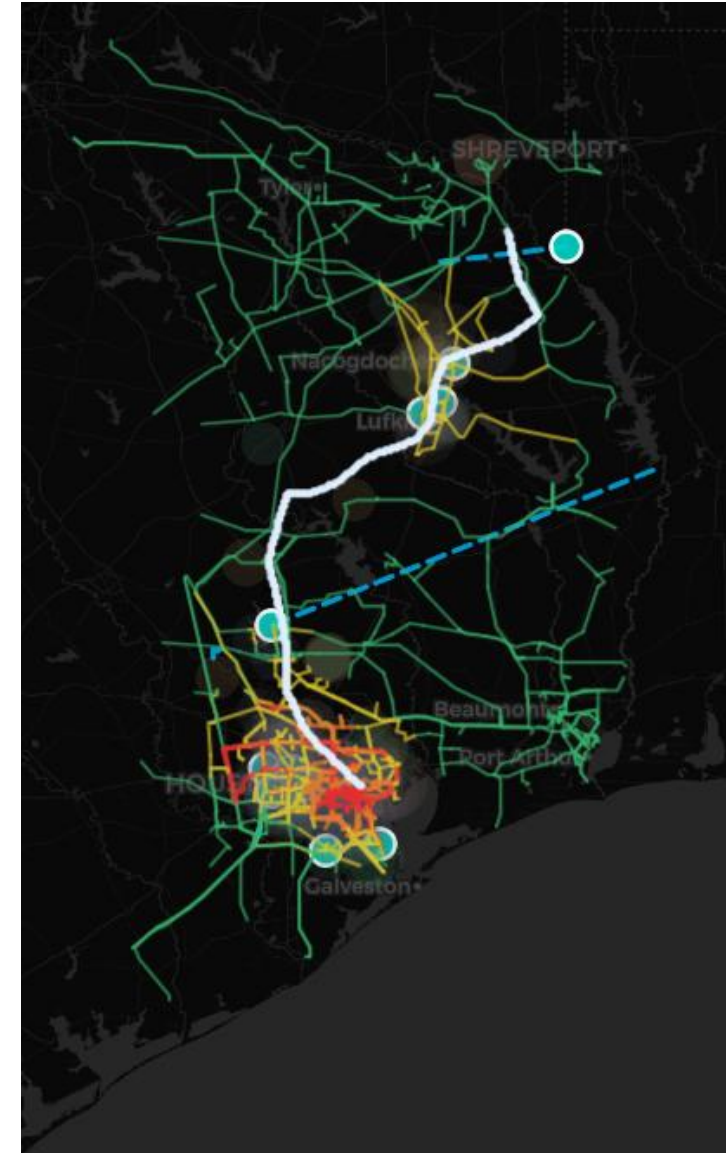
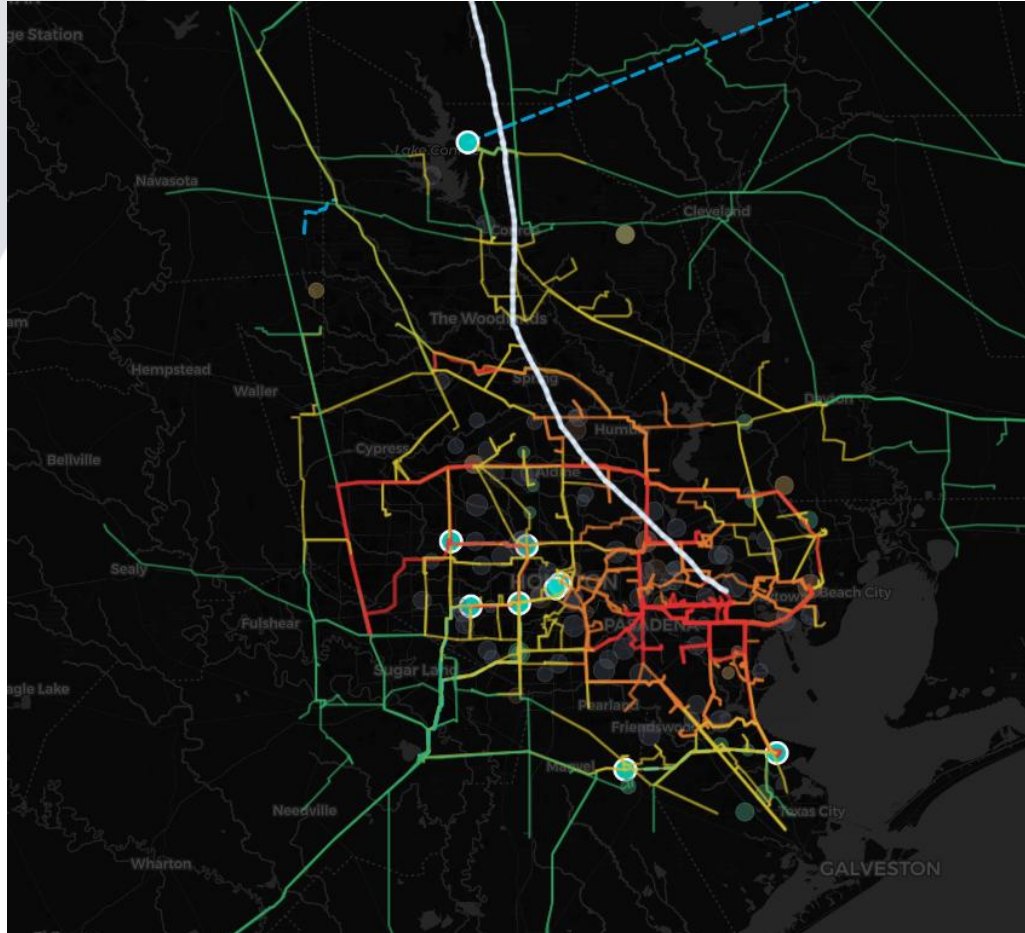
STUDY PROCESS AND TIMELINE



Interconnection Reforms in FERC Order 2023

- **Cluster studies; first ready, first served**; higher **deposits & readiness** criteria for developers
- **Timeline, process, and reporting** requirements for transmission providers; **Financial penalties** for delays
- Visual representation (**heatmaps**) of available **transmission capacity**
- Improved and standardized process for **affected system studies**
- Improved procedures and **flexibility for storage and hybrid resources**
- Consideration of **alternative transmission technologies (GETs)**
- Compliance filing deadline: **May 2024**

Mapping tool



Applicable Standards

- NACE SP0177: Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
- NACE SP21424: Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring
- IEEE 2746: IEEE Guide for Evaluating AC Interference on Linear Facilities Co-Located Near Transmission Lines