2024 INTERNATIONAL CONFERENCE ON OVERHEAD LINES

DESIGN, CONSTRUCTION, INSPECTION & MAINTENANCE

WELCOME

April 15-18, 2024

Fort Collins, Colorado USA

EDM
reliability & innovation

PANEL DISCUSSION:

ISSUES & CHALLENGES SHAPING OUR INDUSTRY

2024 INTERNATIONAL CONFERENCE ON OVERHEAD LINES

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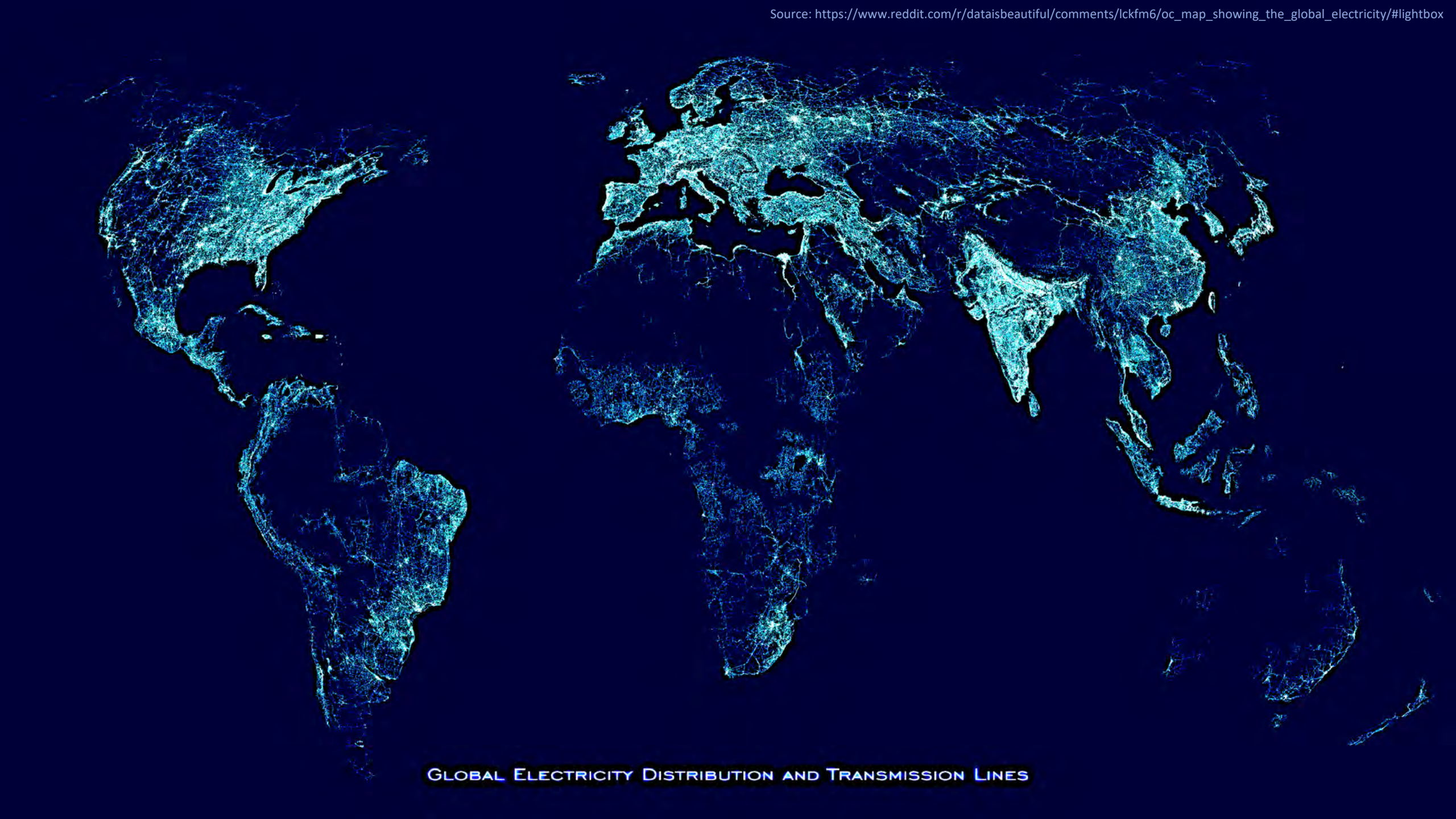
PANELISTS

- **Jesse Parker**
  - Real-Time Engineer – Western Area Power Administration
- **Eric Eriksen**
  - Chief Executive Officer – San Luis Valley Rural Electric Cooperative
- **Nadia El Mallakh**
  - Senior Advisor – Utility & Clean Energy Sectors
- **Moderator:**
  - Andy Stewart – EDM International, Inc.

Source: https://www.reddit.com/r/dataisbeautiful/comments/lckfm6/oc_map_showing_the_global_electricity/#lightbox



T&D STATS

WARNING: THIS INFORMATION IS BASED ON SOME SOLID NUMBERS MIXED WITH SOME WHIZBANG MATH. SOURCES OF THE LESS DUBIOUS DATA: U.S. ENERGY INFORMATION ADMINISTRATION (EIA), U.S. ENVIRONMENT PROTECTION AGENCY (EPA), LINEMAN CENTRAL

UNITED STATES

In 2023 **4,178 terawatt-hours** of electricity were generated via **~25,378** generators at **~12,538** utility-scale generation facilities (i.e., ≥1 MW)

…and now the important stuff, for us. The power was delivered over…

- Lines:
  - **~720,000 miles of T-lines**
  - **~6.4 million miles of D-lines**
- Structures:
  - **Towers: 2.7 million**
  - **Poles: 180 million (all materials)**

WORLDWIDE

- Lines:
  - **~7.8 million miles of T-lines**
  - **~76.1 million miles of D-lines**

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THE 200 WONDERS OF THE WORLD

Source: https://www.wonderspodcast.com

THE ORIGINAL SEVEN WONDERS

1. The Great Pyramid of Giza, Egypt
2. The Hanging Gardens of Babylon, Iraq
3. The Statue of Zeus at Olympia, Greece
4. The Temple of Artemis at Ephesus, Turkey
5. The Mausoleum at Halicarnassus, Turkey
6. The Colossus of Rhodes, Greece
7. The Lighthouse of Alexandria, Egypt

THE SEVEN ADDITIONAL ANCIENT WONDERS

8. Stonehenge, England
9. The Great Sphinx of Giza, Egypt
10. The Temple of Karnak at Luxor, Egypt
11. Luxor Temple, Egypt
12. The Valley of the Kings, Egypt
13. The Temple of Ramesses at Abu Simbel, Egypt
14. The Staircases of Persepolis, Iran

THE SEVEN ADDITIONAL WONDERS OF THE HELLENIC/HELLENISTIC WORLD

15. The Parthenon of Athens, Greece
16. The Oracle of Apollo at Delphi, Greece
17. Petra, Jordan
18. The Fortress of Masada, Israel
19. The Ruins of Heliopolis of Baalbek, Lebanon
20. The Catacombs of Kom el Shoqafa of Alexandria, Egypt
21. The Hagia Sophia of Istanbul, Turkey

THE SEVEN WONDERS OF THE ROMAN WORLD

22. The Roman Forum, Italy
23. The Pont du Gard, France
24. The Ruined Cities of Pompeii and Herculaneum, Italy
25. The Colosseum of Rome, Italy
26. The Pantheon of Rome, Italy
27. The Ruins of Leptis Magna, Libya
28. Diocletian's Palace at Split, Croatia

THE SEVEN WONDERS OF THE PRECOLUMBIAN WORLD

29. The Pyramids of Teotihuacan, Mexico
30. The Temples of Tikal, Guatemala
31. The Nazca Lines, Peru
32. The Temple of the Inscriptions at Palenque, Mexico
33. The Stelae of Copan, Honduras
34. The Pyramid of Kukulkan at Chichén Itzá, Mexico
35. Machu Picchu, Peru

THE SEVEN WONDERS OF CHINESE ARCHITECTURE

36. The Terracotta Army of Xian, China
37. The Great Wall of China
38. The
39. The
40. The
41. The
42. The

THE SEVEN WONDERS OF INDIAN/HINDU ARCHITECTURE

43. The Kailashanatha Temple of Ellora, India
44. The Western Group of Temples of Khajuraho, India
45. Angkor Wat, Cambodia
48. The Red Fort of Delhi, India
49. The Taj Mahal of Agra, India

THE SEVEN WONDERS OF ISLAMIC ARCHITECTURE

50. The Umayyad Mosque of Damascus, Syria
51. The Mezquita of Córdoba, Spain
55. The Registan of Samarkand, Uzbekistan

THE SEVEN WONDERS OF OTHER ASIAN ART AND ARCHITECTURE

57. The Citadel of Sigiriya, Sri Lanka
58. The Mogao Caves of Dunhuang, China
62. The Potala Palace of Lhasa, Tibet
63. The Temple of the Emerald Buddha of Bangkok, Thailand

THE SEVEN WONDERS OF THE MIDDLE AGES

64. Aachen Cathedral, Germany
65. The Bayeux Tapestry, Bayeux, France
69. The Cathedral of Our Lady of Chartres, France

THE SEVEN

71. The
72. The Leaning Tower of Pisa, Italy
73. The Duomo of Florence, Italy
74. Mal
75. The
76. The
77. The

78. Chambord Chateau, France
79. The Sultan Ahmed Mosque of Istanbul, Turkey
80. The Hieronymites Monastery of Lisbon, Portugal
83. Versailles Palace, France
84. Schönbrunn Palace of Vienna, Austria

85. The Clock Tower of Westminster, England
86. Neuschwanstein Castle, Germany
87. The Statue of Liberty of New York, United States
90. The Empire State Building of New York, United States
91. The Golden Gate Bridge of San Francisco, United States

92. Mount Rushmore, United States
93. The Gateway Arch of St Louis, United States
94. The Kennedy Space Center, United States
97. The Guggenheim Museum of Bilbao, Spain
98. The Burj Khalifa, United Arab Emirates

99. The Banaue Rice Terraces, Philippines
100. The Monasteries of Meteora, Greece
101. The Moai Statues of Easter Island, Chile
104. The Hoover Dam, United States
105. The Channel Tunnel, England/France

SEVEN

106. The Canals and Belfries of Bruges, Belgium
107. Český Krumlov, Czechia
108. The Walled City of Dubrovnik, Croatia
109. The Medina of Fès el Bali, Morocco
110. The Djemaa El-Fna of Marrakech, Morocco
111. The Old City of Sana'a, Yemen
112. Stone Town of Zanzibar, Tanzania

113. The Ghats of Varanasi, India
114. The Western Wall of Jerusalem, Israel
115. Mount Tai, China
116. The Mahabodhi Temple Complex at Bodh Gaya, India
117. The Church of the Holy Sepulchre of Jerusalem, Israel
118. Al-Aqsa and the Dome of the Rock of Jerusalem
119. The Golden Temple of Amritsar, India

120. The Museum of Egyptian Antiquities of Cairo, Egypt
121. The British Museum of London, England
122. The Louvre of Paris, France
123. The Uffizi Gallery of Florence, Italy
124. The Museo del Prado of Madrid, Spain
125. The Hermitage of St. Petersburg, Russia
126. The Pergamon Museum of Berlin, Germany

127. The Theater of Dionysus of Athens, Greece
128. The Teatro alla Scala of Milan, Italy
129. The Bolshoi Ballet of Moscow, Russia
130. The West End of London, England
131. The Musikverein of Vienna, Austria
132. The Mormon Tabernacle of Salt Lake City, United States
133. Stage 19 of the Paramount Lot of Hollywood, United States

134. Mount Wilson Observatory of Pasadena, United States
135. The Abbey of St Thomas of Brno, Czechia
136. The Curie Museum of Paris, France
137. Hutton's Unconformity at Siccar Point, Scotland
138. The Einsteinhaus of Bern, Switzerland
139. Trinity College of Cambridge, England
140. The House of Adam Smith of Kirkcaldy, Scotland

THE TEN WONDERS OF EARTH

141. Bryce Canyon, United States
142. Uluru, Australia
143. The Rock Formations of Cappadocia, Turkey
144. Monument Valley, United States
145. The Rock of Gibraltar
146. Carlsbad Caverns, United States
147. The Salar de Uyuni, Bolivia
148. The Giant's Causeway, Northern Ireland
149. The Karst Islands of Halong Bay, Vietnam
150. The Valley of the Li River, China

THE TEN WONDERS OF THE OCEAN

151. The Great Barrier Reef of Australia
152. The Mesoamerican Barrier Reef, Mexico/Belize/Honduras
153. The Reefs of Palau
154. The Bay of Fundy, Canada
155. The Island of Bora Bora, French Polynesia
156. The Pink Sands of Bermuda
157. The Bioluminescent Bay of Vieques, Puerto Rico
158. The Harbor of Rio de Janeiro, Brazil
159. Victoria Harbor of Hong Kong, China
160. The Cliffs of Moher, Ireland

THE TEN WONDERS OF FIRE

161. Yellowstone National Park, United States
162. The Volcanic and Geothermal Features of Iceland
163. Kilauea Volcano, United States
164. Krakatoa Island, Indonesia
165. Paricutin Volcano, Mexico
166. Mount Kilimanjaro, Tanzania
167. Mount Fuji, Japan
168. The Eternal Fires of Mount Chimaera, Turkey
169. Ngorongoro Crater, Tanzania
170. The Caldera of Santorini, Greece

THE TEN WONDERS OF ICE

171. The Aurora Borealis
172. Antarctica
173. Mount Everest, Nepal
174. Yosemite Valley, United States
175. Perito Moreno Glacier, Argentina
176. Banff National Park, Canada
177. The Fjords of Norway
178. The Torres de Paine, Chile
179. Milford Sound, New Zealand
180. The High Passes of Ladakh, India

THE TEN WONDERS OF WATER

181. The Dead Sea, Israel/Jordan/Palestine
182. Iguazú Falls, Brazil/Argentina
183. Victoria Falls, Zambia/Zimbabwe
184. Angel Falls, Venezuela
185. Niagara Falls, Canada/United States
186. The Grand Canyon of the Colorado, United States
187. The Middle Valley of the Rhine, Germany
188. Lake Bled, Slovenia
189. Lake Baikal, Russia
190. The Backwaters of Kerala, India

THE TEN WONDERS OF LIFE

191. The Amazon Rain Forest, Brazil
192. The Galapagos Islands, Ecuador
193. Okavango Delta, Botswana
194. The Monarch Butterfly Migration, Mexico
195. The Serengeti Migration, Tanzania
196. Corcovado National Park, Costa Rica
197. Kruger National Park, South Africa
198. Bwindi Impenetrable National Park, Uganda
199. Wolong National Nature Reserve, China
200. The General Sherman Tree, United States

Nearly 25 years ago, at the dawn of this millennium, the National Academy of Engineering named **Electrification as the greatest engineering achievement of the 20th century**.

Today's T&D system is a massive, complex array of interconnected devices and wires, governed by a no less complex set of policies, statutes, and regulations overseen by myriad stakeholders with diverse interests…

…hence, by the power vested in me as the moderator of this panel, I propose that we put a stake in the ground and lay claim to the **worldwide network of T&D lines** as the **8th Wonder of the World** (everything else can shift by one to make room).

TOP 10 MOST CHALLENGING ISSUES FACING OUR INDUSTRY

(BASED ON THE LAST 10 EDITIONS OF BLACK & VEATCH'S ELECTRIC REPORT)PANELISTS

Issue	2013	2014	2015	2016	2017	2018	2019	2020	2021/2022	2023
#1	Reliability	Reliability	Aging infrastructure	Reliability	Reliability	Reliability	Aging Infrastructure	Aging infrastructure	Renewable integration	Renewable integration
#2	Environmental regulation	Environmental regulation	Reliability	Cybersecurity	Cybersecurity	Cybersecurity	Renewables	Renewables	Cybersecurity	Aging infrastructure
#3	Economic regulation	Economic regulation	Environmental regulation	Environmental regulation	Long-term investment	Aging infrastructure	Aging workforce	Aging workforce	Aging infrastructure	Environmental regulation
#4	Aging infrastructure	Cybersecurity	Cybersecurity	Aging infrastructure	Aging infrastructure	Long-term investment	Environmental regulation	Distribution system upgrade & modernization	Planning / forecasting uncertainty	Planning / forecasting uncertainty
#5	Long-term investment	Natural gas prices	Aging workforce	Long-term investment	Environmental regulation	Physical security	Cybersecurity	Environmental regulation	Aging workforce	Distribution system upgrade & modernization
#6	Cybersecurity	Long-term investment	Economic regulation	Economic regulation	Emerging technology	*NP	Energy storage	Cybersecurity	Lack of skilled workforce	Lack of skilled workforce
#7	Natural gas prices	Aging infrastructure	Emerging technology	Aging workforce	Economic regulation	*NP	Economic regulation	Energy storage	Environmental regulation	Reliability
#8	Technology	Physical security	Natural gas prices	Natural gas prices	Physical security	*NP	Distributed energy resources	Economic regulation	Reliability	Aging workforce
#9	Fuel policy	Natural gas fuel supply reliability	Long-term investment	Emerging technology	Market structure	*NP	Reliability	Distributed energy resources	Distribution system upgrade & modernization	Economic regulation
#10	Physical security	Fuel policy	Market structure	Physical security	Aging workforce	*NP	Market structure	Reliability	Distributed energy resources (DER) integration	Distributed energy resources (DER) integration

*NP= Not provided

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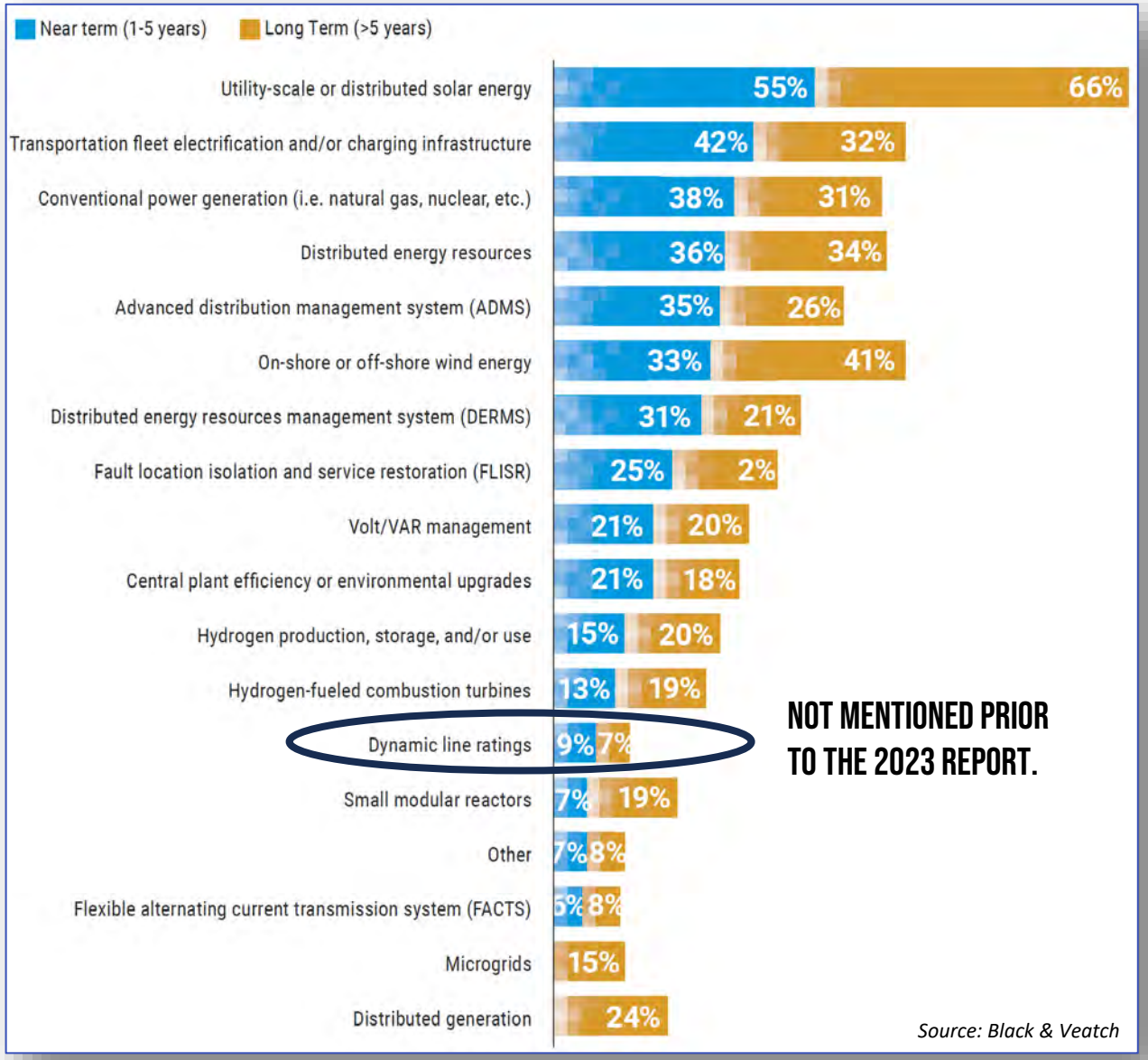
PLANNED TECHNOLOGY INVESTMENTS: NEAR & LONG-TERM



NOT MENTIONED PRIOR TO THE 2023 REPORT.

Source: Black & Veatch

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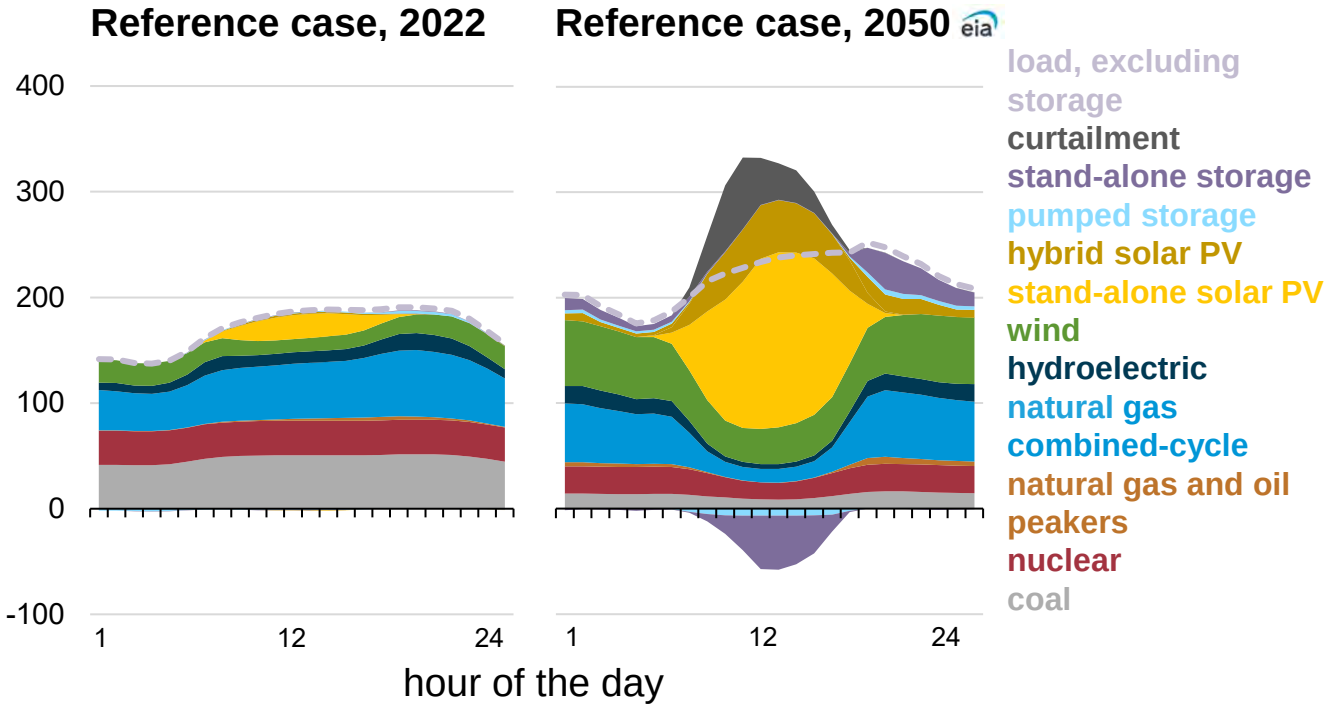
IT'S NOT AS SIMPLE AS BUILDING SOLAR AND WIND FARMS

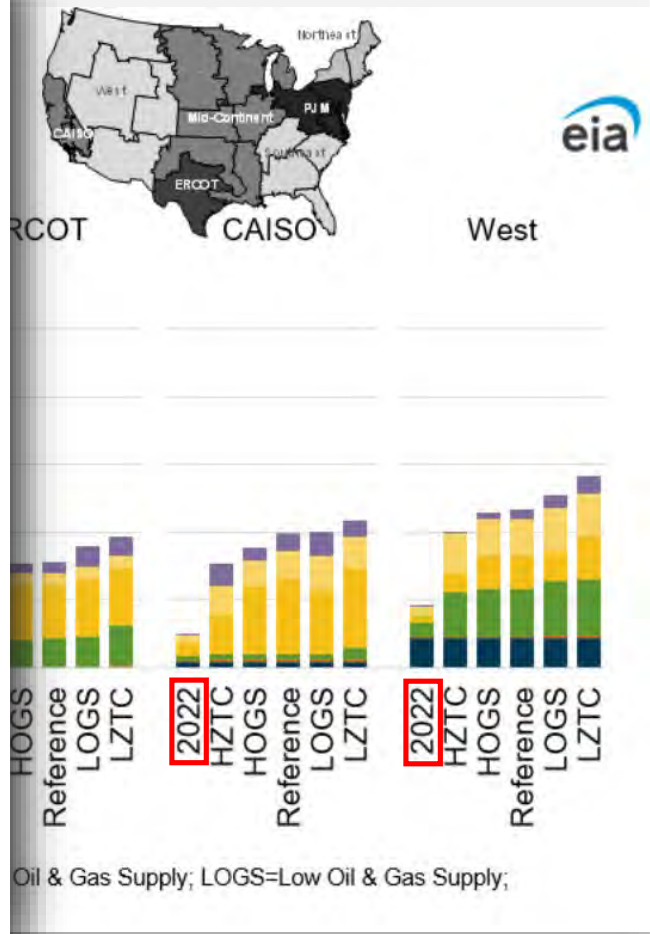
Hourly U.S. electricity generation and load by fuel for selected cases and representative years

billion kilowatthours



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)

Note: Negative generation represents charging of energy storage technologies such as pumped hydro and battery storage. Hourly dispatch estimates are illustrative and are developed to determine curtailment and storage operations; final dispatch estimates are developed separately and may differ from total utilization as this figure shows. Standalone solar photovoltaic (PV) includes both utility-scale and end-use PV electricity generation.



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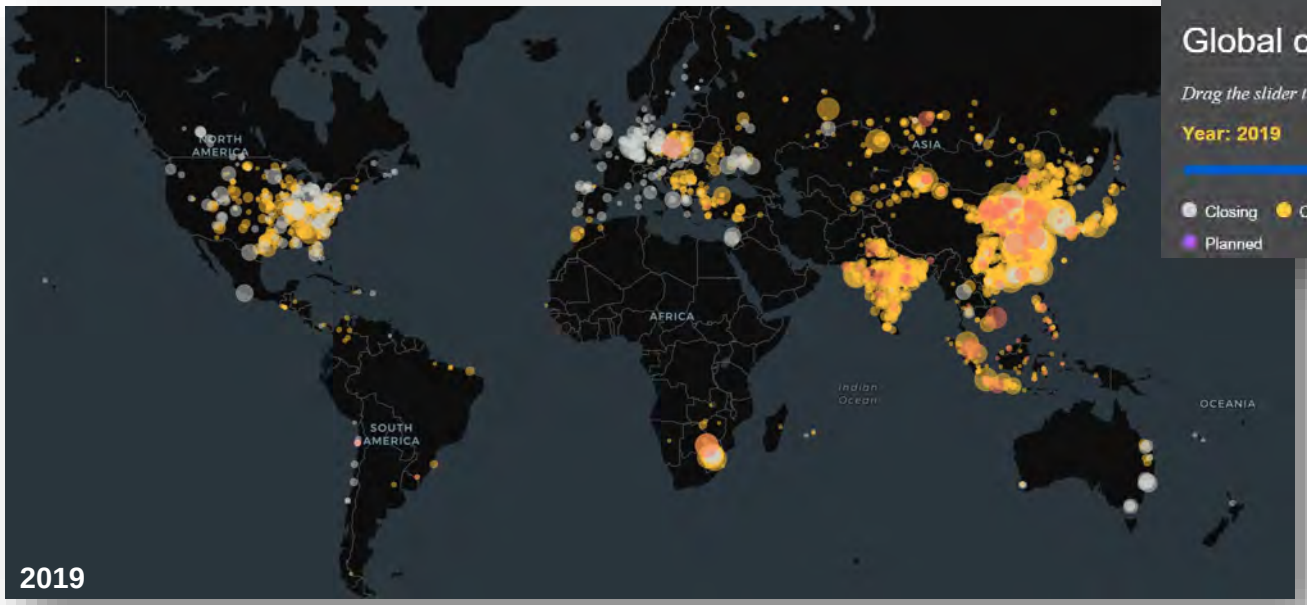
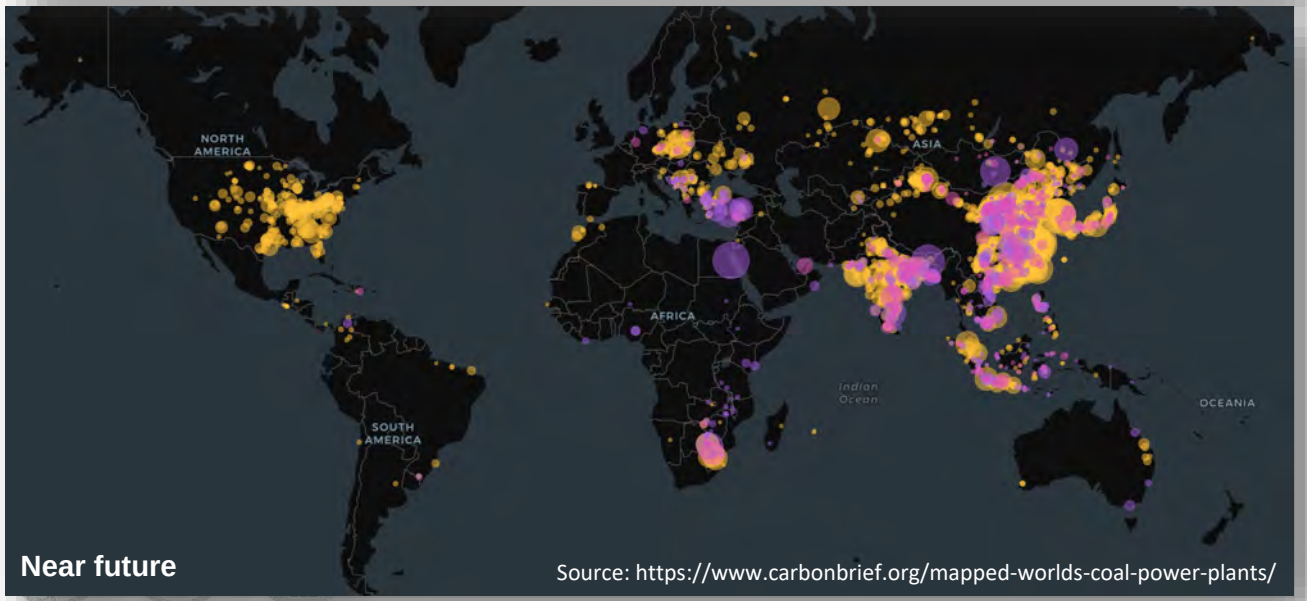
HOW'S THE WORLD DOING WITH CLIMATE TARGETS?

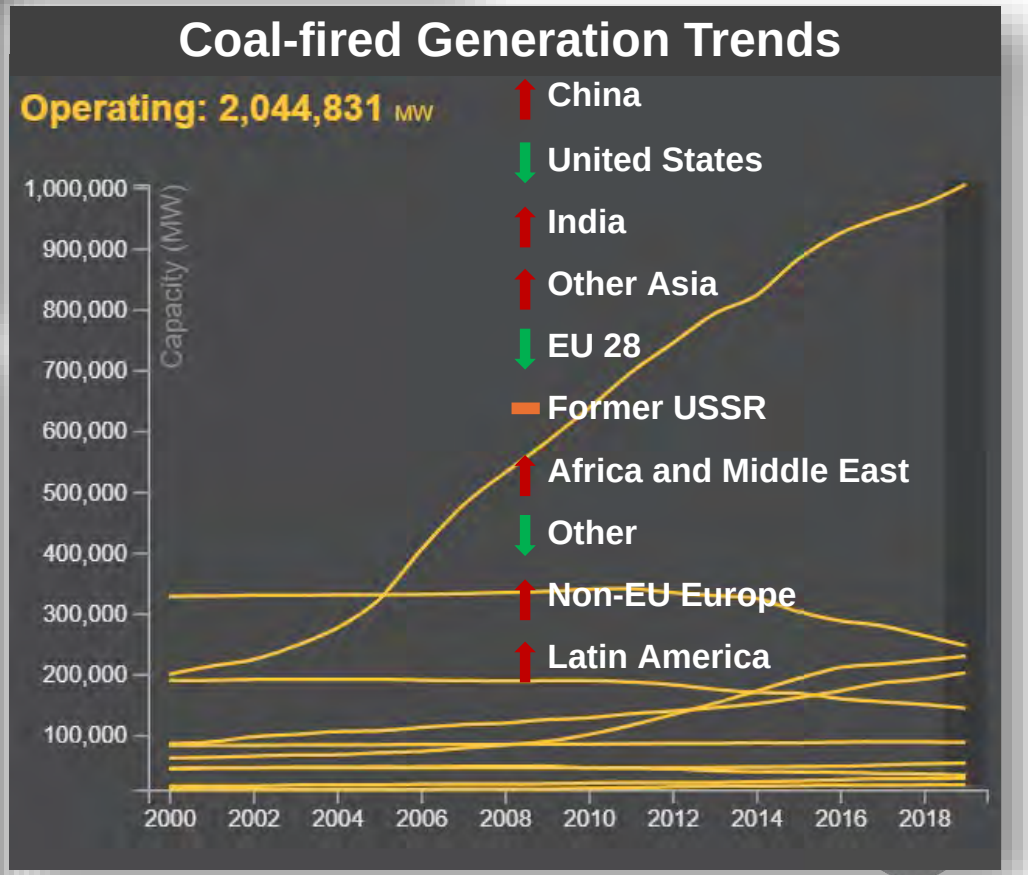


2019



Near future

Source: https://www.carbonbrief.org/mapped-worlds-coal-power-plants/



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ASCE REPORT CARD – AMERICA'S INFRASTRUCTURE (2021 (QUADRENNIAL))

ASCE found:

- Aggregate grade = **C-**
- Cost to improve **ALL** infrastructure to good condition from 2021 to 2029?
  - **Needed: $5.94 trillion**
  - **Funded: $3.35 trillion**
  - **Gap: $2.59 trillion**

How about the **ELECTRIC UTILITY INDUSTRY**?

At present, the projected cumulative investment **gap** between 2021 and 2029 for maintaining and improving existing T&D infrastructure (and similar generation activities) is estimated to be...

$197 billion

Category	2001	2005	2009	2013	2017	2021
Aviation	D	D+	D	D	D	D+
Bridges	C	C	C	C+	C+	C
Dams	D	D+	D	D	D	D
Drinking Water	D	D-	D-	D	D	C-
Energy						
Hazardous Waste	D+	D	D	D	D+	D+
Inland Waterways	D+	D-	D-	D-	D	D+
Levees	-	-	D-	D-	D	D
Public Parks and Recreation	-	C-	C-	C-	D+	D+
Rail	-	C-	C-	C+	B	B
Roads	D+	D	D-	D	D	D
Schools	D-	D	D	D	D+	D+
Solid Waste	C+	C+	C+	B-	C+	C+
Transit	C-	D+	D	D	D-	D-
Wastewater	D	D-	D-	D	D+	D+
Ports	-	-	-	C	C+	B-
America's Infrastructure GPA	D+	D	D	D+	D+	C-

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HOW MUCH TRANSMISSION INFRASTRUCTURE IS NEEDED WORLDWIDE TO SUPPORT CLIMATE TARGETS AND ENERGY SECURITY TARGETS?

iea 50 Energy system Topics Countries Data Reports

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CLEAN ENERGY

The world has to add or replace 50 million miles of transmission lines by 2040, IEA says

PUBLISHED TUE, OCT 17 2023·5:13 PM EDT

Catherine Clifford
@IN/CATCLIFFORD/
@CATCLIFFORD

SHARE

Efforts to tackle climate change and ensure reliable supplies of electricity could be put at risk unless policy makers and companies quickly take action to improve and expand the world's electricity grids, according to a special report released today by the IEA.

IEA = International Energy Association

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CURRENT STATE: AN UNPRECEDENTED RATE OF CHANGE

Administrator's Foreword

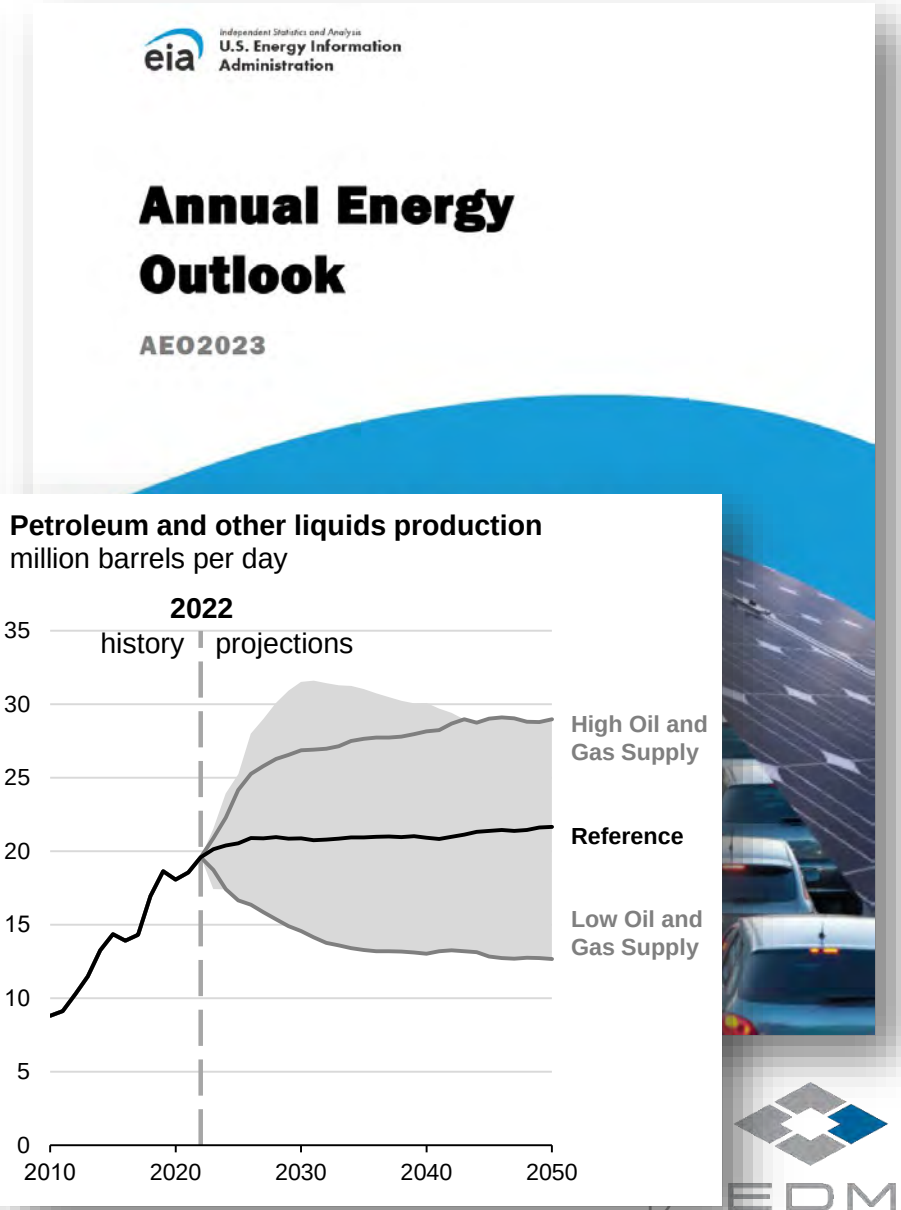
"The U.S. energy system is rapidly changing. In recent years, technology innovation has accelerated the deployment of renewable energy, expanded markets for electric vehicles, and established record-high levels of petroleum and natural gas production. Heightened geopolitical risks have also influenced the energy system. And this year, recent federal legislation authorizes historic levels of investment in clean energy technology."

"Ideally, we would model these dynamics to produce precise numerical forecasts that demonstrate how energy prices, technology deployment, and emissions will shift over time. Unfortunately, such precise forecasts are not possible. The 30-year decision landscape we model is too complex and uncertain. Thus, our objective must be to identify robust insights rather than precise numbers—think ranges and trends, not predictions and point estimates."

"The AEO includes a series of projections—which we refer to as *cases*...The Reference case represents our best guess under nominal conditions, which presumes no new policy or laws over the modeled time horizon. … For some readers, this approach may be unsatisfying because policy rarely remains static for long periods."

"Visualizing uncertainty

…So, in each of the figures in this report, you will see shaded areas that represent the range of results .. a cone of uncertainty'



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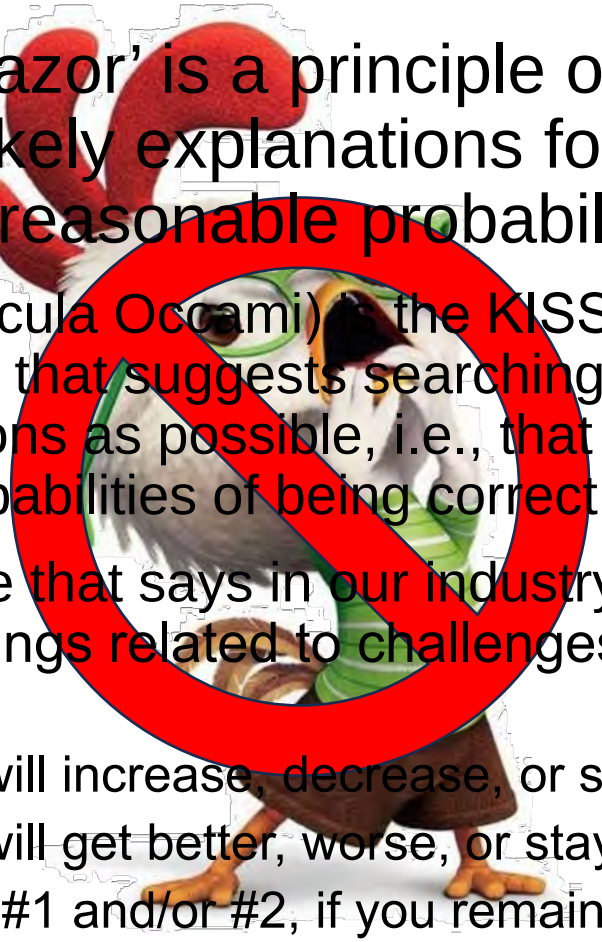
CLOSING THOUGHTS 😉

Razor: In philosophy a 'razor' is a principle or rule of thumb applied to 'shave off' unlikely explanations for a phenomenon and make best guesses with reasonable probabilities of being correct.



- ***Occam's Razor*** (Latin: novacula Occami) is the KISS principle applied to problem-solving. It that suggests searching for explanations based on as few considerations as possible, i.e., that overly complex explanations have lower probabilities of being correct.
- ***Andy's Razor*** is the principle that says in our industry (and much of life) that there are three things related to challenges and change you can count on:
  1. _____(fill in the blank) will increase, decrease, or stay about the same.
  2. _____(fill in the blank) will get better, worse, or stay about the same.
  3. Regardless of the trends in #1 and/or #2, if you remain curious and creative most challenges and changes transform into opportunities.

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PANEL DISCUSSION:
THANK YOU !
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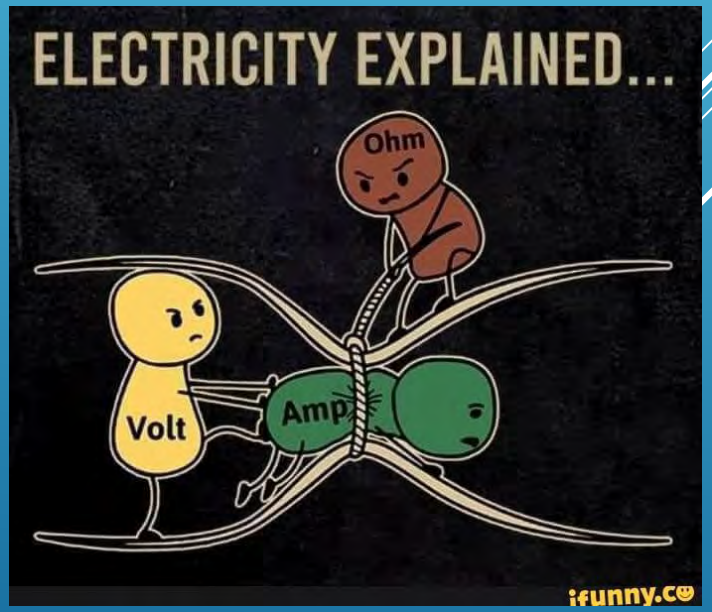
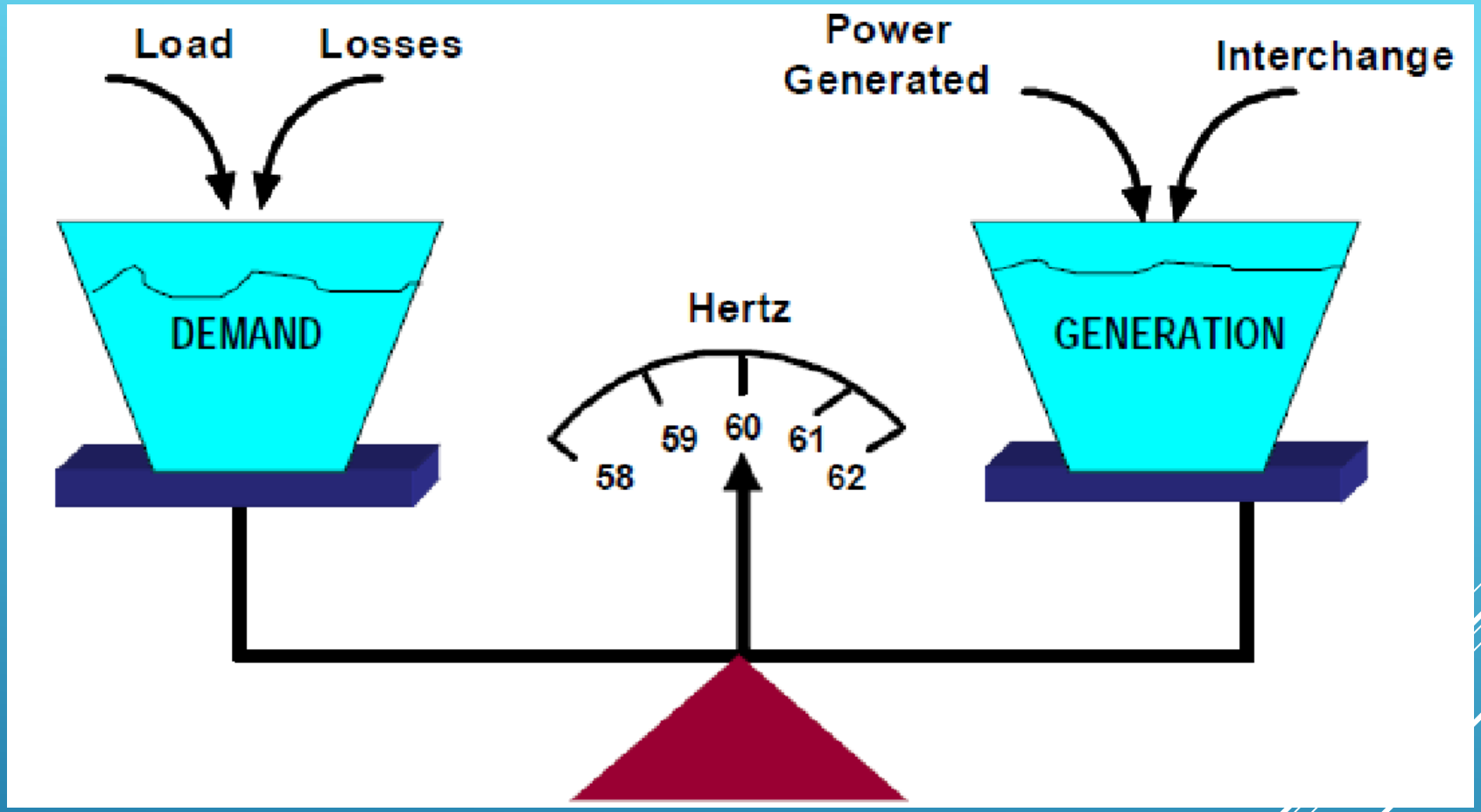
Panel Discussion - Jesse Parker

CHALLENGES AND OPPORTUNITIES WITH THE BULK ELECTRIC SYSTEM (TRANSMISSION)

- Managing Frequency
- Changes in Generation Mix and Fuel Diversity





MANAGING FREQUENCY

Western Interconnection Balancing Authorities (38)

AESO - Alberta Electric System Operator
AVA - Avista Corporation
AZPS - Arizona Public Service Company
BANC - Balancing Authority of Northern California
BCHA - British Columbia Hydro Authority
BPAT - Bonneville Power Administration - Transmission
CFE - Comision Federal de Electricidad
CHPD - PUD No. 1 of Chelan County
CISO - California Independent System Operator
DEAA - Arlington Valley, LLC
DOPD - PUD No. 1 of Douglas County
EPE - El Paso Electric Company
GCPD - PUD No. 2 of Grant County
GRID - Gridforce
GRIF - Griffith Energy, LLC
GRMA - Sun Devil Power Holdings, LLC
GWA - NaturEner Power Watch, LLC
HGMA - New Harquahala Generating Company, LLC
IID - Imperial Irrigation District
IPCO - Idaho Power Company
LDWP - Los Angeles Department of Water and Power
NEVP - Nevada Power Company
NWMT - NorthWestern Energy
PACE - PacifiCorp East
PACW - PacifiCorp West
PGE - Portland General Electric Company
PNM - Public Service Company of New Mexico
PSCO - Public Service Company of Colorado
PSEI - Puget Sound Energy
SCL - Seattle City Light
SRP - Salt River Project
TEPC - Tucson Electric Power Company
TIDC - Turlock Irrigation District
TPWR - City of Tacoma, Department of Public Utilities
WACM - Western Area Power Administration, Colorado-Missouri Region
WALC - Western Area Power Administration, Lower Colorado Region
WAUW - Western Area Power Administration, Upper Great Plains West
WWA - NaturEner Wind Watch, LLC

MANAGING FREQUENCY

- Desired Frequency Range:
  - 59.932 – 60.068
- Under Frequency Load Shedding: Around 59.3-59.5
- Under Frequency Generation Tripping: 59.5 and lower (next slide)

https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/NERC_IRPTF_PRC-024-2_Gaps_Whitepaper_FINAL_CLEAN.pdf

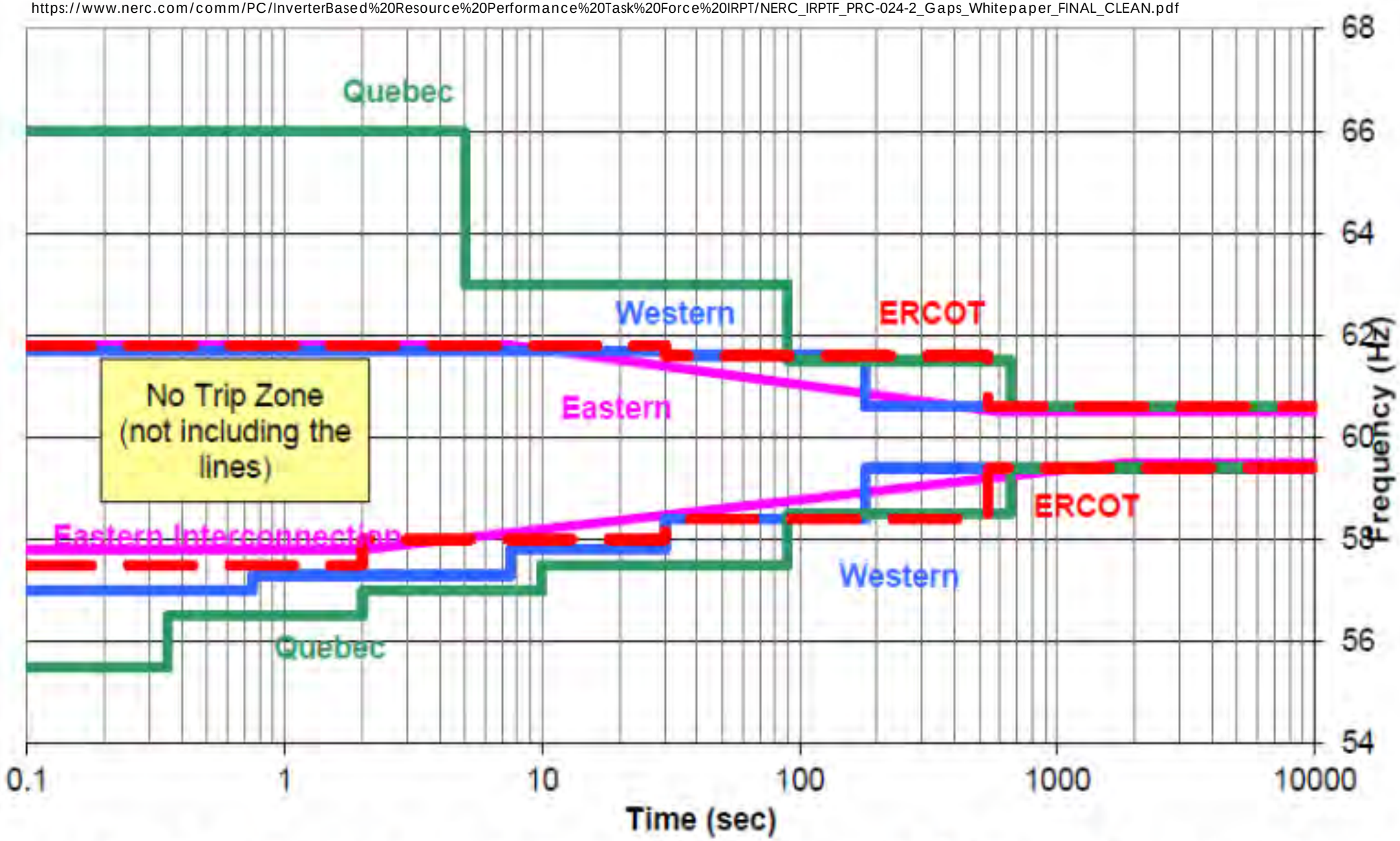
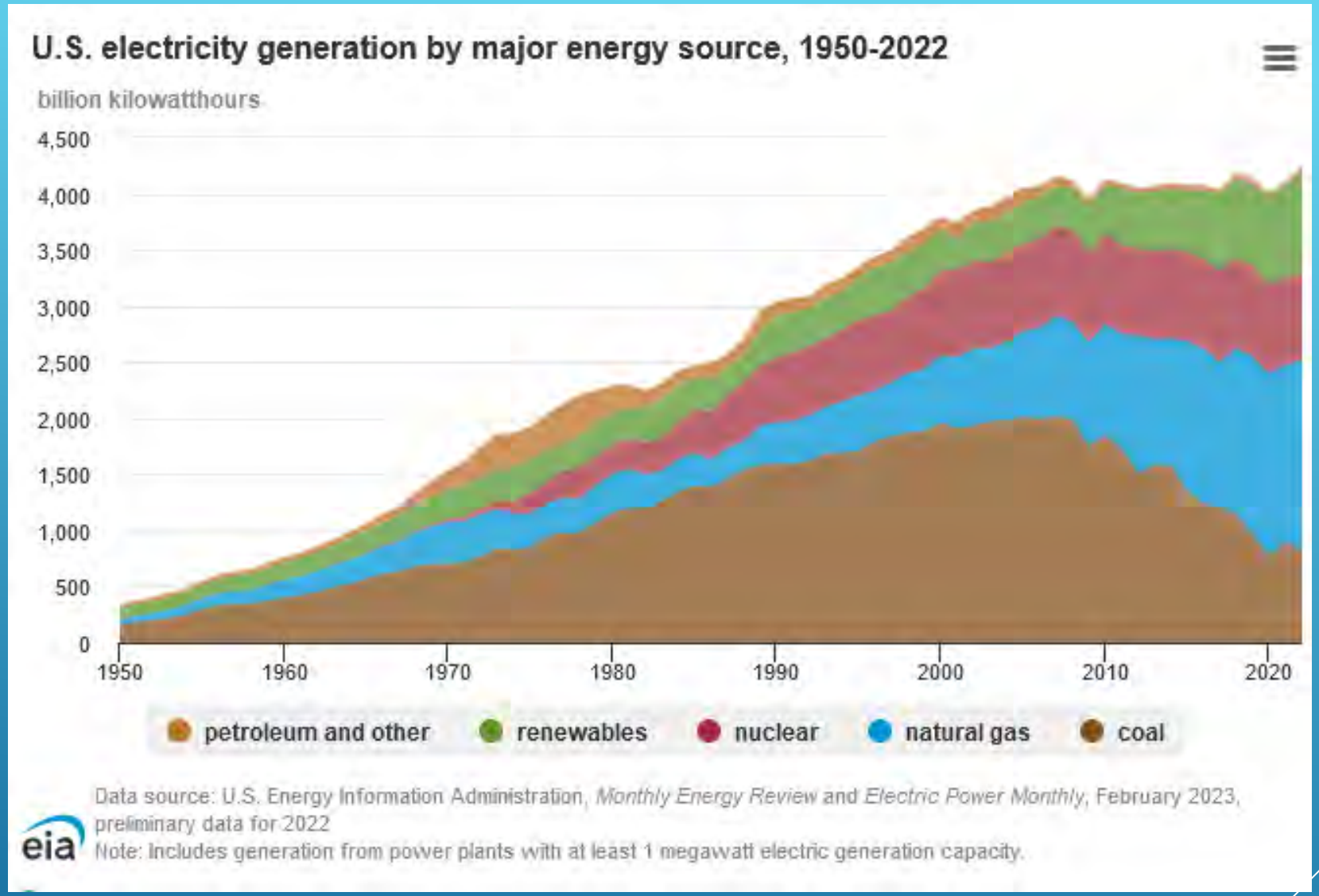
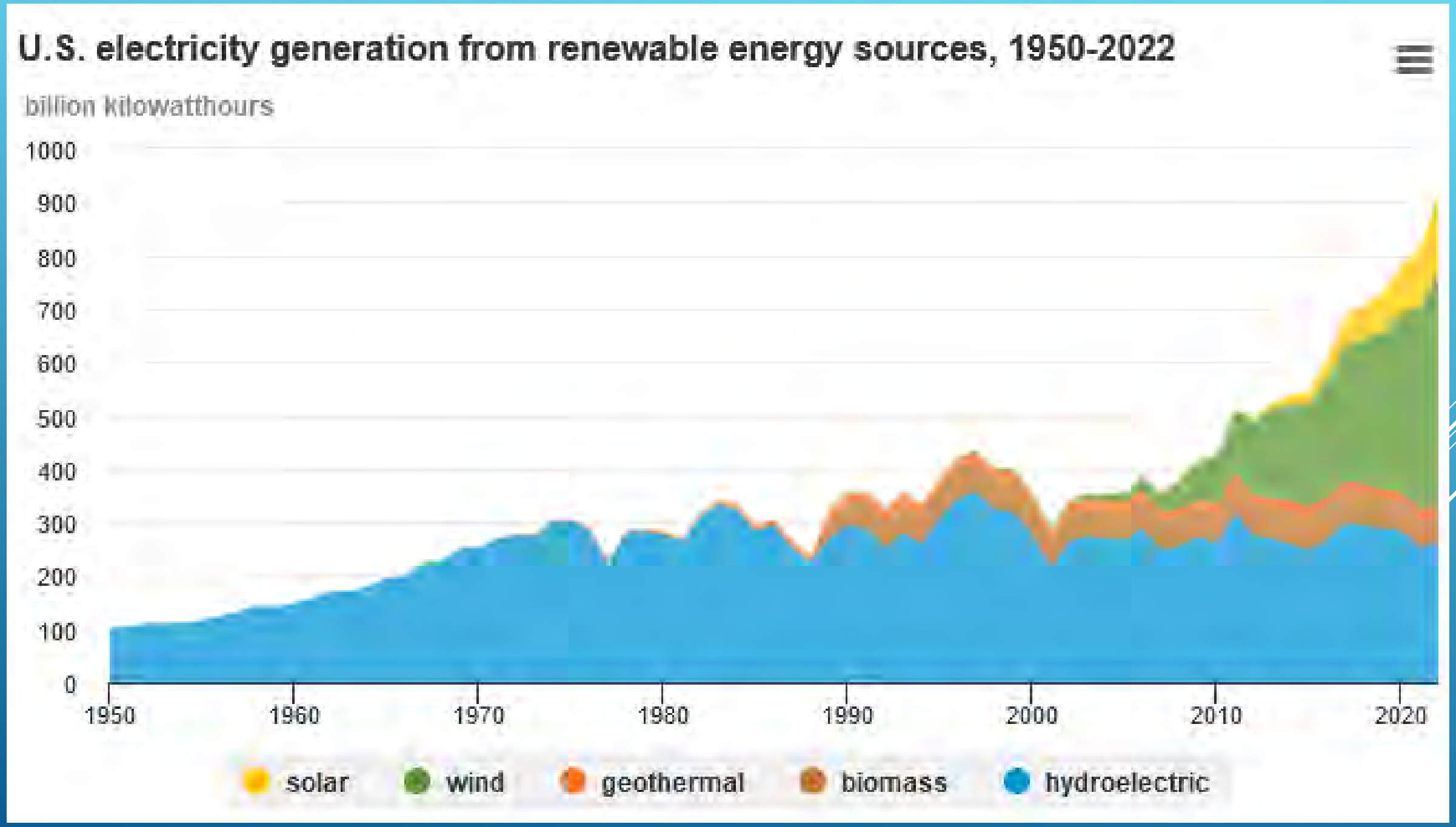


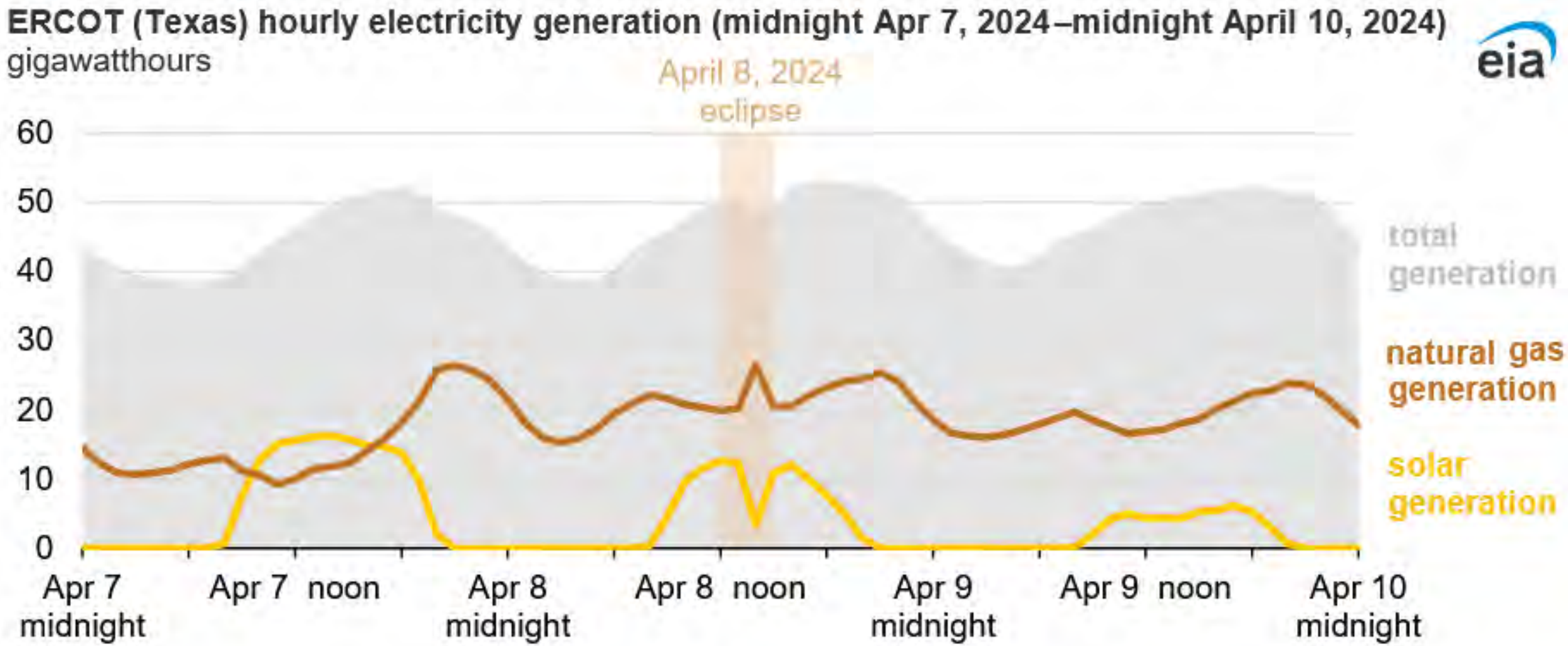
Figure 1: PRC-024-2 Frequency Ride-Through Curve



CHANGING GENERATION MIX


U.S. electricity generation from renewable energy sources, 1950-2022
billion kilowatthours
1000
900
800
700
600
500
400
300
200
100
0
1950
1960
1970
1980
1990
2000
2010
2020
solar
wind
geothermal
biomass
hydroelectric

Natural gas filled in most of the drop in solar generation in Texas during April 8 eclipse



Data source: U.S. Energy Information Administration, *Hourly Electric Grid Monitor*

THANK YOU

SAN LUIS VALLEY REC
A Powerful Connection
ciello

PANEL DISCUSSION:

ISSUES & CHALLENGES SHAPING OUR INDUSTRY

2024 INTERNATIONAL CONFERENCE ON OVERHEAD LINES

Presented by Eric Eriksen

Shocking Truth: ***The World is Changing Around Us***

Shocking Truth: ***We have Legacy Challenges***

Aging Infrastructure
Rate Pressure
Regulations

"The way we've always done it."

Path Forward: ***Strategic Planning***

1. **DEFINE** – objectives
2. **MEASURE** – current state
3. **ANALYZE** – data, rank solutions
4. **IMPROVE** – future state
5. **CONTROL** – evaluate and correct

Path Forward: ***Improve Productivity***

1. **Workforce Development**
2. **Process Improvement**
3. **Technology**

Path Forward: ***Get Comfortable with Data***

DATA-DRIVEN COMPANIES:

- 88% believe data analytics will transform their business.
- 162% more likely to significantly outperform laggers.
- 68% of available data goes unused.

Sources: MIT Technology Review 2021, Foundry Study 2022

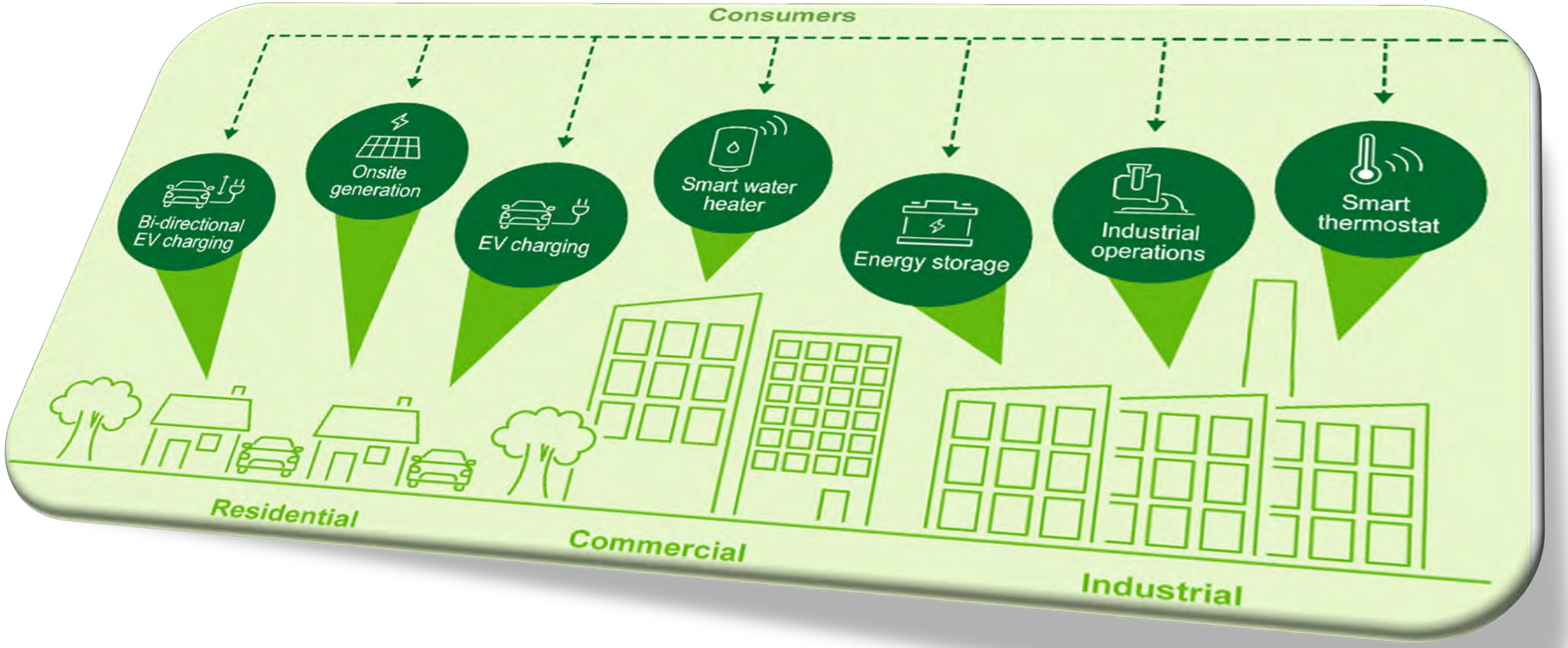
“Data is the key to better, faster decisions.”

SAN LUIS VALLEY REC
A Powerful Connection
ciello

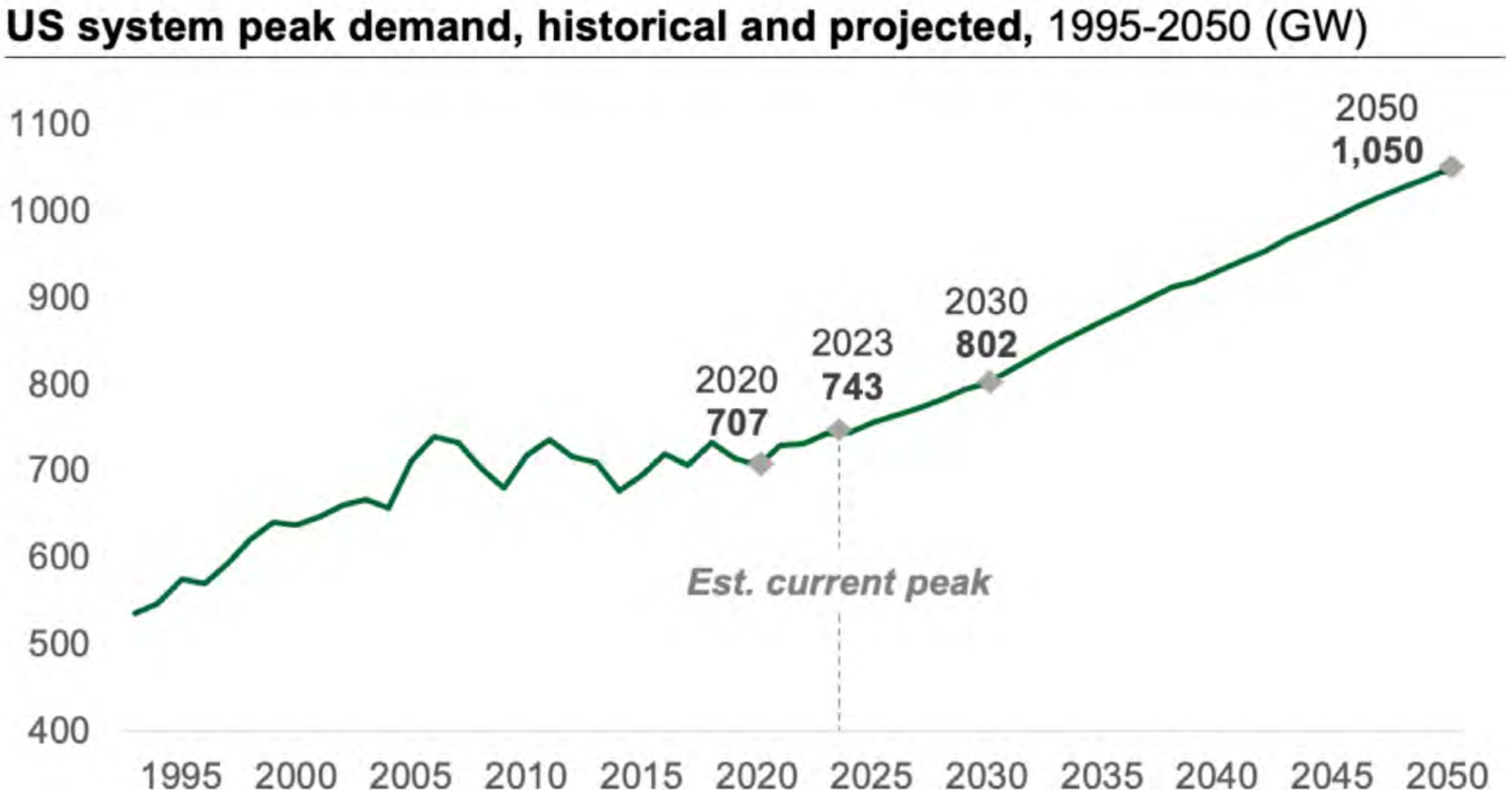
Thank You!

PANEL DISCUSSION: ISSUES & CHALLENGES SHAPING OUR INDUSTRY – THE CUSTOMER AND FUTURE GRID

2024 INTERNATIONAL CONFERENCE ON OVERHEAD LINES, APRIL 15, 2024, NADIA EL MALLAKH



Increased Electric Demand Is Here and More Is Coming



Source: US Dept. of Energy, “Pathways to Commercial Liftoff: Virtual Power Plants,” Sept. 2023

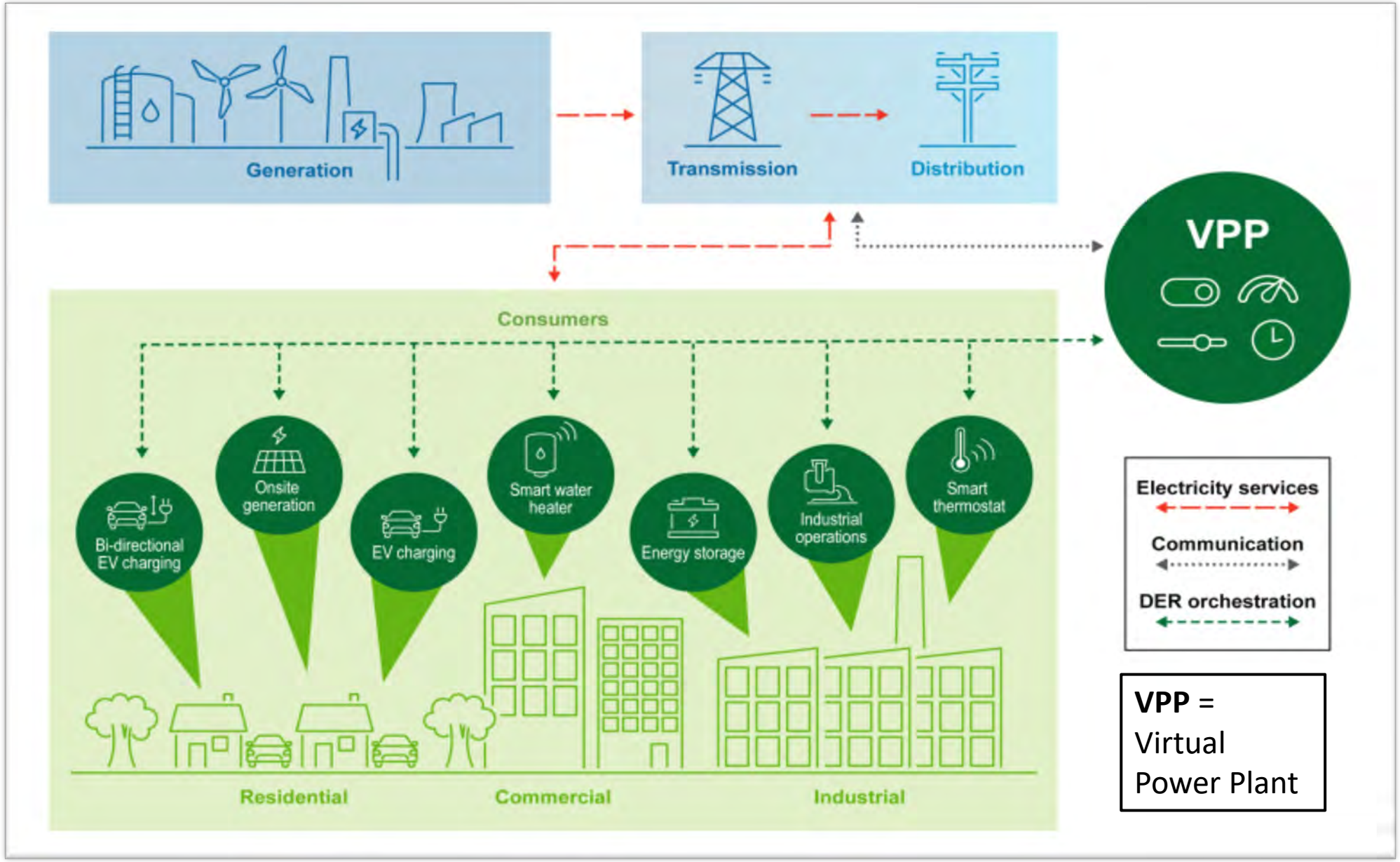
Electric Vehicles (EV) - One Key Driver

2024 Trends

- EV sale growth will continue, although with some bumps
- Grid constraints will impact Medium and Heavy Duty (M/HDV) charging interconnections
- Battery technology (e.g., solid-state) will continue to develop

Source of diagram: [EV Infrastructure: How to Start & How to Expand - Green Fleet - Government Fleet (government-fleet.com)]

Integration of Distributed Energy Resources and Grid Impacts



But, the infrastructure will not be virtual!

Source: US Dept. of Energy, "Pathways to Commercial Liftoff: Virtual Power Plants," Sept. 2023

Will the VPP Value Proposition Become Real And Scalable?

VPP value proposition

Resource adequacy	Affordability	Reliability & resilience	Decarbonization & air pollution reduction	T & D infrastructure relief	Community empowerment	Versatility & flexibility
• Integrate distributed generation and storage capacity • Shift demand to follow supply	• Defer grid capex (generation, T & D) • Avoid fuel costs • Compensate consumers and businesses	• Integrate back-up power • Eliminate single-point-of-failure	• Add distributed renewable generation • Reduce curtailment of renewables • Reduce reliance on fossil fuels	• Increase efficiency by smoothing peaks • Alleviate congestion with local dispatch	• Enable consumers to optimize energy cost, use, and source • Retain and create good jobs	• Customize design to fit grid needs • Reconfigure as needs evolve

Source: US Dept. of Energy, "Pathways to Commercial Liftoff: Virtual Power Plants," Sept. 2023

Customer Behavior?

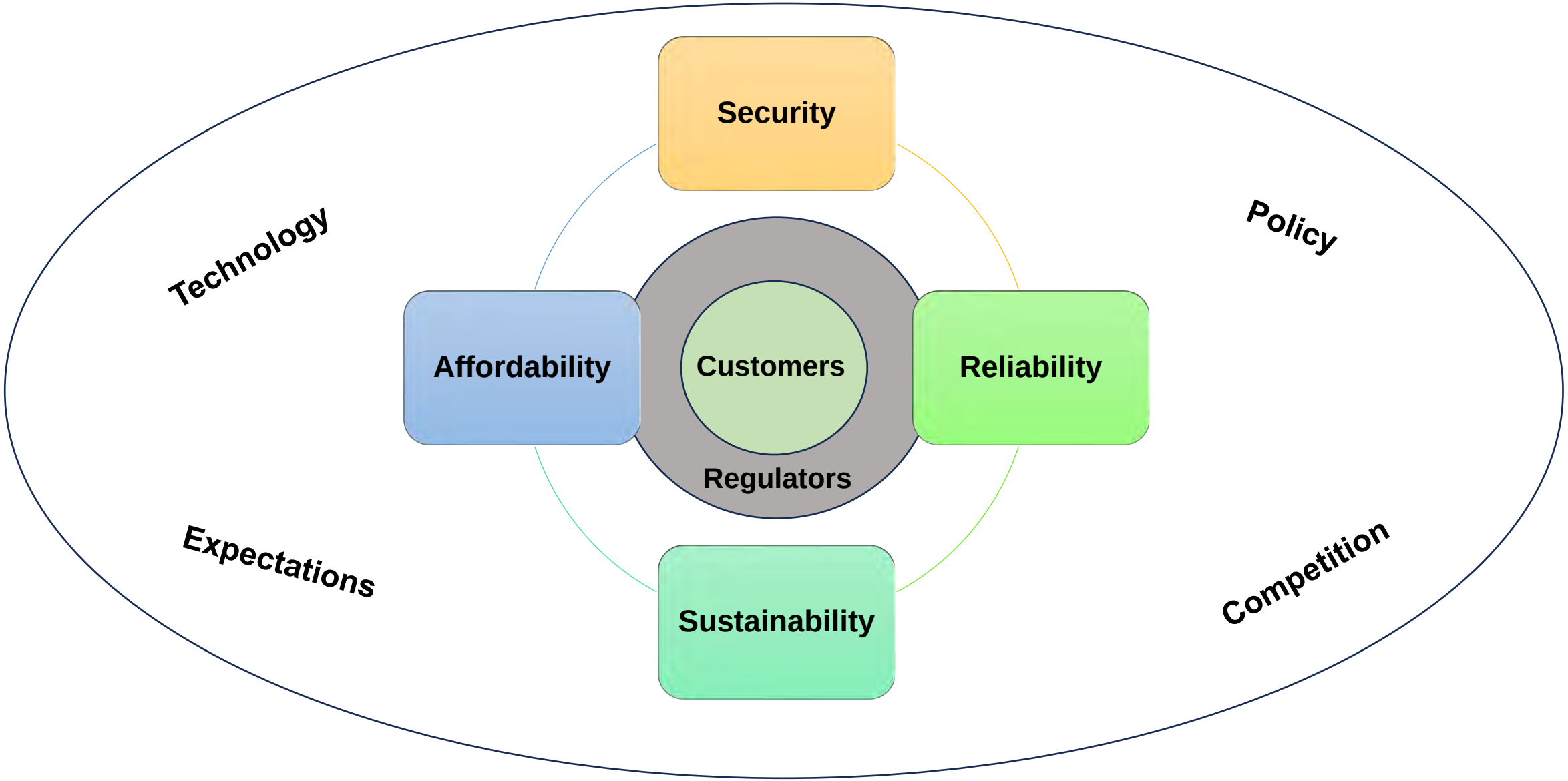
Technology Integration?

Timing Mismatch?

Reliability?

Workable Economics?

Customer + Regulators' Roles Are Dynamic and Impacts the Grid



Colorado Power Pathway

0 to 600 Miles in 7 Years Flat

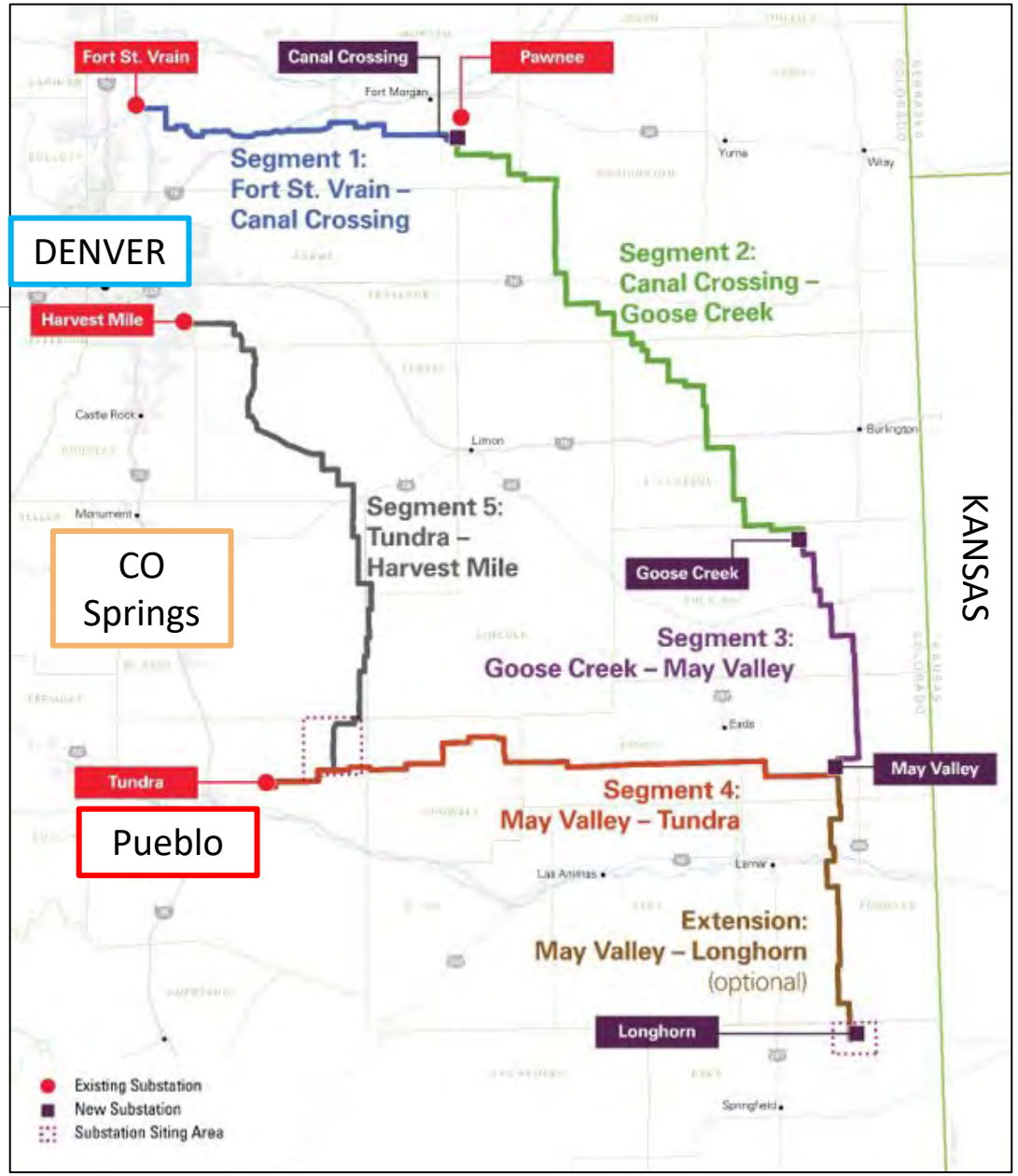
PARKER WROZEK, TRANSMISSION LINE ENGINEERING MANAGER

JOSH PETERSON, PRINCIPAL TRANSMISSION LINE ENGINEER

Xcel Energy®

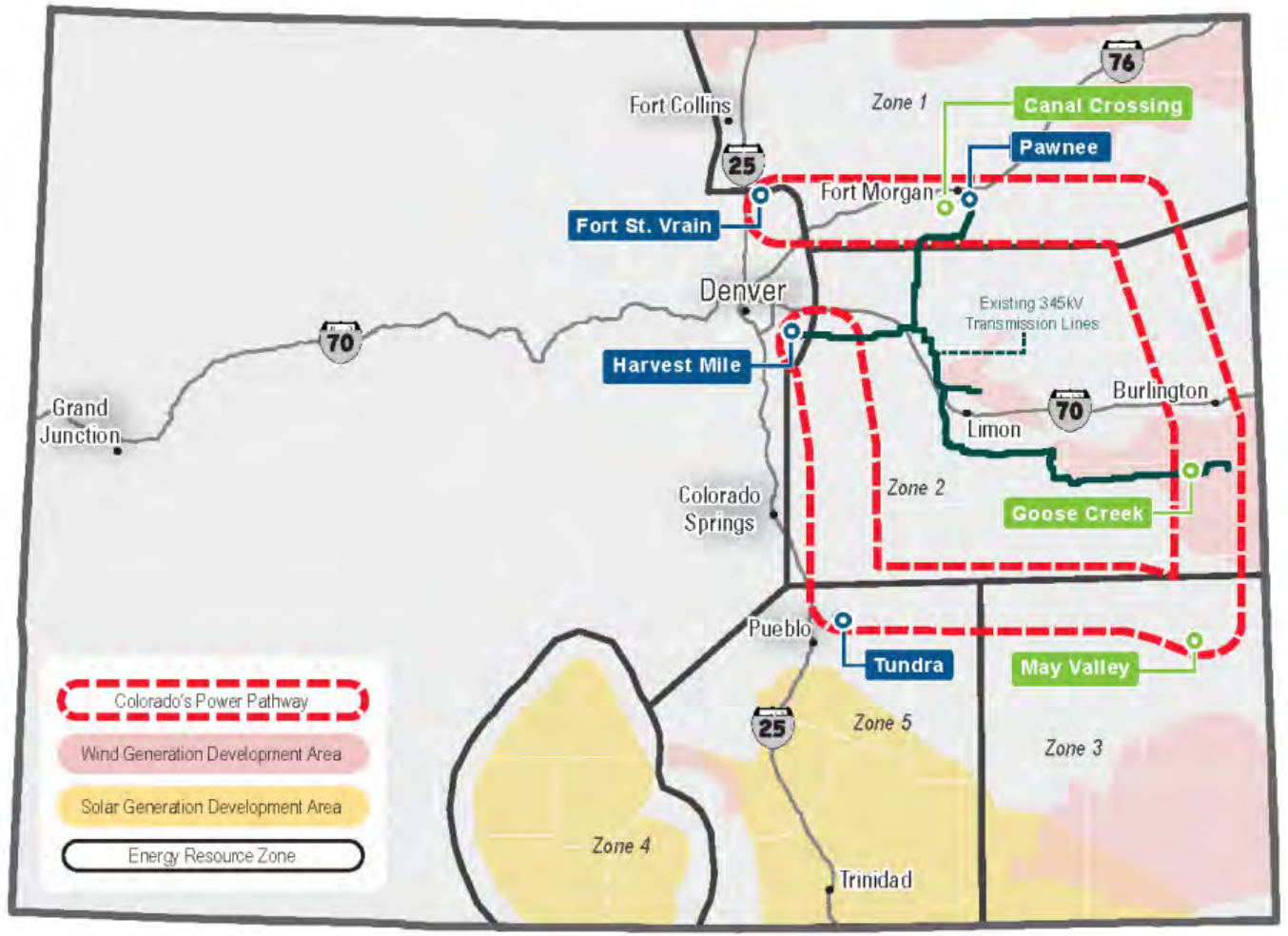
What is the CO Power Pathway?

- 600 Mile Double Circuit 345kV Transmission Line
- 4 New Substations, 3 Upgraded Substations
- $2 Billion
- Network Loop in Eastern Colorado
- Integrate 4000 MW of renewable energy
- 6 Total Transmission Line Segments

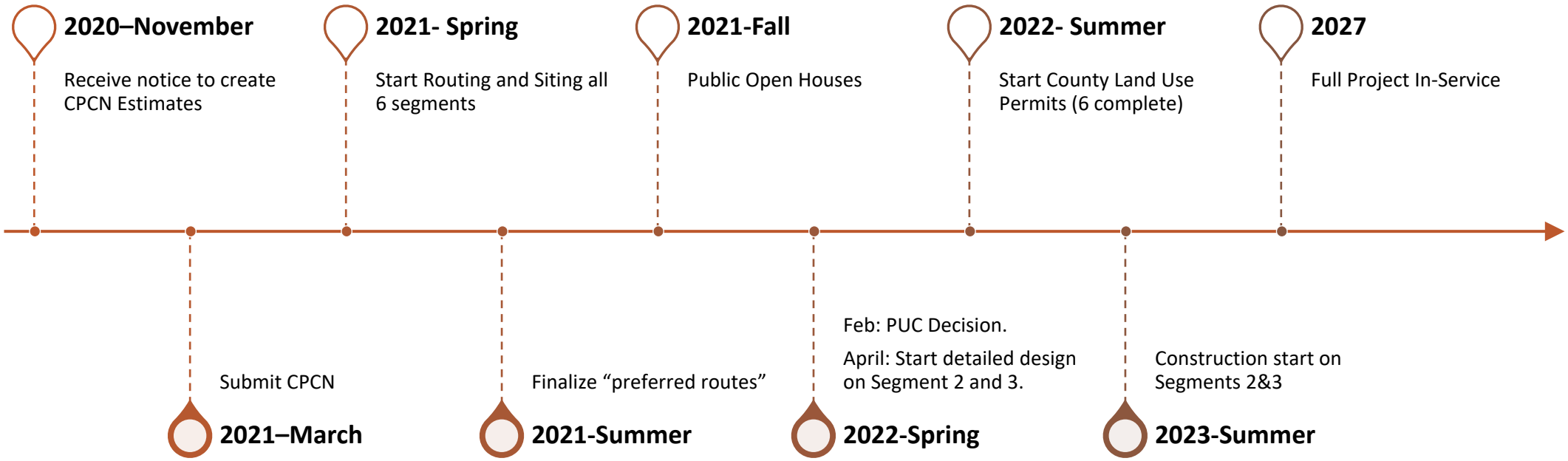


Why Build the Pathway?

- HB19-1261 was passed and signed into law
- It requires all utilities in Colorado to reach an 80% reduction in greenhouse gas emissions by 2030
- The eastern area of Colorado is wind and solar dense
- Numerous solar and wind projects have been locked out of the grid due to a weak system
- Pathway becomes the high voltage highway to bring these resources onto the grid, deliver it to the load centers, and meet company and State greenhouse gas reduction goals.



Schedule


2020–November
Receive notice to create CPCN Estimates
2021–March
Submit CPCN
2021- Spring
Start Routing and Siting all 6 segments
2021-Summer
Finalize “preferred routes”
2021-Fall
Public Open Houses
2022-Spring
Feb: PUC Decision.
April: Start detailed design on Segment 2 and 3.
2022- Summer
Start County Land Use Permits (6 complete)
2023-Summer
Construction start on Segments 2&3
2027
Full Project In-Service

Public Utility Commision Process and Decision

After filing, an intense period of discovery occurred, Xcel fielded roughly 1000 discovery questions in 2 months

Interveners filed testimony in support or opposition of the project

Xcel files rebuttal testimony to address concerns of interveners

Three-day hearing with the PUC commissioners

PUC determined the project was in the public interest, Certificate of Public Convenience and Necessity (CPCN) – June 2021

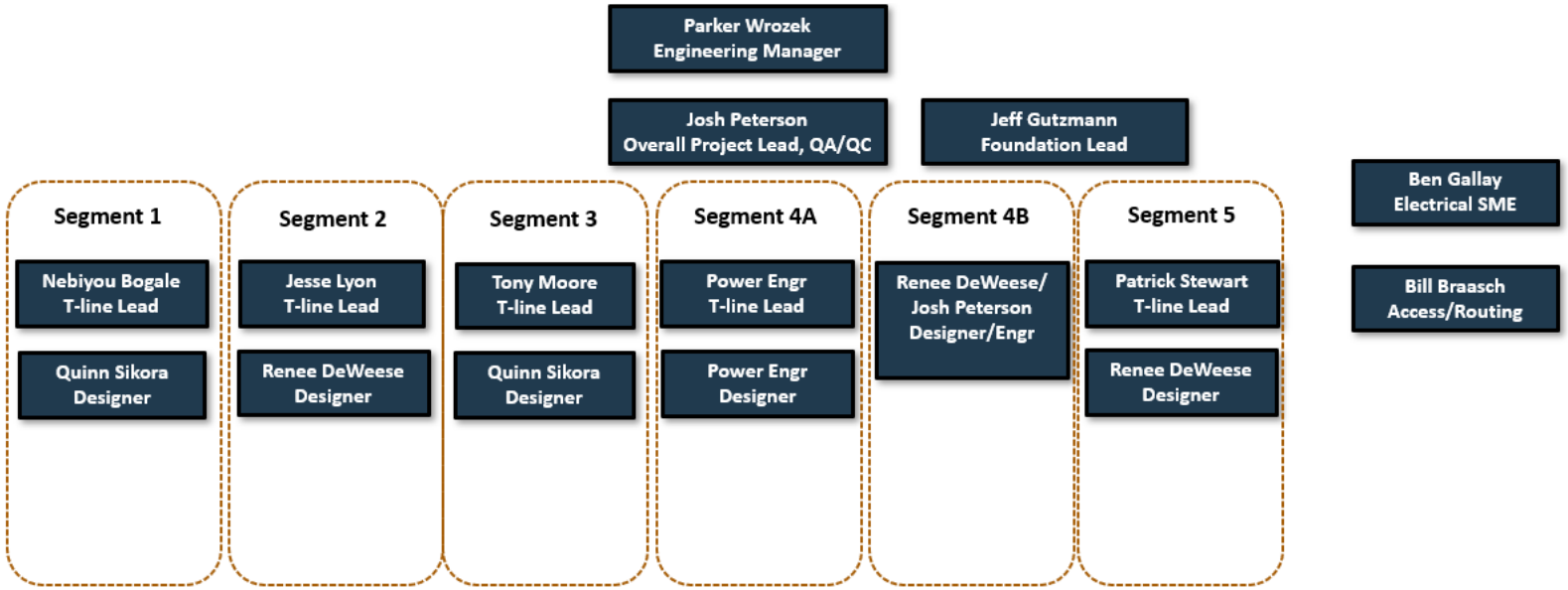
Segment 6 was given conditional approval pending 2022 Energy Resource Plan (ERP) results (currently not approved)

Performance Incentive Mechanisms (PIMs) put in place

Carbon Core Study Required – Determined ACSR Bittern best Net Present Value cost

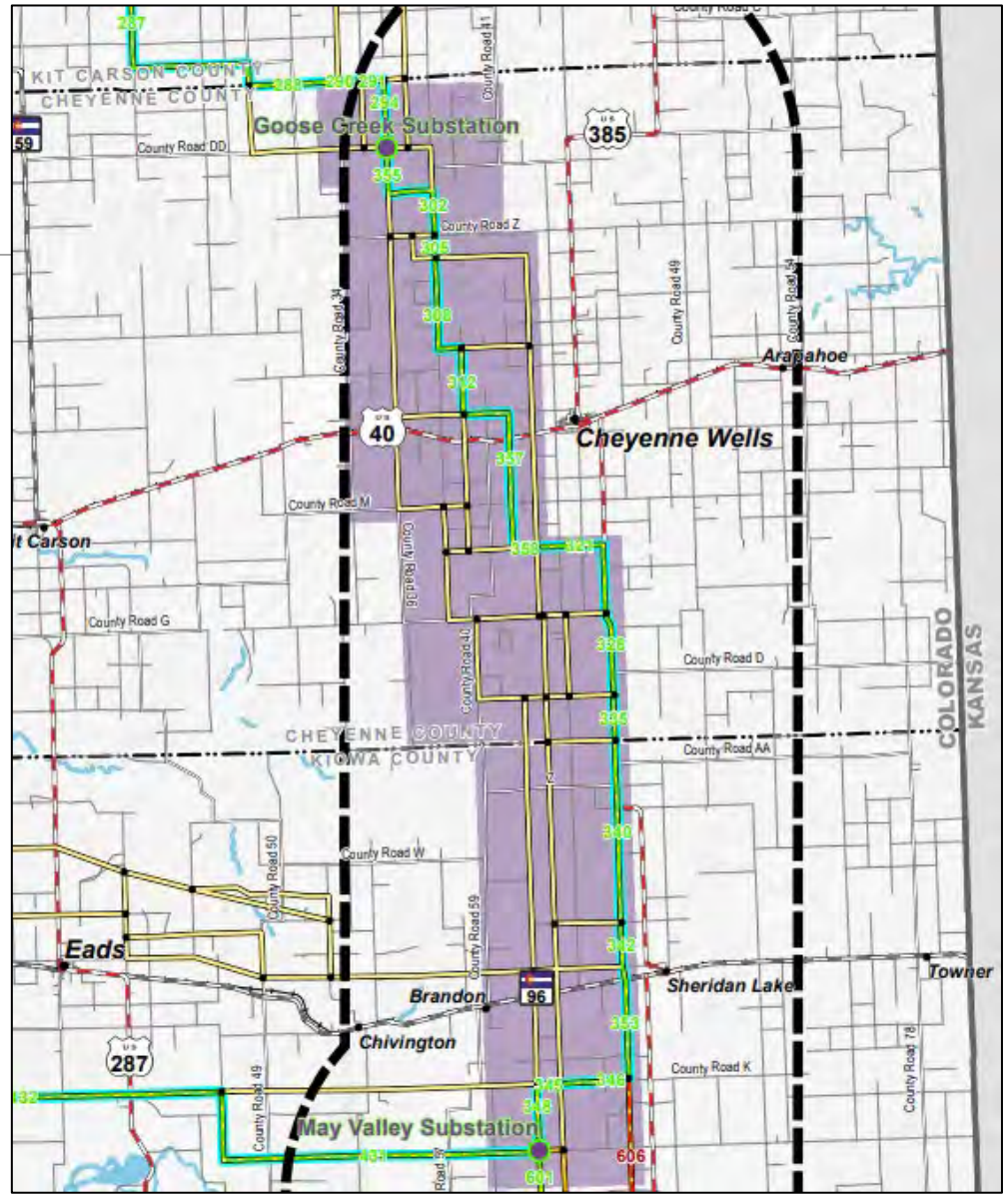
Engineering Team

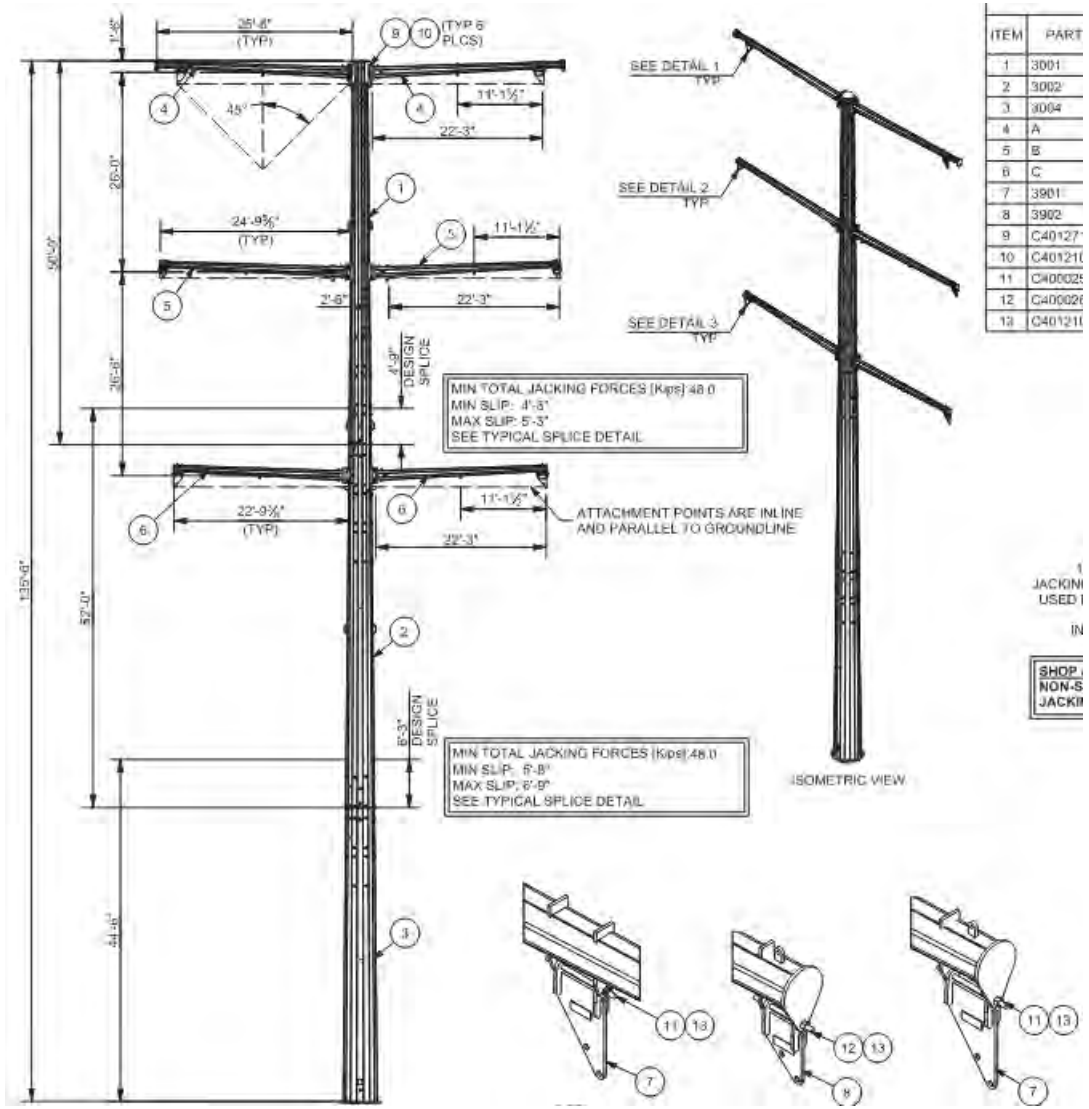
- Consistent leadership and QA/QC strategy
- Significant preliminary engineering work
- Junior team member development
- Broad skill set with significant greenfield experience
- Outside partner engagement as needed



Routing and Siting

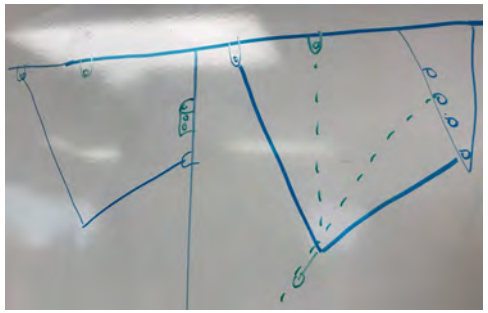
- 2,900+ miles of route options analyzed
  - Desktop reviews of various constraints
  - Detailed PLS CADD modeling of specific pinch points
  - A lot of driving around eastern CO
  - Ongoing micro siting in current segments
- 44 Public meetings in 14 counties
  - Meeting with landowners and other stake holders to review current route options
  - Taking input and updating route options accordingly

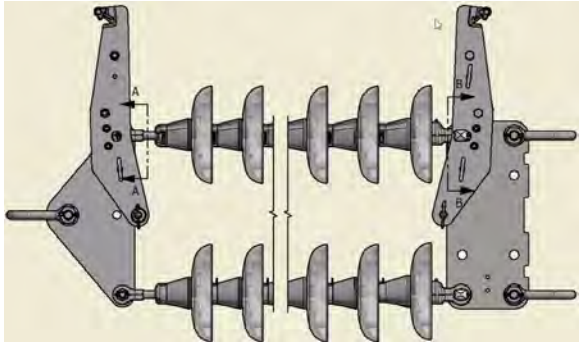


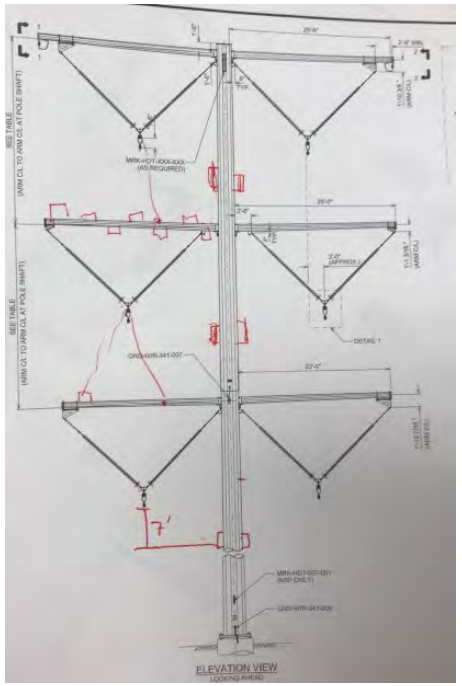


Preliminary Engineering

- Preliminary engineering took place in parallel with routing and siting, but before detailed design on final routes.
- Goal to create an engineering template for consistency across all engineers and design segments.
  - Design Criteria
    - Consistency in ice and wind structural loading zones, wire galloping zones, etc.
  - Material selection, specifications, drawings
  - Structure configurations
  - Structure loading calculations and drawings
  - PLS-Pole files, PLS-CADD template models
  - Steel pole vendor calculations and fabrication drawings







Structure Family

- Developed structure configurations and loading drawings
  - Tangent, angle, and dead-end framing and loading categories.
  - Multiple structure types within each category (single/double ckt, BLP, V-string, H-frame, Transposition, etc.)
  - ~2500 Design variations
  - Two steel vendors provided design calculations and drawings for “most used” structure types.
  - Unit weight per structure savings of 21% over CPCN estimate values.

- Constructability
  - Reviewed geometry and working points with internal and external construction.
  - Added working and lifting points. Modified dead-end hardware to work with standard hot line tools.

Foundations

Concrete Piers

- 95% are concrete piers with full length anchor bolts
  - Tangents ~6ft Diameter x 30ft Deep
  - Dead-ends ~11ft Diameter x 40ft Deep

Vibratory Caissons

- 5% galvanized steel vibe caissons
  - Used when soils are loose/sandy
  - Faster install than concrete piers
  - Cost savings per location ~$15k
  - Magnetic particle testing of baseplate welds after install, no issues
  - Tangents ~4ft Diameter x 30ft Deep
  - Dead-ends ~9ft Diameter x 40ft Deep

Construction and Inspection

- QISG (Quanta Company) selected as GC over all Pathway

- QISG began providing constructability input in routing and siting.
- Negotiations included a fixed cost cap, cost sharing, and LD's. Greatly impacted overall project risk.

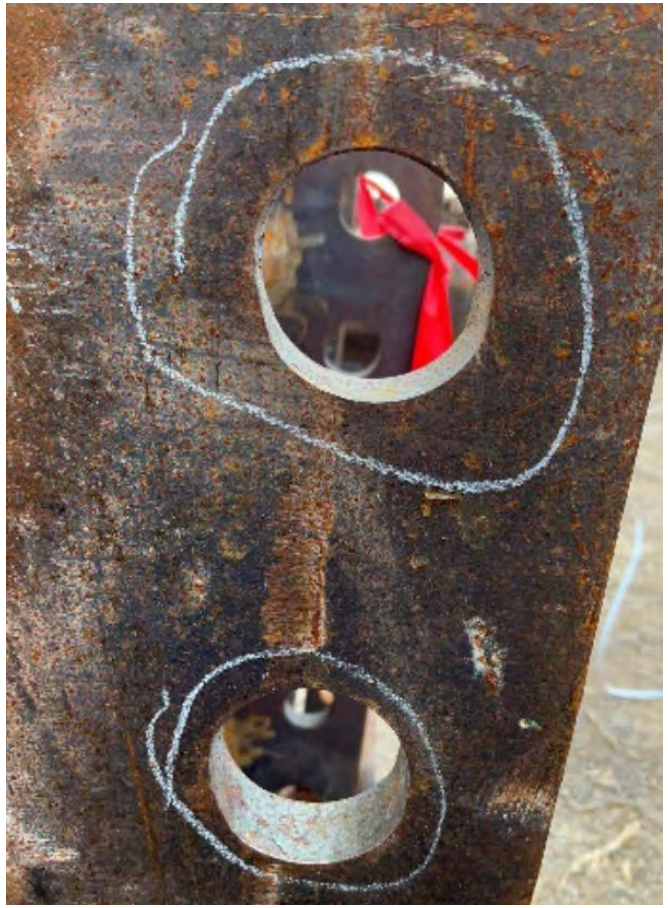
- Steel Pole Inspection from EDM

- Rich Tedesco and his team performed inspection of steel poles at 4 different plants
- Goal to find fabrication issues at the plant before they showed up in the field.
- Over 1100 structures in the first 200-mile construction group started in late summer 2023. Of which EDM inspected 100% of dead ends and angles, and 10% of tangents.

- Foundation Inspection from Vivid Engineering

- Vivid is performing concrete testing and foundation/anchor bolt cage inspection
- Mobile lab for concrete testing onsite to save travel time and not hold back construction schedule

- Overhead T-line Inspection also being performed by EDM



Current Status

Construction:

Construction started on the first 200 miles in late summer 2023.

About 2/3 of the concrete foundations are complete (~800).

Wire stringing began in February 2024.

Permitting/Easement Acquisition:

County land use permit hearings about half complete.

Easement acquisition complete on first 200 miles.

In Service Dates:

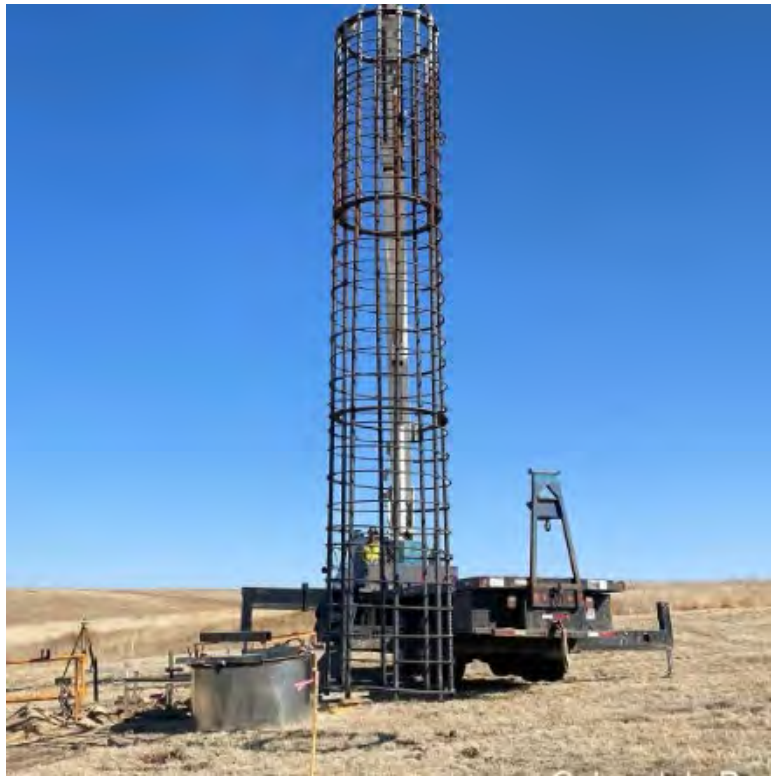
- Group 1 ~ 200 miles: 2025

- Group 2 ~ 75 miles: 2026

- Group 3 ~ 255 miles: 2027

Thank you!

Any Questions?



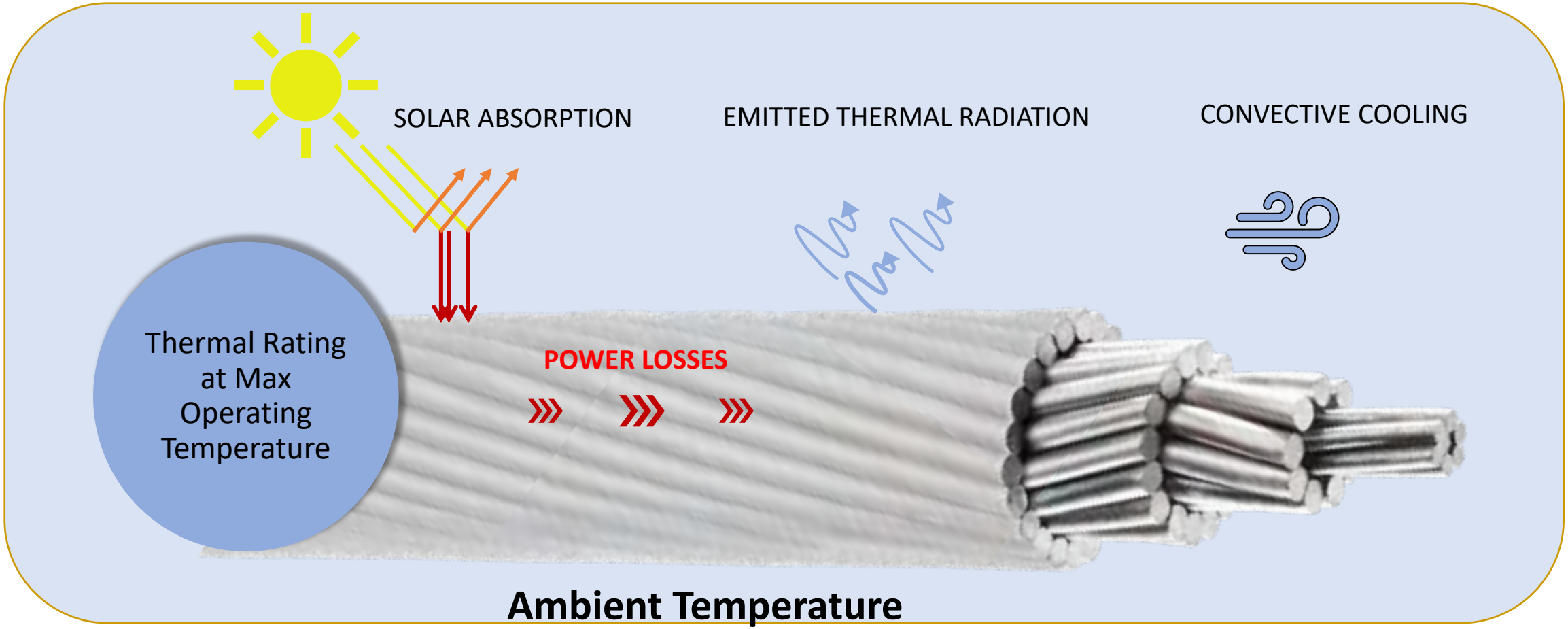
FERC Order 881

And the Evolution of Transmission Conductor Ratings

Joe Coffey

prysmian

FERC 881: Accuracy of Ratings



"In this final rule, the Federal Energy Regulatory Commission is adopting reforms…to improve the **accuracy** and **transparency** of electric transmission line ratings used by transmission providers"

Pre- 881 utilities may have “optimized” ratings over time to increase line capacity
Faster wind, hotter conductors, better emissivity

Example of how Facility Rating Methodology for ACSR conductor has changed over time at one utility

Revision to Methodology	**1**	**2**	**3**
Maximum Operating Temperature (°C)	75	100	100
Ambient Temperature (°C)	25	35	35
Emissivity	0.5	0.5	0.9
Absorptivity	0.5	0.5	0.9
Wind Speed normal to conductor (ft/s)	2	2.93	4.4
Amps (Drake ACSR)	**912**	**1136**	**1293**

Excerpt from Order 881:

82. Prysmian discourages mandatory AAR implementation without consideration of other variables and without a holistic evaluation of all transmission line rating inputs to determine whether an overall transmission line rating methodology is conservative or not. Prysmian states that AARs can also lead to situations in which near-term transfer capability is overstated.[196]

FERC 881 Excerpt: Industry Concerns listed in Order

[11] BPA states that if it uses AARs as proposed, it would need to make its wind assumptions more conservative, de-rating transmission, to mitigate the risk of operating near the conductor limit.[112]

FERC Order 881 Excerpt

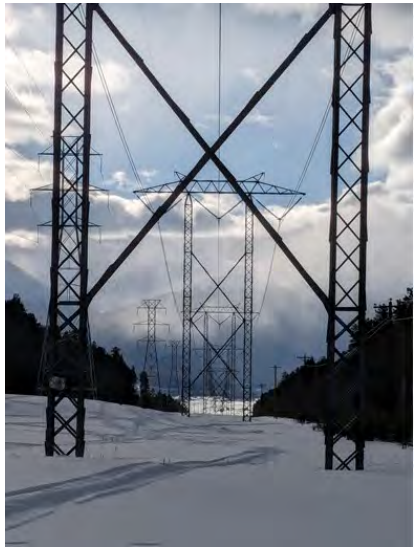
"Many transmission line ratings are currently calculated based on assumptions about ambient conditions that are not regularly adjusted and therefore do not accurately reflect the near-term transfer capability of the transmission system.[5] For example, when seasonal or static temperature assumptions exceed actual ambient air temperatures, transmission line ratings may understate the near-term transfer capability that the transmission system can actually provide, leading to unnecessarily restricted flows and potentially increased congestion costs. Alternatively, when ambient air temperatures exceed seasonal or static temperature assumptions, transmission line ratings may overstate the near-term transfer capability of the system, creating potential reliability and safety problems. In either case, the continued use of seasonal and static temperature assumptions may result in transmission line ratings that do not accurately represent the transfer capability of the transmission system. We find that transmission line ratings and the rules by which they are established are practices that directly affect the cost of wholesale energy, capacity, and ancillary services, as well as the cost of delivering wholesale energy to transmission customers; thus, we find that inaccurate transmission line ratings result in Commission-jurisdictional rates that are unjust and unreasonable."

Understated ratings are a problem

Overstated ratings are a problem

Accuracy is required

What is an “Accurate” transmission line rating?

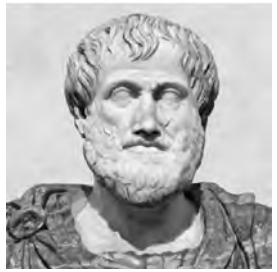


Performance History

NERC FAC-008

Art

Philosophy

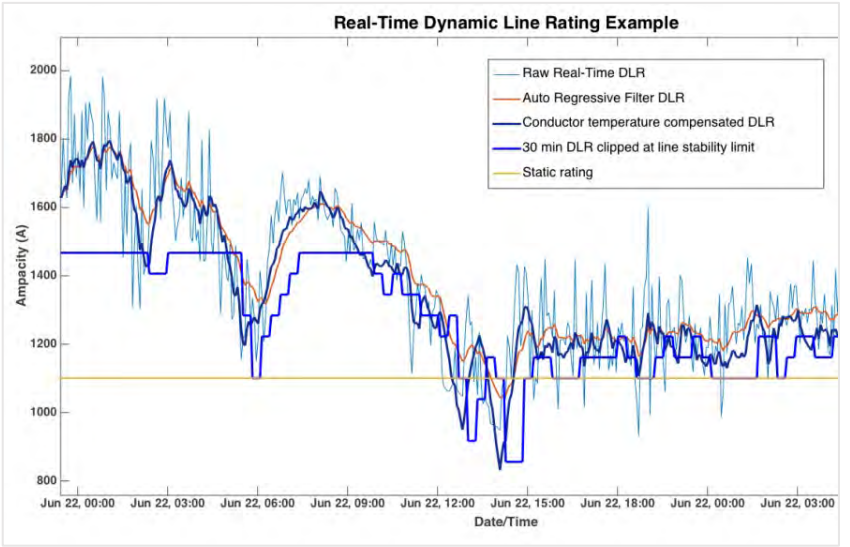


Industry Standards

IEEE

cigre

Testing & Analysis



Equipment Manufacturers

CODE WORD (1)	SIZE AWG OR kcmil	TYPE	NO. AL. WIRES	FILL FACTOR	EQUIVALENT AL. DIA. INCHES	STEEL CORE NO. X DIA. INCHES	STEEL CORE O.D. INCHES	CROSS-SECTION SQ. INCHES		O.D. INCHES	RESISTANCE (4) OHMS/1000 FT				AMPACITY (5)	
								TOTAL	AL.		DC @ 20°C	AC @ 25°C	AC @ 75°C	AC @ 200°C	75°C	200°C
Mohawk/ ACSS/TW	571.7	13	18	92.2	0.1782	7x0.1030	0.3090	0.5072	0.4489	0.85	0.0289	0.0297	0.0357	0.0506	725	1295
Calument/ ACSS/TW	565.3	16	20	91.5	0.1681	7x0.1146	0.3438	0.5161	0.4438	0.86	0.0292	0.0299	0.0359	0.0510	725	1295
Mystic/ ACSS/TW	666.6	13	20	92.3	0.1826	7x0.1111	0.3333	0.5915	0.5236	0.91	0.0248	0.0256	0.0307	0.0434	800	1430
Oswego/ ACSS/TW	664.8	16	20	92.3	0.1823	7x0.1244	0.3732	0.6073	0.5222	0.93	0.0248	0.0255	0.0306	0.0434	800	1440
Maumee/ ACSS/TW	768.2	13	20	93.0	0.1960	7x0.1195	0.3585	0.6817	0.6032	0.98	0.0215	0.0222	0.0267	0.0377	870	1570
Wabash/ ACSS/TW	762.8	16	20	92.9	0.1953	7x0.1331	0.3993	0.6963	0.5989	0.99	0.0216	0.0223	0.0267	0.0378	875	1575
Kettle/ ACSS/TW	957.2	7	33	92.2	0.1703	7x0.0973	0.2919	0.8038	0.7518	1.06	0.0175	0.0184	0.0226	0.0327	965	1730
Suwanee/ ACSS/TW	959.6	16	22	93.4	0.2089	7x0.1493	0.4479	0.8764	0.7539	1.11	0.0172	0.0178	0.0213	0.0301	1005	1825

FERC 881

By July 2025, utilities under FERC jurisdiction will be required to

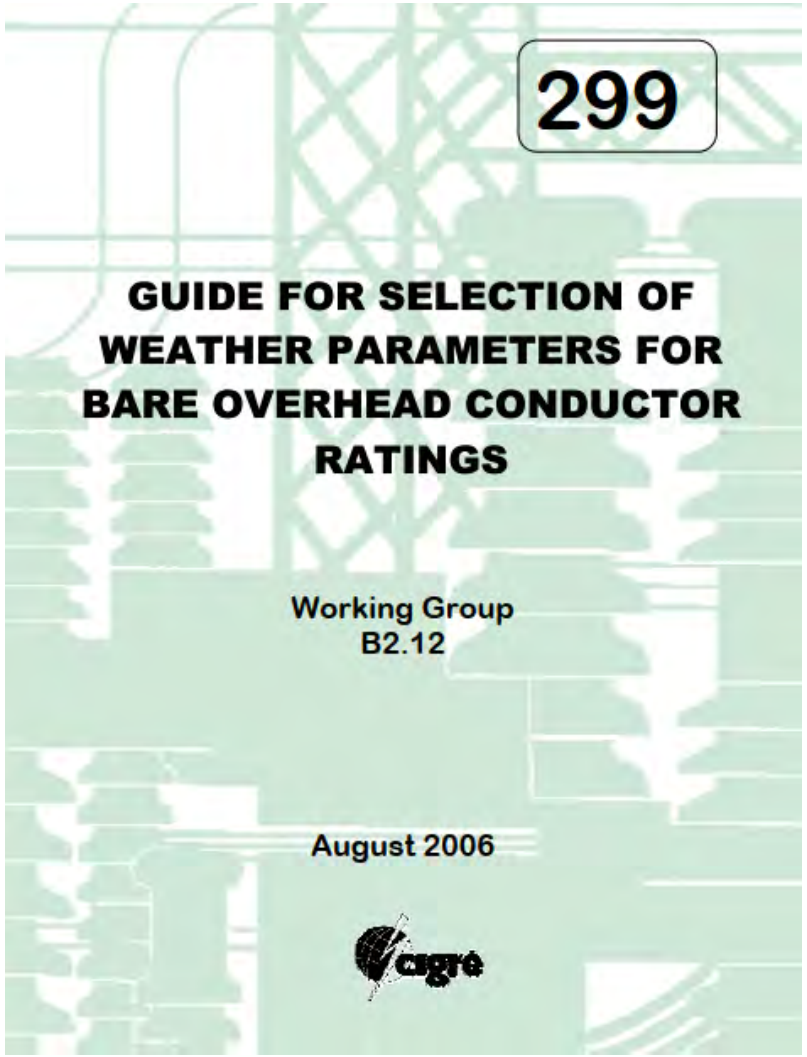
1)Implement Ambient Adjusted Ratings
2)Forecast AARs out to 10 days
3)Develop Emergency Ratings
4)Implement Seasonal Ratings
5)Disclosure of rating methodology to stakeholders

Be Accurate!

FERC 881 Excerpt

"Similarly, in response to comments from BPA that if BPA uses AARs as proposed, it would need to make its current liberal wind assumptions (and therefore, the resultant transmission line ratings) more conservative to mitigate the risk of operating near the conductor limit,[245] we reiterate that the AAR requirements will ensure more accurate transmission line ratings, not necessarily higher transmission line ratings. We further clarify that there is no requirement to change wind speed assumptions. Utilities have operated reliably for decades with AARs.[246] However, if any transmission owner finds it necessary to change its wind speed assumptions consistent with good utility practice, we clarify that nothing in this rulemaking prevents it from doing so"

Resources: CIGRE TB299 guidance on AARs and Wind Speed



1.5.3 Variable ratings

1.5.3.1 Continually ambient-adjusted ratings.

Ratings can be adjusted based on varying ambient temperatures measures at the time. These are termed continually ambient-adjusted ratings. In this case, unless real time rating systems are used, the wind speed should be based on the assumption of a more conservative effective wind speed than Base ratings. The extensive literature review by the JTF clearly indicates that ambient temperature and wind speed are not independent parameters, higher wind speeds being associated with high ambient temperatures.

If the Base Rating is to be adjusted for daytime conditions, the JTF recommends the following: If the ambient temperature adjustment is less than 8°C compared to the temperature selected for Base Rating conditions (for example, if the base ambient temperature is 35°C and the actual ambient temperature is between 35°C and 27°C), the effective wind speed should be selected as no higher than 0.5 m/s. If the temperature adjustment is more than 8°C, the effective wind speed should be selected as no more than 0.4 m/s. For nighttime ambient-adjusted ratings (between sunset and sunrise when solar radiation is zero), wind speed should be selected as zero (natural convection only), and solar radiation can also be considered nil. Continually ambient-adjusted ratings can provide technically justified ampacity increases for lines which are designed for low maximum conductor temperatures, e.g. below 60-70°C. On the other hand, they will generally not provide technically justified benefits for lines designed for 100 °C or higher temperatures [6] and their use is not recommended.

If a study-based line rating is to be adjusted for ambient temperature, the engineer must be careful to reduce the assumed wind speed to account for correlation with ambient temperature. As with ambient adjustment of Base ratings, the wind speed at night should be much lower.

Resources: IEEE 738-2023 guidance on Emissivity

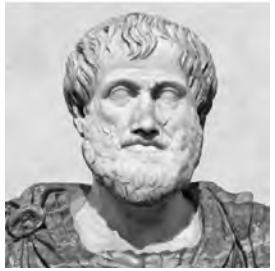
5.4 Conductor emissivity and absorptivity

Values for emissivity and absorptivity for some conductors can be obtained from the conductor manufacturer. Emissivity and absorptivity are generally correlated, with absorptivity assumed to be slightly higher than emissivity. Recent laboratory measurements of conductor samples by EPRI [B39] [B40], support the use of an initial value of between 0.2 and 0.4 for bare aluminum that will gradually increase in most environments. The exact rate of increase depends on the density of atmospheric particulates and the line's operating voltage. Existing testing does not support use of values above 0.6 for aged conductors. These guidelines do not apply to conductors that are coated with special materials to increase emissivity, decrease absorptivity, or both.

Historically, in North America, values for thermal rating calculations have been either that both parameters are 0.5 or that both are in the range of 0.7 to 0.9. An incorrect emissivity or absorptivity value increases risks related to inaccurate ratings. Incorrect assumed values lead to large rating calculation errors at high conductor temperatures, but even at modest conductor temperatures (less than 100 °C), the total temperature error is small in magnitude but can represent an important portion of available capacity and influence the overall risk of exceeding design limits for a line.

At high conductor temperatures (greater than 150 °C), the value of emissivity has a larger impact on thermal rating because of increased radiation heat loss. At low conductor temperatures (less than 75 °C), the value of absorptivity has a larger impact on rating because of the importance of solar temperature rise.

The Art and Philosophy of FERC 881 compliance:



- What does “accurate” mean?
- Is utility philosophy to be conservative, or to “push the limits”
- Many utilities have accepted that there are periods where real time conditions could cause conductor to exceed maximum temperature for periods of time. Is that still OK?
- Are errors amplified with newer conductors operating at higher temperatures?
- Does risk profile change with new power flows patterns and seasonal peaks?
- Compliance is a good reason to evaluate current rating assumptions especially around wind speed and emissivity

Backup:
DLR pilots are showing current static ratings often overestimate line capacity

DLR Pilot at National Grid
DLR data below Static Rating 23% of time in winter

LineVision-National Grid_2021-CIGRE-NGN-Paper.docx (website-files.com)

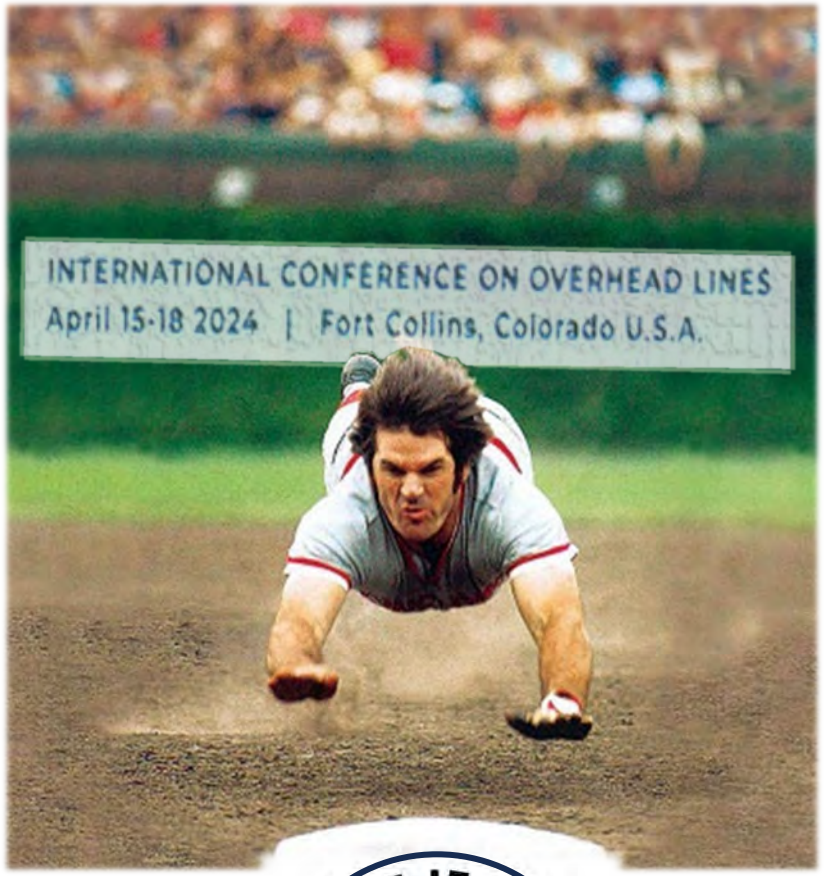
DLR Pilot at NYPA
DLR data below Static Ratings as much as 48% of time

WindSim Power Logos

What will industry do when sensor data reveals that many lines need to be de-rated?

Is “Good Enough” good enough?

Quality of Structures Supporting Overhead Power Lines



Kenneth L. Sharpless, PE, F.SEI, F.ASCE
ksharpless@exoinc.com

Quality is foundational to Reliability & Resiliency.

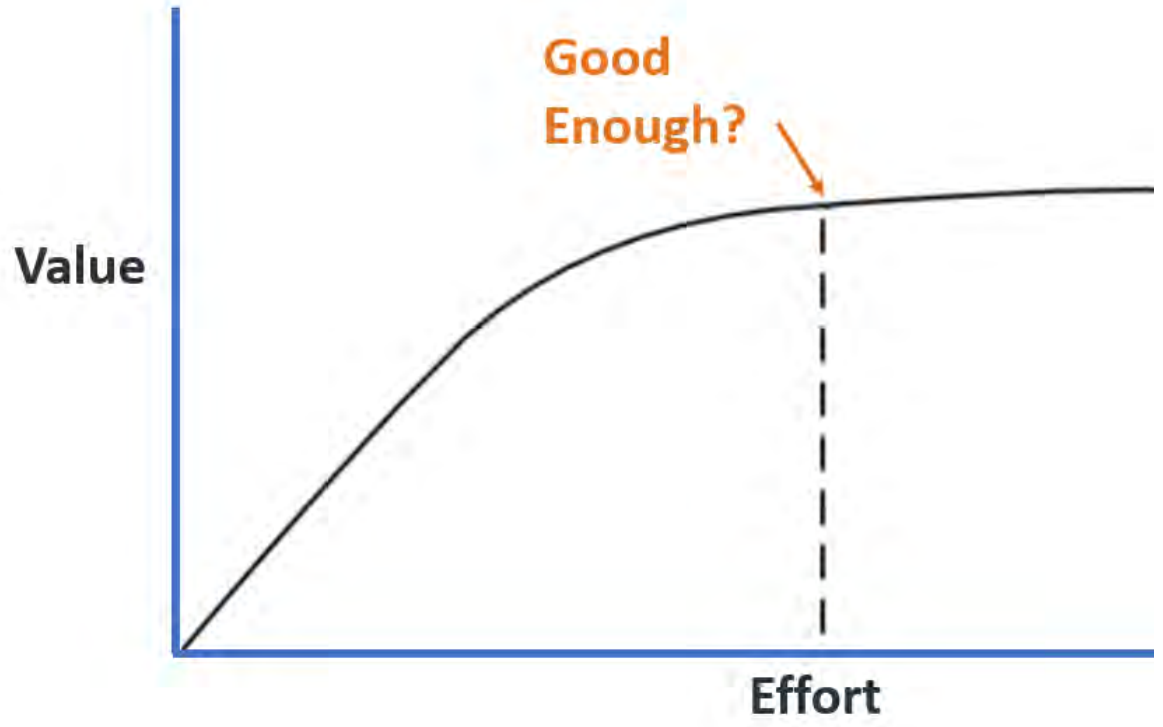
"Where a few brave souls work tirelessly to ensure absolutely Nothing happens!"

John Oliver – Infrastructure (YouTube)

However, establishing a quality mindset and matching it with quality reality is not automatic.

"Holding a culture of quality and a track record of quality is under real and constant pressure."

What is “Good Enough”?



Who determines when the continued effort (time or resources expended) is not worth the additional value it brings?

What is the quality metric for “Good Enough”?

If we adopt a 99% quality metric as a standard?

No electricity at your home for **87 hours** each year.

If we adopt a 99.99% quality metric as a standard?

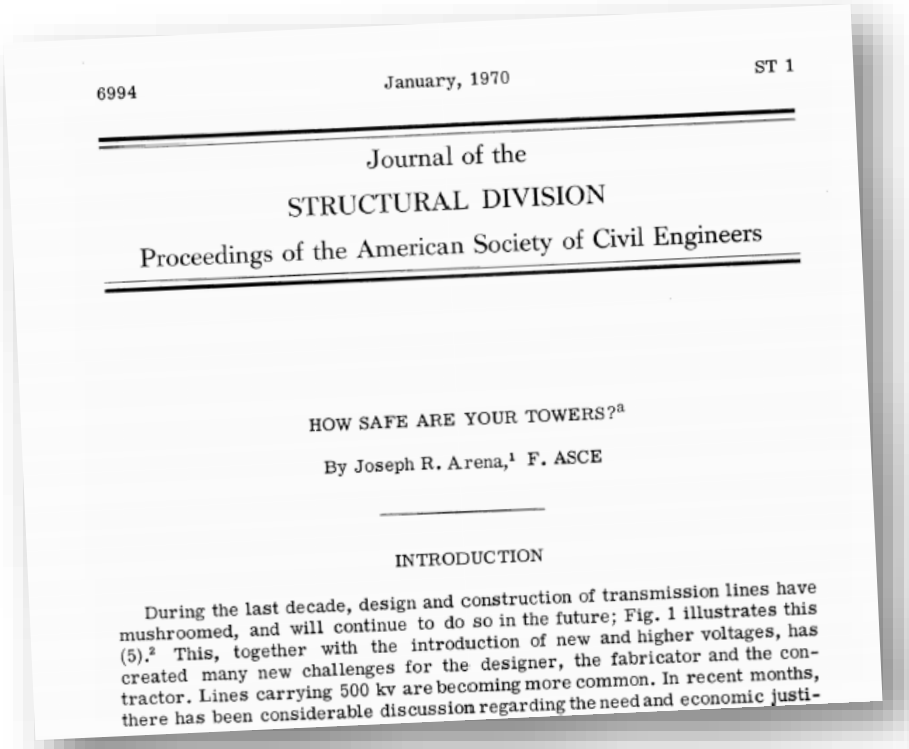
No electricity at your home for **52 minutes** each year.

If we adopt a 99.9997% quality metric as a standard (Six Sigma)

No electricity at your home for **30 seconds** each year.

What are we willing to accept (RISK) and pay for?

There are inherent RISKS associated with poor quality materials and custom designed product manufacturing.



6994 January, 1970 ST 1

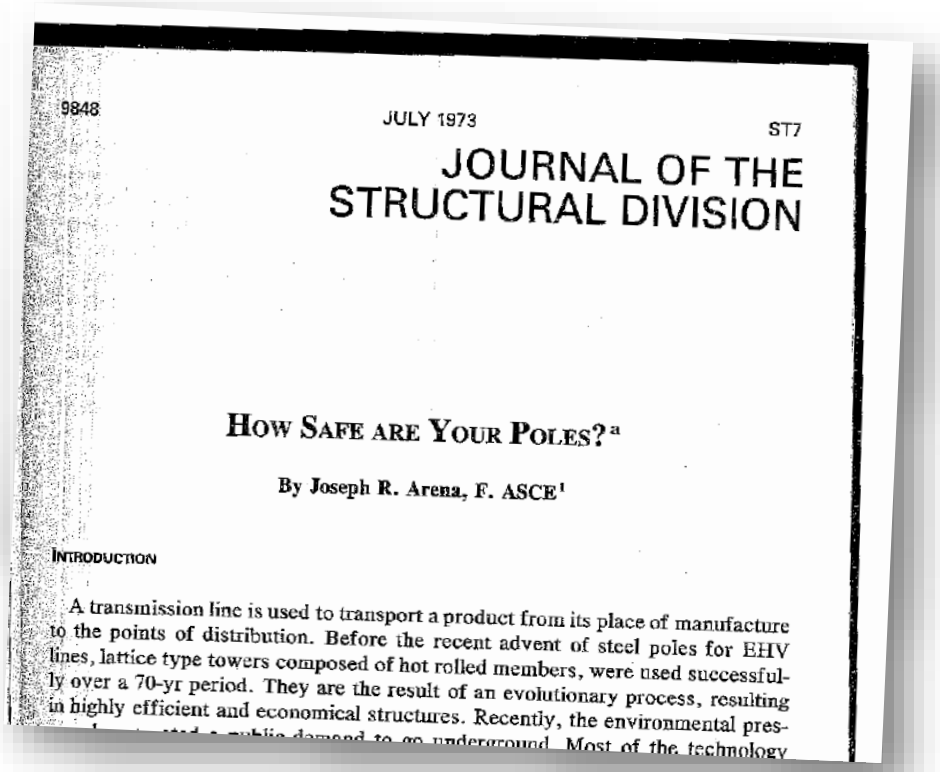
Journal of the
STRUCTURAL DIVISION
Proceedings of the American Society of Civil Engineers

HOW SAFE ARE YOUR TOWERS?[a]

By Joseph R. Arena,[1] F. ASCE

INTRODUCTION

During the last decade, design and construction of transmission lines have mushroomed, and will continue to do so in the future; Fig. 1 illustrates this (5).[2] This, together with the introduction of new and higher voltages, has created many new challenges for the designer, the fabricator and the contractor. Lines carrying 500 kv are becoming more common. In recent months, there has been considerable discussion regarding the need and economic justi-



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JOURNAL OF THE
STRUCTURAL DIVISION

HOW SAFE ARE YOUR POLES?[a]

By Joseph R. Arena, F. ASCE[1]

INTRODUCTION

A transmission line is used to transport a product from its place of manufacture to the points of distribution. Before the recent advent of steel poles for EHV lines, lattice type towers composed of hot rolled members, were used successfully over a 70-yr period. They are the result of an evolutionary process, resulting in highly efficient and economical structures. Recently, the environmental pres-

There are problematic industry trends making quality more challenging and more critical.

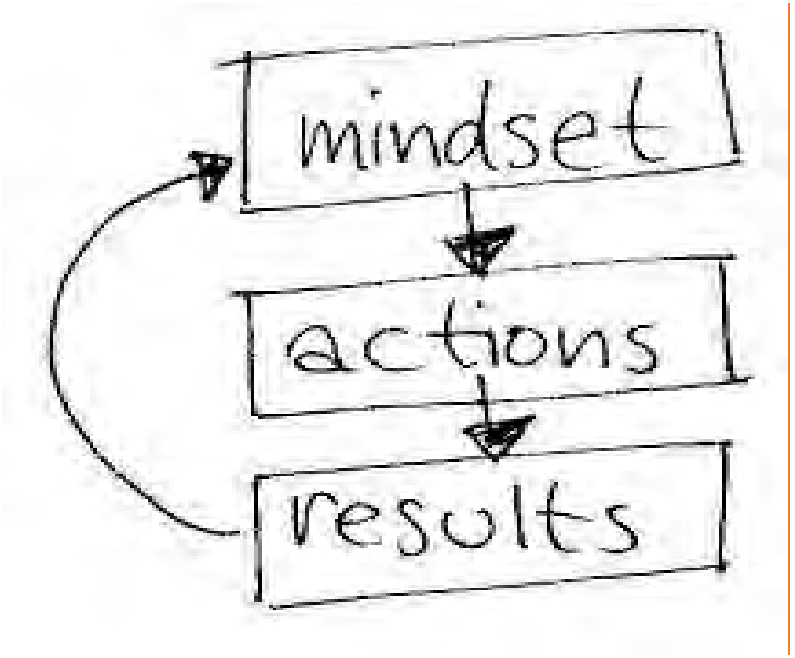
- ***Structure Designs are less conservative and performed by less experienced "designers" rather than "engineers".***
- ***Significant increase in turnover rate on shop floor level***
- ***Changes in Materials***
- ***High Volume vs. High Quality Welding***
- ***Subcontracting***

What are Strategic quality characteristics?

- *Conformance*
- *Durability*
- *Performance*
- *Reliability*
- *Serviceability*

“The perception has long been that quality is born out of compliance, but is that where it ends?”

How important is Quality Culture to the outcomes that define project success?



"the industry's approach to quality must adapt…it must take on, rather than shun, a quality mindset to compete and prosper."

What is the supplier's Quality Mindset on your project?:

The work doesn't need to be "perfect", only "good enough".

"This is the way we have always done it, ..."

From a Paper: *"Powerline Tower Arm Failure Analysis", Authored by Dr. Wayne Reitz, Ph.D., PE*

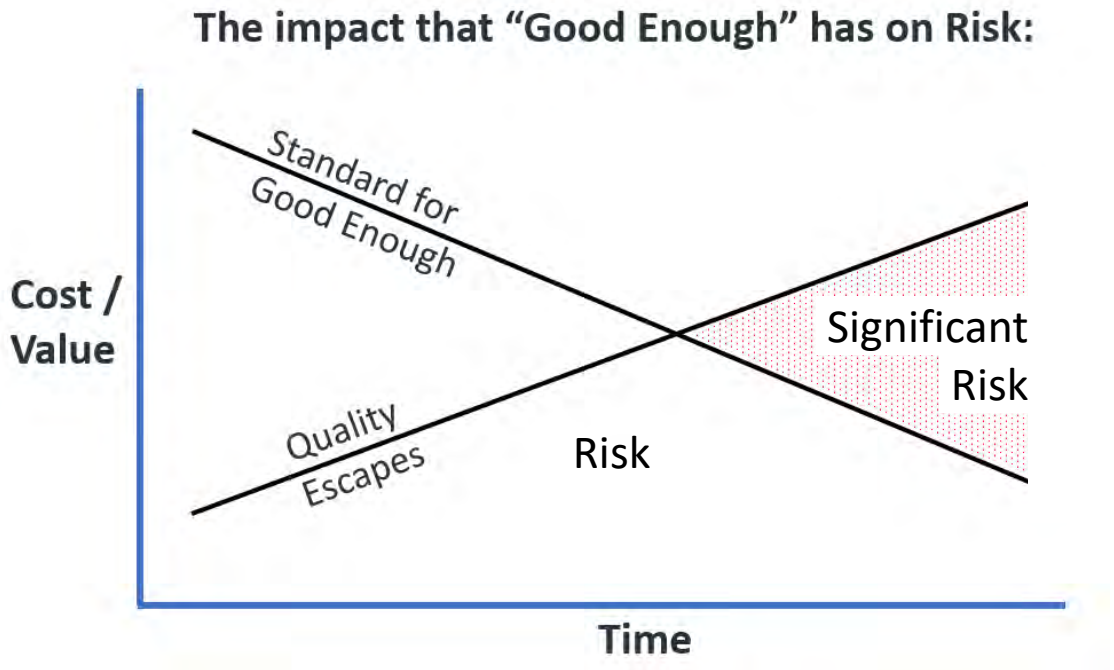
What does that even mean?... good enough to _____.

What is the acceptable non-conformance rate for products on your project?

- ***Errors of Knowledge***
- ***Errors of Performance***
- ***Errors of Intent***

Most Structural Failures (or premature structural degradation) are Caused by Human Errors.

What is the acceptable risk tolerance on your project?



The real problem is that the best way for Utilities to manage their risk of poor-quality materials isn't always clear

What is the impact on schedule and budget associated with quality escapes on your project?

Quality Escape:

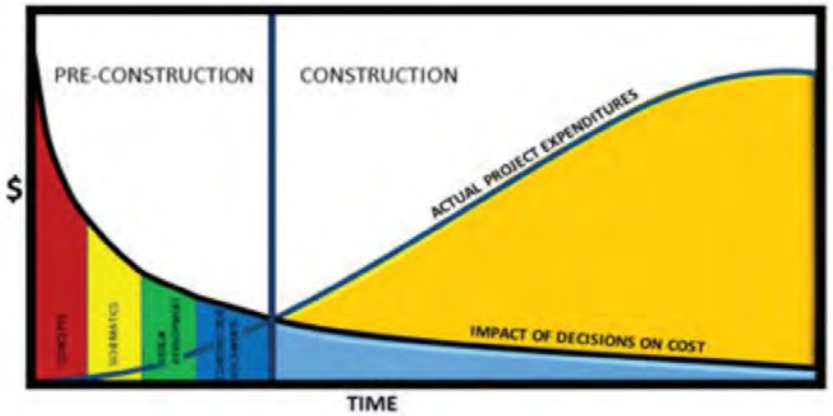
Any product or service containing a deviation/defect that is released from point of origin, whether caught before it reached the end external customer or not.

Non-conforming Materials will not perform over the long-term as expected.

Why is it important to establish a quality plan from the earliest stages for your project?


Hawthorne Works, ca. 1925

And the Corollary:



Structure Magazine Feb 2024

The "Hawthorne Effect"

(also referred to as the **observer effect**)

People tend to do a better job when they know they are being observed!

The "Hostage Effect"

Once Materials are delivered to the field your, options are very limited when a fabrication quality issue arises!

The Role of:
Codes, Standards, & Specifications

To ensure structural reliability,

. . . . but also, to avoid repeating past mistakes!

CODES:

A collection of laws or regulations pertaining to a specific activity or subject.

Examples:

- National Electric Safety Code
- Structural Welding Code
- International Building Code

STANDARDS:

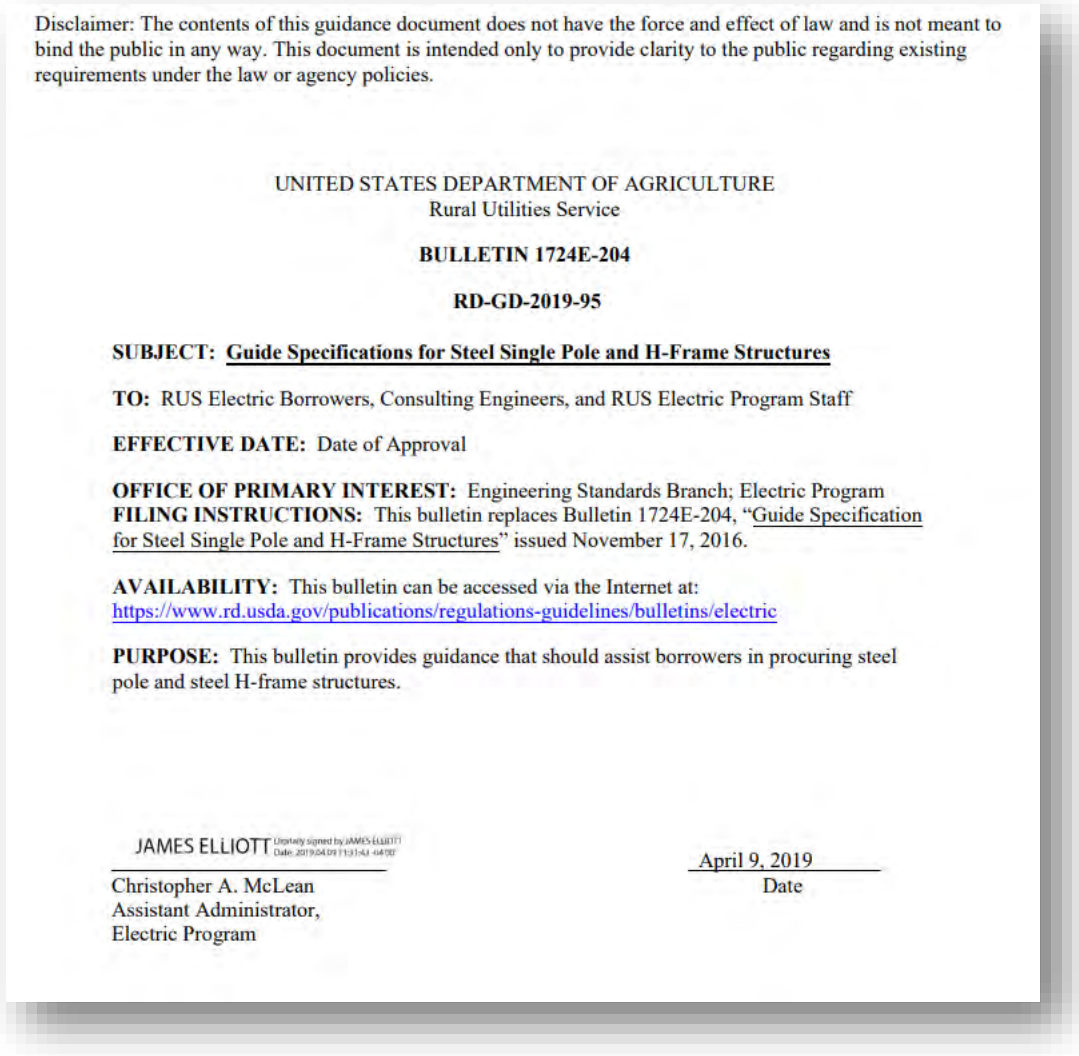
Industry consensus collection of "best practice requirements" pertaining to a specific activity or subject.

Examples:

- **ASCE Standards:**
  (ASCE 48-19 Steel Pole Standard, ASCE 10-15 Tower Standard)
- **AISC Standards**
  (AISC 360-10 Standard Practices for Design & Fabrication)
- **ASTM Standards**
  (ASTM A6 ASTM A572, ASTM A123, etc.)
- **IEEE Standards**

SPECIFICATIONS:

Are a specific instruction of workmanship, materials, etc., required to be followed to achieve a required level of performance in our pole and tower products.



Disclaimer: The contents of this guidance document does not have the force and effect of law and is not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1724E-204

RD-GD-2019-95

SUBJECT: **Guide Specifications for Steel Single Pole and H-Frame Structures**

TO: RUS Electric Borrowers, Consulting Engineers, and RUS Electric Program Staff

EFFECTIVE DATE: Date of Approval

OFFICE OF PRIMARY INTEREST: Engineering Standards Branch; Electric Program
FILING INSTRUCTIONS: This bulletin replaces Bulletin 1724E-204, "Guide Specification for Steel Single Pole and H-Frame Structures" issued November 17, 2016.

AVAILABILITY: This bulletin can be accessed via the Internet at:
https://www.rd.usda.gov/publications/regulations-guidelines/bulletins/electric

PURPOSE: This bulletin provides guidance that should assist borrowers in procuring steel pole and steel H-frame structures.

JAMES ELLIOTT Digitally signed by JAMES ELLIOTT Date: 2019.04.09 11:31:42 -04'00'

Christopher A. McLean
Assistant Administrator,
Electric Program

April 9, 2019
Date

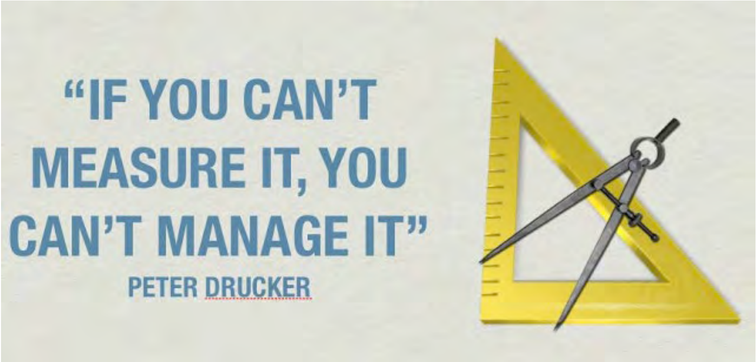
PROMISES:

A declaration or assurance that a supplier will do a particular thing or that a particular thing will happen if they are awarded an order for their product

- **Promise of capability**
- **Promise of qualification**
- **Promise of quality**
- **Promise of schedule**
- **Promise of transparency**

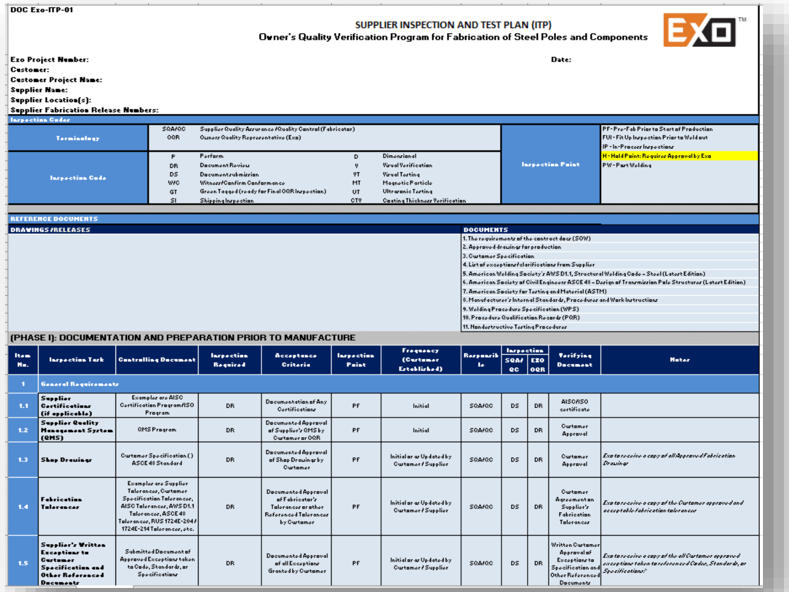
INSPECTION TEST PLAN:

Summary of QA/QC implementation with a proactive communication protocol, establishing cooperation early in a project.



These programs work best when:

- ***Everyone is transparent with information.***
- ***Everyone shares information/data quickly.***
- ***Disagreements are resolved quickly.***
- ***Everyone keeps a "non-adversarial" attitude.***



DOC Exo-ITP-01

SUPPLIER INSPECTION AND TEST PLAN (ITP)
Owner's Quality Verification Program for Fabrication of Steel Poles and Components

EXO™

Exo Project Number: Date:
Customer:
Customer Project Name:
Supplier Name:
Supplier Location(s):
Supplier Fabrication Release Numbers:

Inspection Codes

Terminology	SQA/QC	Supplier Quality Assurance/Quality Control (Fabricator)			Inspection Point	PF - Pre-Fab Prior to Start of Production
	OQR	Owners Quality Representative (Exo)				FUI - Fit Up Inspection Prior to Weld out
Inspection Code	P	Perform	D	Dimensional		IP - In-Process Inspections
	DR	Document Review	V	Visual Verification		H - Hold Point: Requires Approval by Exo
	DS	Document submission	VT	Visual Testing		PW - Post Welding
	W/C	Witness/Confirm Conformance	MT	Magnetic Particle		
	GT	Green Tagged (ready for Final OQR Inspection)	UT	Ultrasonic Testing		
	SI	Shipping Inspection	CTV	Coating Thickness Verification		

REFERENCE DOCUMENTS

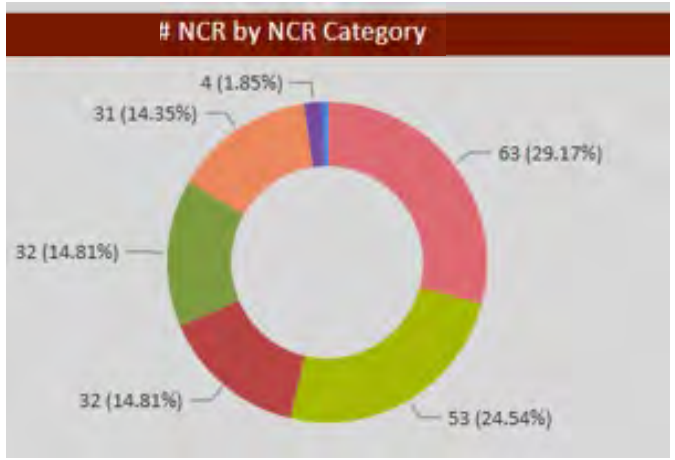
DRAWINGS/RELEASES	DOCUMENTS
	1. The requirements of the contract docs (SOW)
	2. Approved drawings for production
	3. Customer Specification
	4. List of exceptions/clarifications from Supplier
	5. American Welding Society's AWS D1.1, Structural Welding Code – Steel (Latest Edition)
	6. American Society of Civil Engineers ASCE 48 – Design of Transmission Pole Structures (Latest Edition)
	7. American Society for Testing and Material (ASTM)
	8. Manufacturer's Internal Standards, Procedures and Work Instructions
	9. Welding Procedure Specification (WPS)
	10. Procedure Qualification Records (PQR)
	11. Nondestructive Testing Procedures

(PHASE I): DOCUMENTATION AND PREPARATION PRIOR TO MANUFACTURE

Item No.	Inspection Task	Controlling Document	Inspection Required	Acceptance Criteria	Inspection Point	Frequency (Customer Established)	Responsible	Inspection SQA/QC	Inspection EXO OQR	Verifying Document	Notes
1	General Requirements										
1.1	Supplier Certifications (if applicable)	Examples are AISC Certification Program/ISO Program	DR	Documentation of Any Certifications	PF	Initial	SQA/QC	DS	DR	AISC/ISO certificate	
1.2	Supplier Quality Management System (QMS)	QMS Program	DR	Documented Approval of Supplier's QMS by Customer or OQR	PF	Initial	SQA/QC	DS	DR	Customer Approval	
1.3	Shop Drawings	Customer Specification () ASCE 48 Standard	DR	Documented Approval of Shop Drawings by Customer	PF	Initial or as Updated by Customer / Supplier	SQA/QC	DS	DR	Customer Approval	*Exo to receive a copy of all Approved Fabrication Drawings*
1.4	Fabrication Tolerances	Examples are Supplier Tolerances, Customer Specification Tolerances, AISC Tolerances, AWS D1.1 Tolerances, ASCE 48 Tolerances, RUS 1724E-204 / 1724E-214 Tolerances, etc.	DR	Documented Approval of Fabricator's Tolerances or other Referenced Tolerances by Customer	PF	Initial or as Updated by Customer / Supplier	SQA/QC	DS	DR	Customer Agreement on Supplier's Fabrication Tolerances	*Exo to receive a copy of the Customer approved and acceptable fabrication tolerances*
1.5	Supplier's Written Exceptions to Customer Specification and Other Referenced Documents	Submitted Document of Approved Exceptions taken to Code, Standards, or Specifications	DR	Documented Approval of all Exceptions Granted by Customer	PF	Initial or as Updated by Customer / Supplier	SQA/QC	DS	DR	Written Customer Approval of Exceptions to Specification and Other Referenced Documents	*Exo to receive a copy of the all Customer approved exceptions taken to referenced Codes, Standards, or Specifications*

Reality of Quality

Prevented “Quality Escapes” (after supplier green tag)



69 Welding Nonconformance Items (70% of project NCRs):

- 37 NCRs: Welding outside the parameters of the welding procedure specification (WPS).
- 15 NCRs: Visual welding defects that are rejectable to the AWS D1.1 code requirement.
- 6 NCRs: Ultrasonic rejections on both the complete joint penetration weldments and partial joint penetration weldments were observed by Exo that were missed by the nondestructive testing inspectors.
- 5 NCRs: Shop floor individuals welding without qualifications or welding in a position that they are not qualified to weld in (vertical and overhead welding requires additional qualification).
- 3 NCRs: Backing bar was not conforming to the requirements of AWS D1.1. There were interrupted joints and excessive gaps for backing.
- 2 NCRs: Preheat values not meeting the requirements of AWS D1.1 or the WPS. Preheat is required to reduce residual stress on the weldments.
- 1 NCR: Structure number that was welded incorrectly on a pole shaft.

“Be a yardstick of quality. Some people aren’t used to an environment where excellence is expected.”

Steve Jobs

Is “Good Enough” good enough?

Quality of Structures Supporting Overhead Power Lines

Kenneth L. Sharpless, PE, F.SEI, F.ASCE
ksharpless@exoinc.com

- ✓ Specification Review
- ✓ Engineering Drawing Review
- ✓ Supplier Qualification Audit
- ✓ In-Process Fabrication Inspection
- ✓ Prototype Inspection
- ✓ Assembly & Installation Inspection
- ✓ End of Warranty Inspection
- ✓ Line Condition Assessment
- ✓ Subject Matter Expertise
- ✓ Forensic Engineering


EDM
T&D SERVICES
ENVIRONMENTAL SERVICES
PRODUCTS
Overcoming utility infrastructure challenges by merging excellence in engineering, science and technology with a passion for client satisfaction.