BURNS McDONNELL

CONSIDERATIONS FOR THE DESIGN OF 765-KV TRANSMISSION LINES

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HISTORY

1959
Project EHV, led by General Electric, studies corona and insulation for switching surge and power frequency for 380-750 -kV.

Massachusetts, USA

1979
Eskom partners with Enel at Italian lab CESI to study the effects of altitude on conductor corona phenomena.

South Africa

1981/1982
Two high altitude test labs (NETFA and CSIR) are founded to study dielectric strengths of tower window shapes for 765-kV lines.

South Africa

1960s-Today
Thousands of miles of 735/765-kV lines are built around the world—including in Quebec and the Eastern US—drawing on this global research.

Worldwide

2024 and beyond
ERCOT and its partners pioneers the design and construction of new era of 765-kV lines in Texas, providing reliable, cleaner energy to your members and leading the industry in innovation and collaboration.

Texas, USA

20 years → 23 years → 65years

TECHNICAL CONSIDERATIONS

IEEE Survey – Use of 765-kV systems

“A third use of higher-voltage lines was to provide an overlay on an existing well-developed lower-voltage system. The purpose of such an overlay was to enable the bulk power transfer between generating plants and load centers, which permitted the integrated operation of the overall system in an economical and reliable manner. Such a system results in a complex network that is strongly interconnected with neighboring systems. Examples of such systems can be found all over the world, with the AEP 765-kV system as a prime example in the United States.”

- IEEE PES, 2005

TECHNICAL CONSIDERATIONS

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IEEE Survey

- The environmental constraints, particularly audible noise limits set by EPRI and EPA will dictate the conductor selection. Other environmental impacts include radio interference, corona and line losses.
- Conductor optimization:
  - GMR and GMD.
  - Evaluate financial impacts for multiple options.
- Selection with these limits on the edge of the RoW as it will govern the diameter of the conductor and can be referenced in EPRI and EPA.
  - This will dictate what the required RoW will be.
  - This can be tested for confirmation.
- Shield wire / grounding specification—design for fault clearing time and current.
- HW & Insulation design—design for insulation and maintenance.
- Basic tower head geometry:
  - Design for optimized electrical performance.
  - Fix phase-to-phase and phase-to-ground clearance requirements.

TECHNICAL CONSIDERATIONS

IEEE Survey

Why do some lines need more phase spacing?

Why do some lines need more cables?

Company / Country	Nominal Voltage (kV)	No. of Sub-conductors	Conductor Diameter (in.)	Phase Spacing (ft.)	Min. Conductor Heights (ft.)
Hydro-Quebec 1	735	4	1.38	50.2	50.2
Hydro-Quebec 2	735	4	1.40	42.0	46.3
AEP 1	765	4	1.17	44.9	40.0
AEP 2	765	4	1.39	44.9	40.0
AEP 3	765	6	1.06	44.9	44.9
NYPA	765	4	1.39	44.9	50.9
Eskom	765	6	1.13	51.8	49.2
FURNAS	765	4	1.26	46.9	42.7
EDELCA 1&2	765	4	1.31	49.2	48.2
EDELCA 3	765	4	1.31	43.3	44.9
KEPCO	765	6	1.20		62.3
POWERGRID	765	4	1.38	50.5	49.2

*Imperial conversion of units from IEEE PES, Overview of Transmission Lines Above 700kV, 2005

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Eskom	765	6	1.13	51.8

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TECHNICAL CONSIDERATIONS

IEEE Survey

Why do some lines need a wider right-of-way?

Company / Country	Width of RoW (ft.)	Mean Altitude (ft.)	Audible Noise (Rain) (dBA)	Max. Electric Field (kV/m)	Electric Field Edge of RoW (kV/m)
Hydro-Quebec 1	300.2	<985	51.2	2.85	0.46
Hydro-Quebec 2	262.5	<985	54.7	3.05	0.52
AEP 1	197.2	<985	59.2	4.07	1.22
AEP 1	197.2	1968.5	61.2	4.07	1.22
AEP 2	197.2	1968.5	57.5	3.44	1.25
AEP 3	299.9	2624.7	54.5	3.67	1.34
NYPA 1	350.1	<985	50.5	3.02	0.49
Eskom	262.5	**4921.3**	53	3.28	0.73
FURNAS 1 & 2	574.1	2624.7	58		
FURNAS 3	295.3	2624.7	58		
EDELCA 1&2	393.7	<985	52.2	3.12	0.21
EDELCA 3	295.3	<985	55	3.35	0.40
KEPCO	121.4	<985	50		1.07
POWERGRID	278.9	<985	54.3	3.28	0.61

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TECHNICAL CONSIDERATIONS

IEEE Survey

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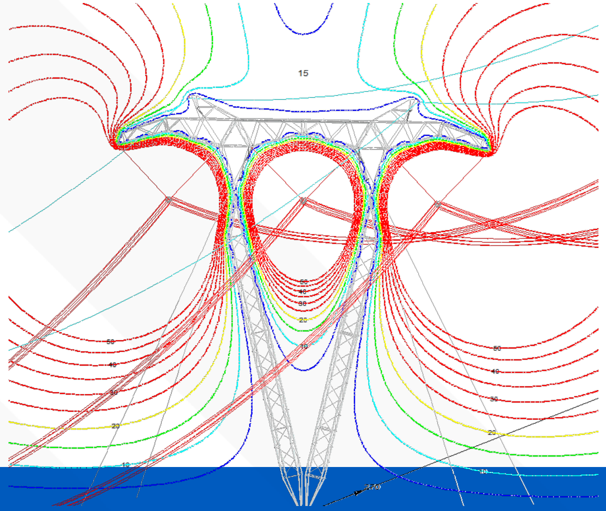
TECHNICAL CONSIDERATIONS

Studies
- EMI
- Conductor Selection
- Insulator Coordination
- EMF
- Corona
- Lightning & Grounding

Common Concerns
Adjacent Utility Impacts
Nuisance Shocks
Transmission Line Performance
EMF
Audible Noise
Outages

IF YOU DON'T TEST, YOU DON'T KNOW



TECHNICAL CONSIDERATIONS

Design Decisions - Standardization

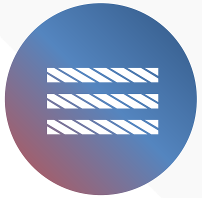
- Tower Family
  - Base Tangent
  - Dead-end / Angle Structures
- Hardware Design
  - Suspension Assemblies
  - Dead-end Assemblies
- Maintainability
  - Design for Live-line Maintainability

- Station A-frame Structures

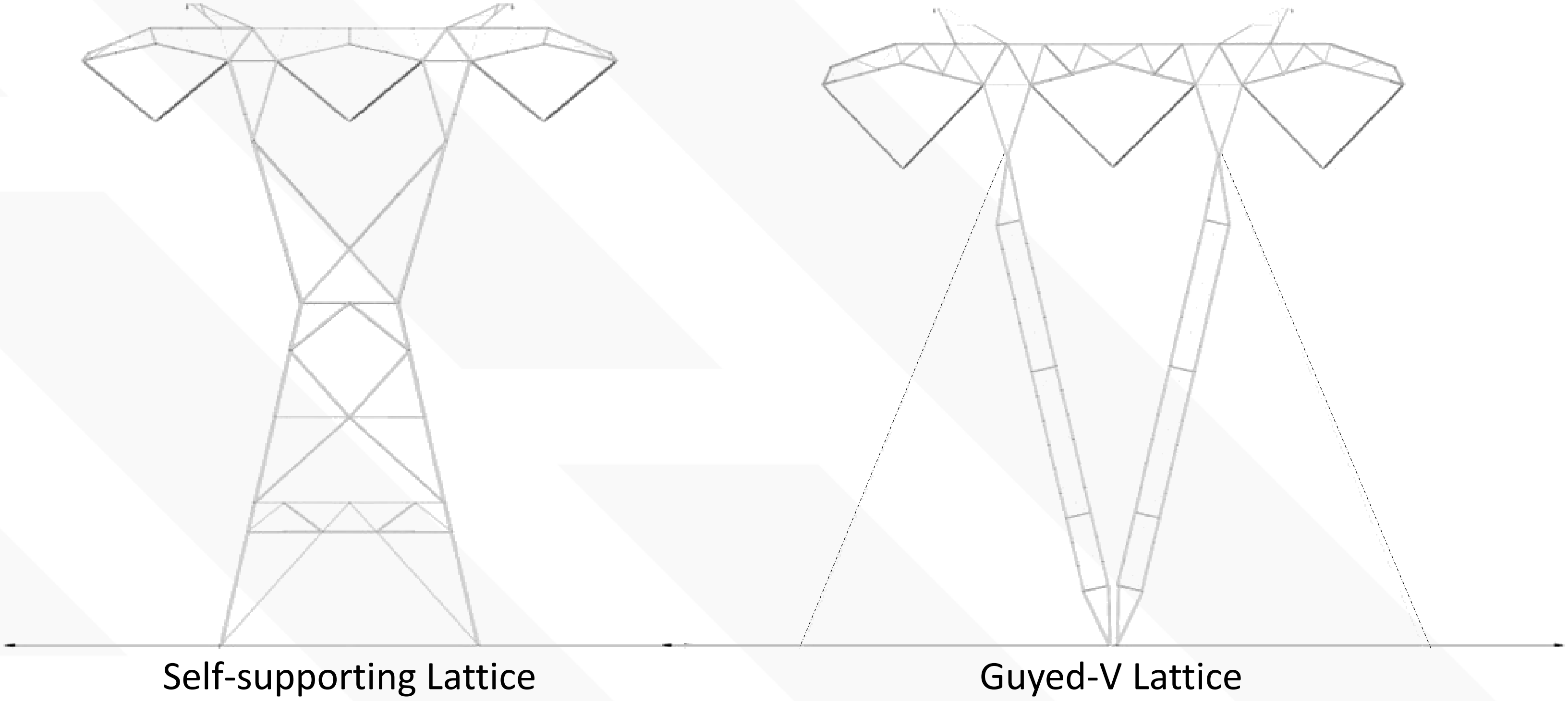
TECHNICAL CONSIDERATIONS

Studies

- Tower Compaction – Task affecting structure electrical performance (surge clearances)
  - System performance impact (increased power flow)
- Risk Mitigation in Construction – Quantifying risk in design



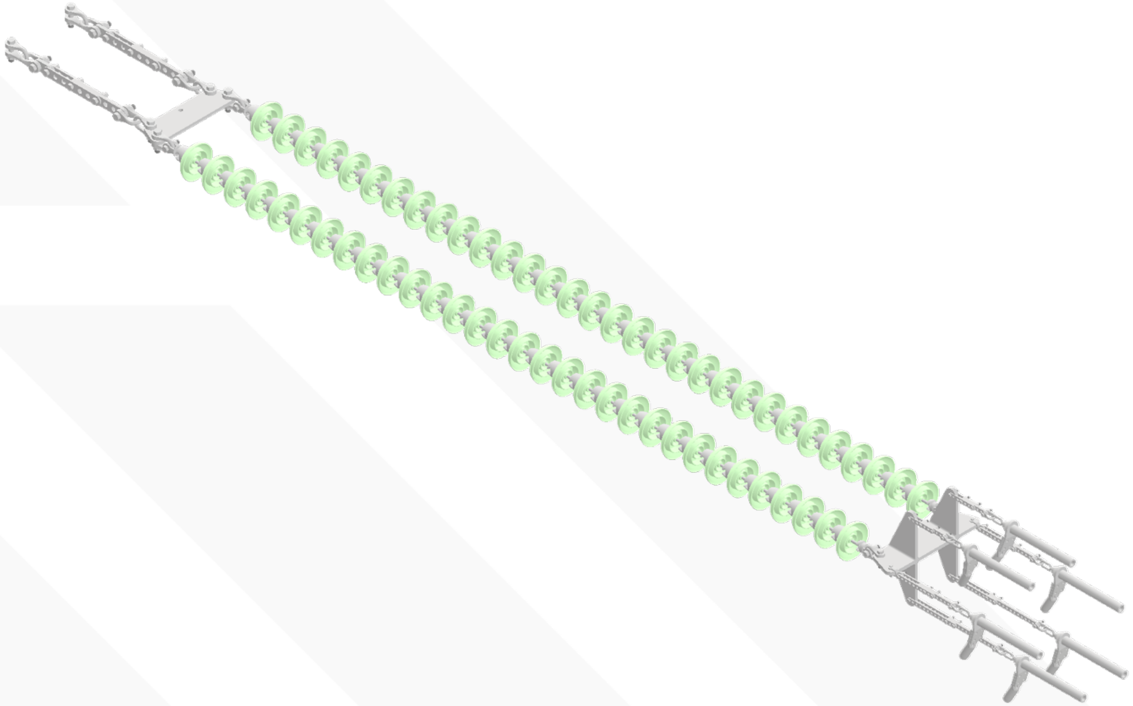
What is the real benefit of guyed-V structures?



TECHNICAL CONSIDERATIONS

Cost Benefit

- A double circuit 500kV tower is usually taller than a single circuit 765kV tower.
- Environmentally friendly
  - Insulator and air gaps are typically large enough that they cannot be breached by bird streamers.
- Less structural load than a 500kV Double Circuit line (vertical and transverse)
- Less assemblies, less insulators, lesser risk
- Less conductor cost
- Lower risk of cascade failure



What are the other benefits?

TECHNICAL CONSIDERATIONS

Vendor Management & Equipment Testing

- It is not only T-line designers that have not done EHV design for a long time.
- Hardware manufacturers must make custom assemblies and test them.
  - Can add 8 months to critical path for testing.
  - Review & Testing of Aeolian vibration damping devices on hex bundles.

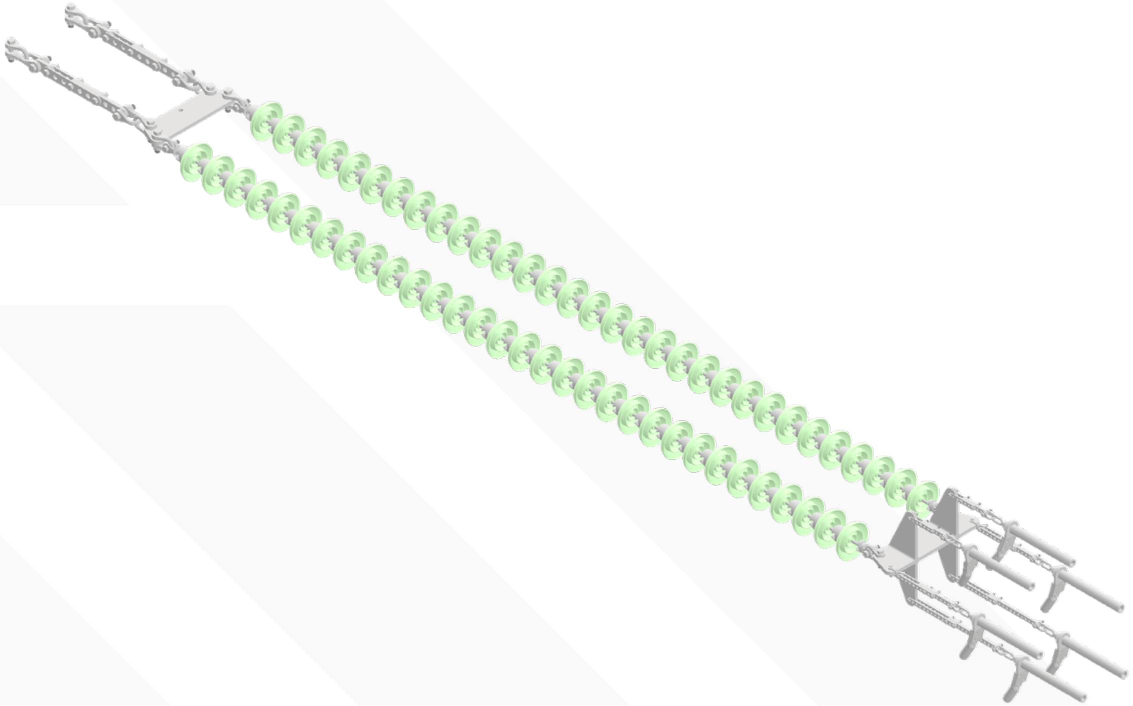
1. Establish Standards
2. Secure Knowledgeable Team
3. Find & Assess the Vendors
4. Inspect Manufacturing Facilities
5. Identify Testing Stations
6. Test Manufactured Assemblies

TECHNICAL CONSIDERATIONS

Strategy for success

- Needs more time in planning and testing:
  - Planning and switching studies
  - Hardware testing
  - Tower gap testing (possible req.)
  - RIV/Corona & Noise testing
  - Structure destructive testing

- Due to increased risk associated with faults, testing is required. It is expensive to fix after application.



What are the other benefits?

Questions?

CREATE AMAZING.