OCTOBER 24, 2023

HVDC Transmission: Case Study

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The Energy Transition

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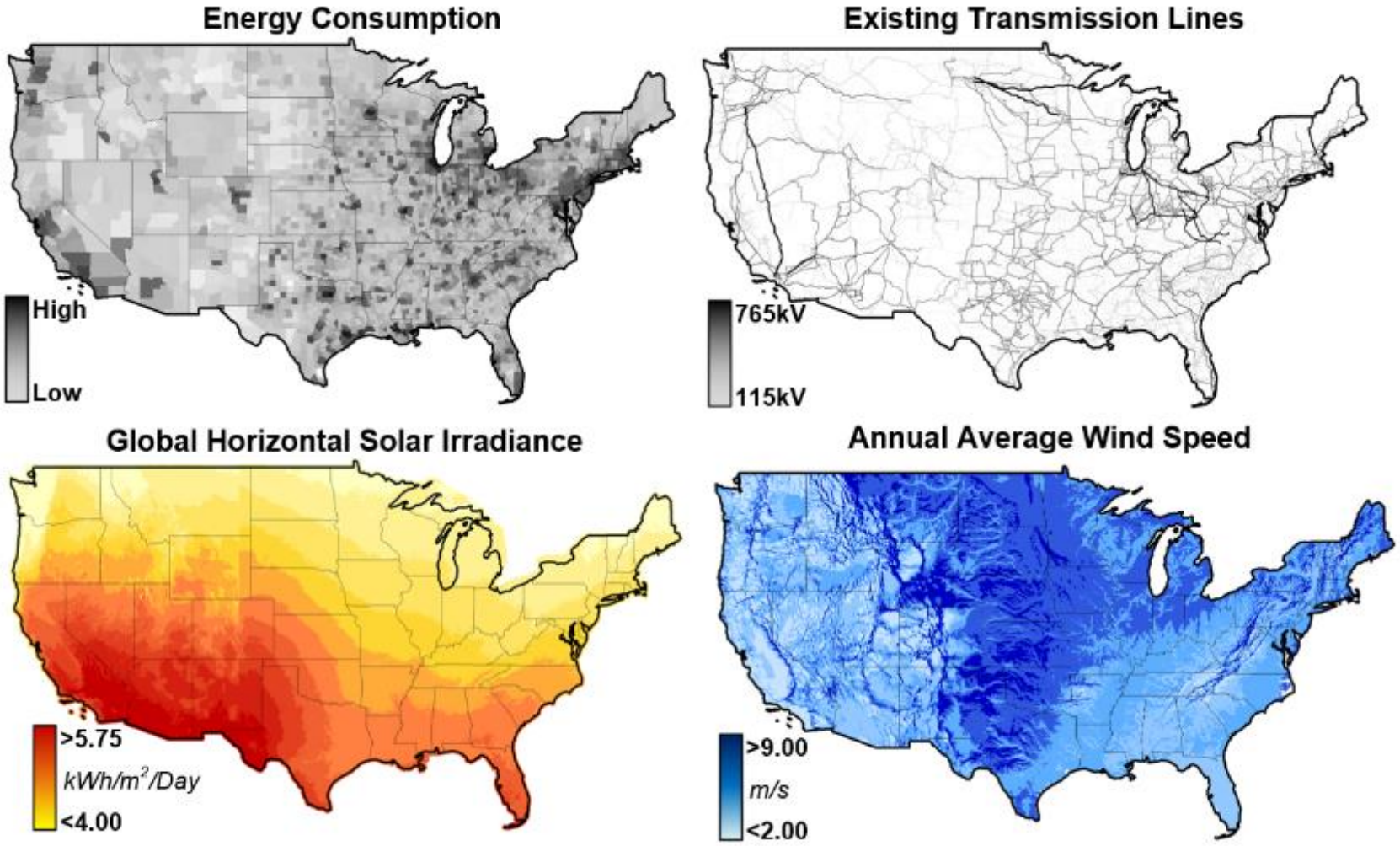
Renewable Resource vs. Infrastructure



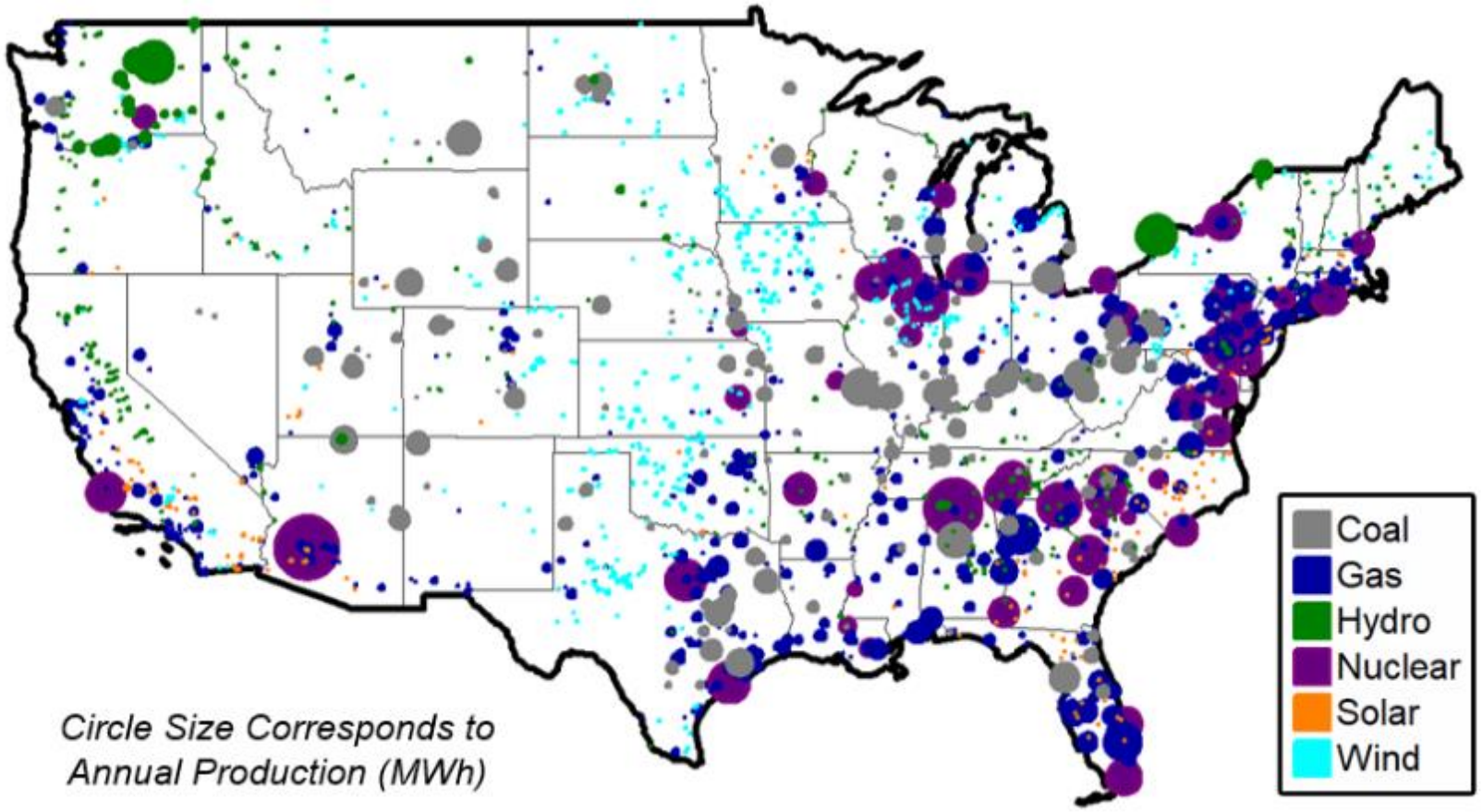
Origins as a regional network of thermal generation and nearby load

- Limited transmission across broader regions
- Bottleneck limiting access to best renewable resource

Map data from NREL and EIA, 2023

U.S. Generation, 2022

Renewable generation is concentrated in areas with high resource efficiency



Map data from HIFLD, 2023

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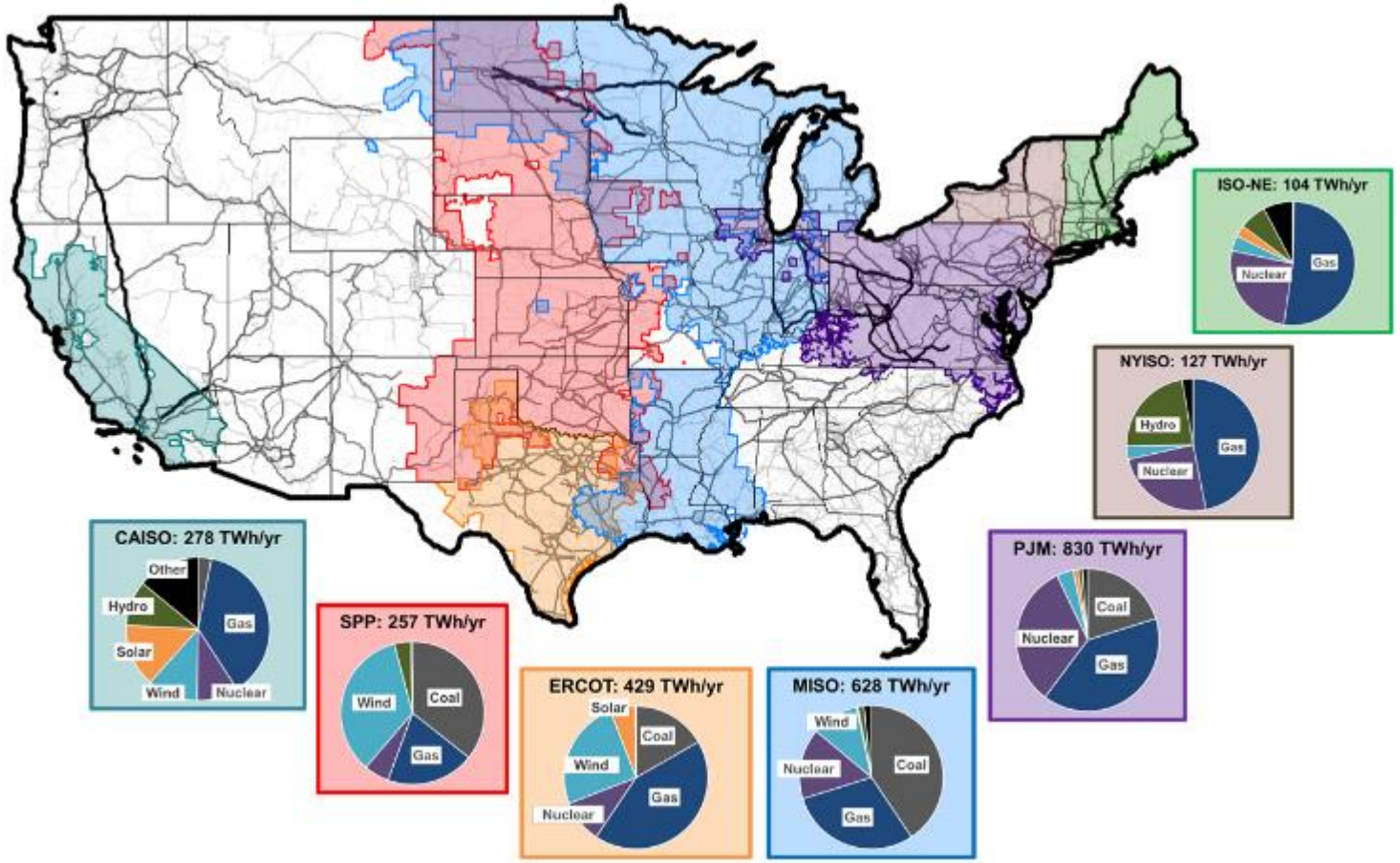
Limited Interregional Transmission

Interregional transmission is necessary to extend reach of best renewable resource



Map data from HIFLD, 2023.
Generation mix data per ISOs

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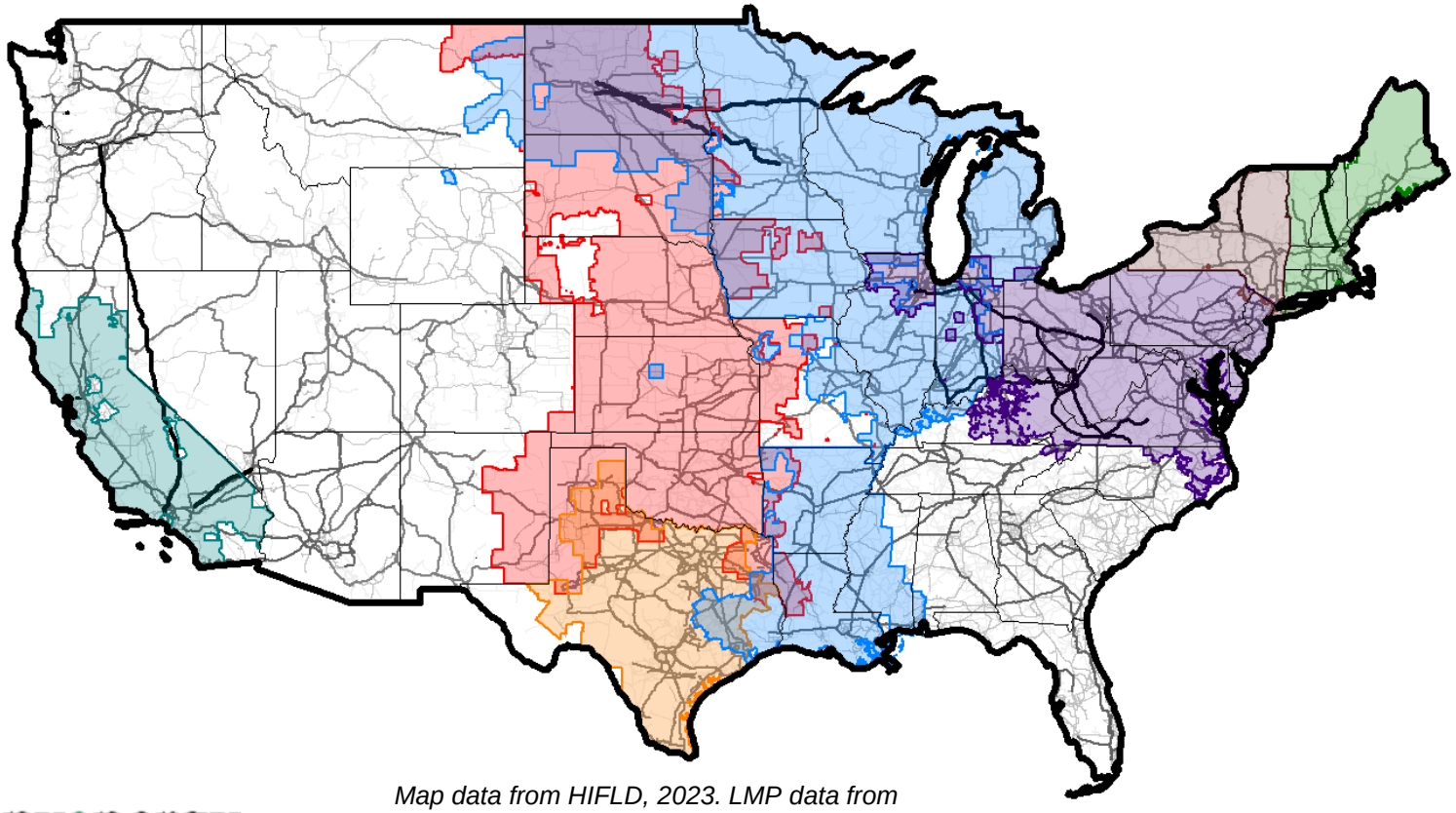
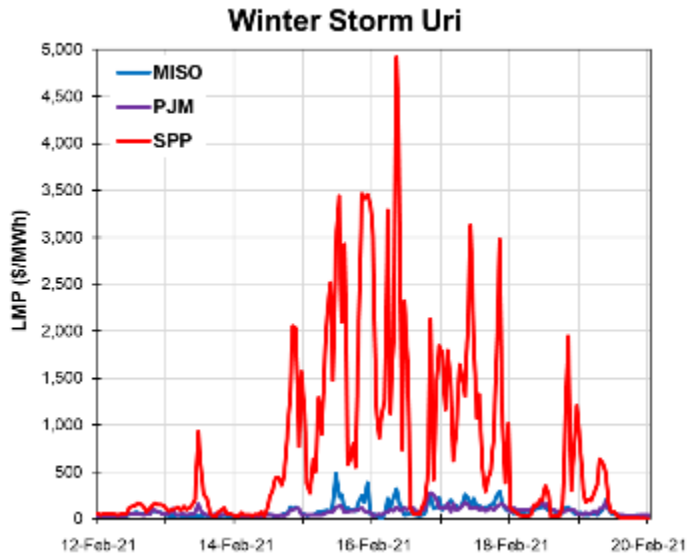
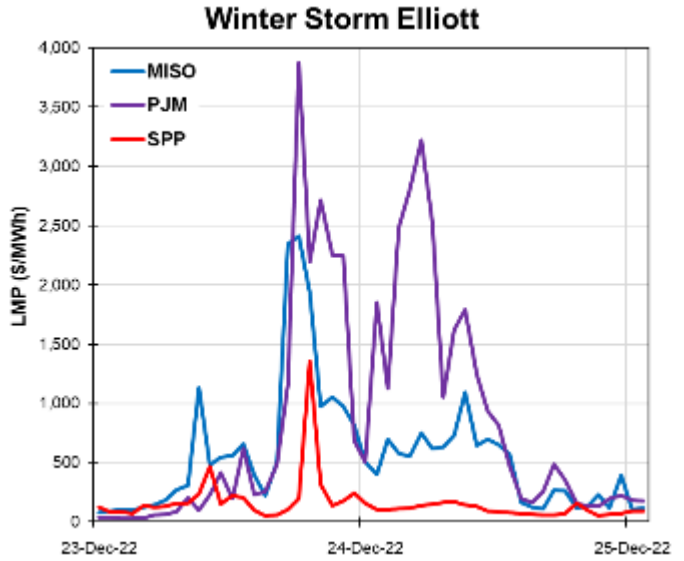
Limited Interregional Transmission

Interregional transmission would provide support in extreme weather events



Map data from HIFLD, 2023. LMP data from Hitachi Energy Velocity Suite





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HVDC as a Solution

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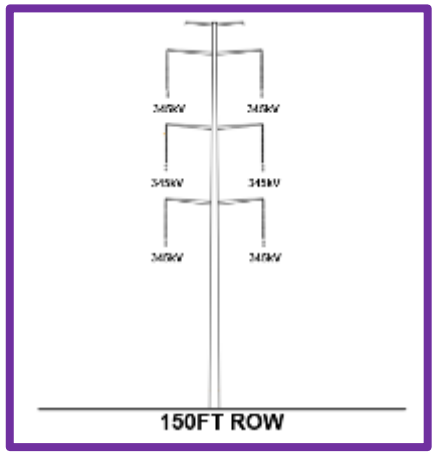
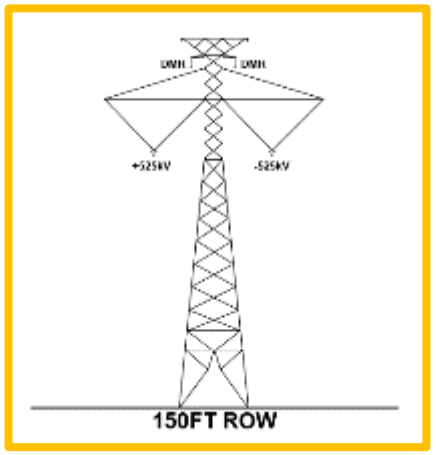
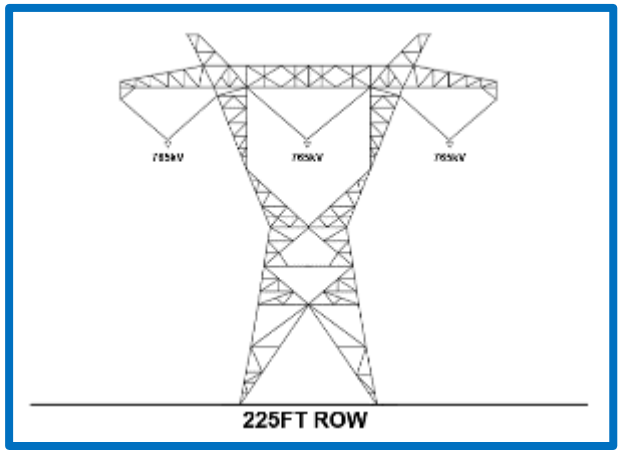
Potential Solutions

Double Ckt. 345kV



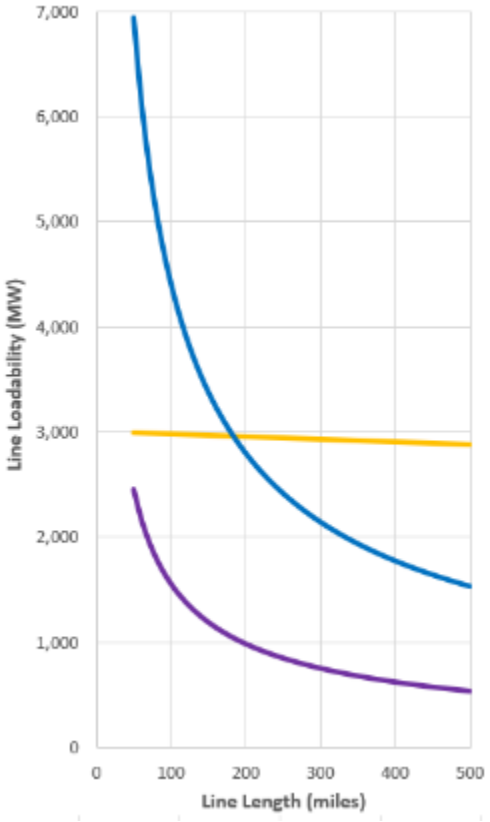
HVDC Bipole





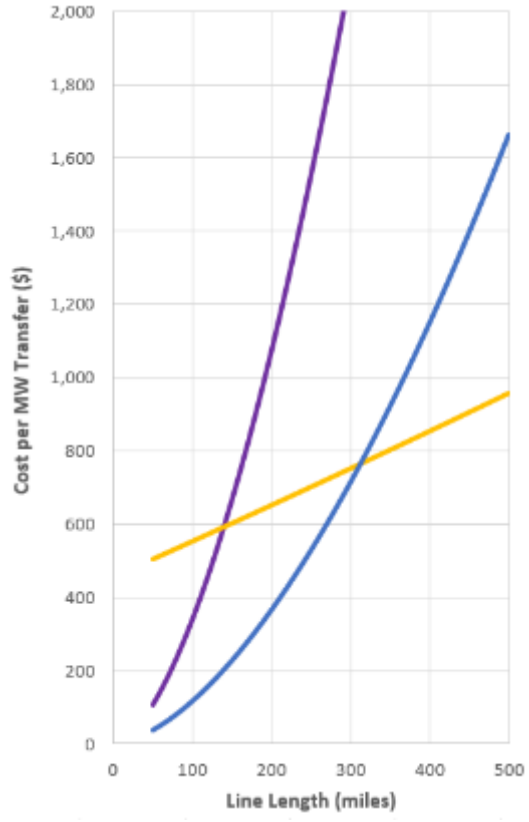
Single Ckt. 765kV

Power Transfer Capability*



*without series compensation

Cost of Power Transfer**



** estimates per 2023 MISO Cost Estimation Guide

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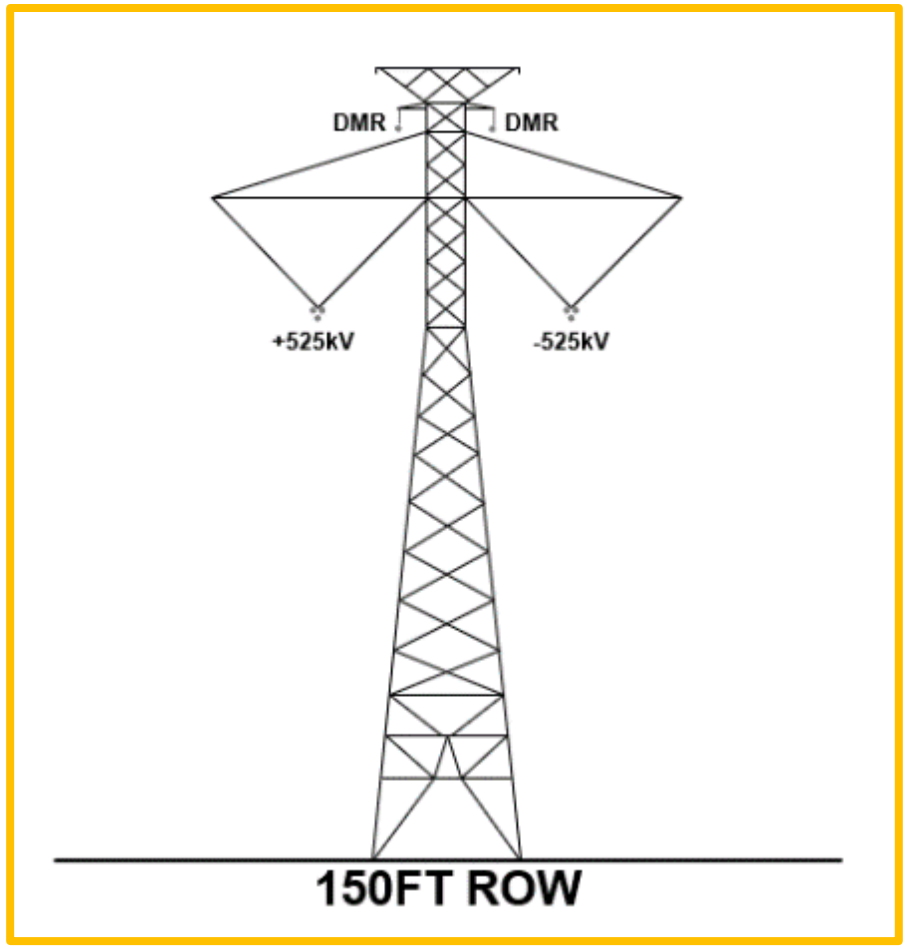
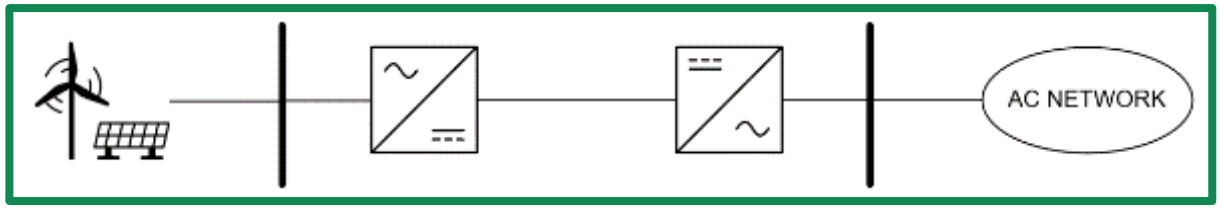
HVDC for Interregional Transmission



Long-distance, high power, and weak AC systems: VSC-HVDC

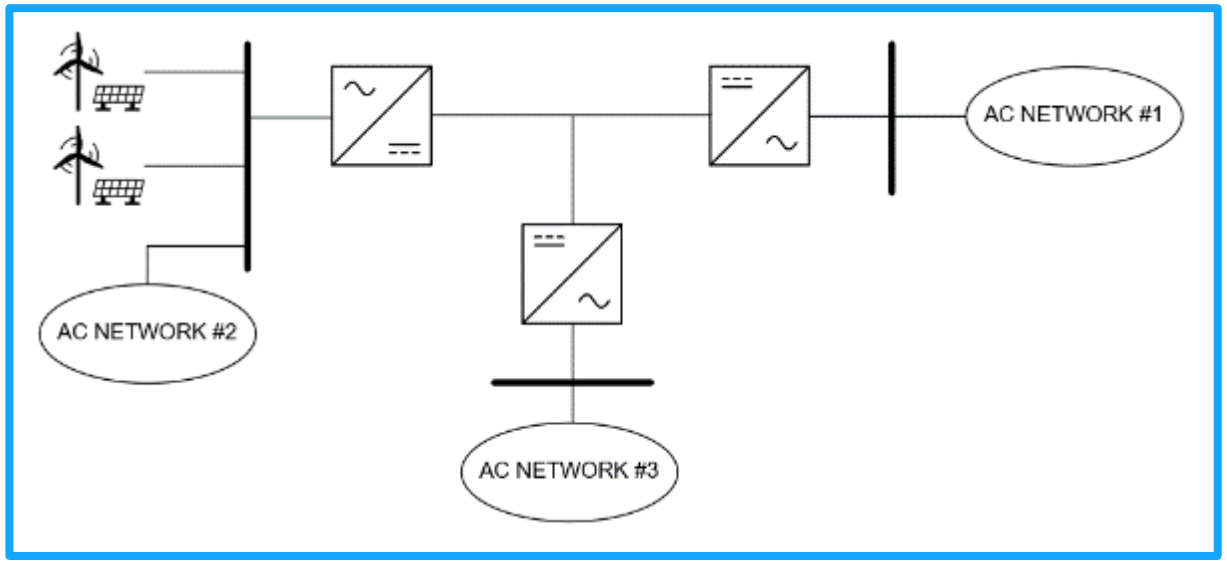
- Greater electrical efficiency
- Smaller rights of way
- Improved system stability and control
- Less conductor cross section
- Avoids AC compensation
- Connections between weak AC systems
- Connections between asynchronous interconnections

HVDC Project Topologies



Typical Renewable Energy Interconnector

- Islanded generation system
- Point-to-point HVDC
- Similar to offshore wind applications



Designing for Interregional Transfer Capability

- Long distance overhead line
- Multiterminal HVDC
- AC network connection at generation bus

AC Interconnection Challenges

Interconnection Procedures

- Different procedures for each RTO
- Often no specific procedures for HVDC
- HVDC may be lumped into the lengthy generation process
- *Need to standardize HVDC interconnection procedures*

Technical Requirements

- Inconsistent between RTOs, system operators, and utilities
- Often not defined, vague, and/or based on general IBR requirements
- May not fully utilize VSC-HVDC ancillary services
- *Need to develop standardized HVDC requirements*

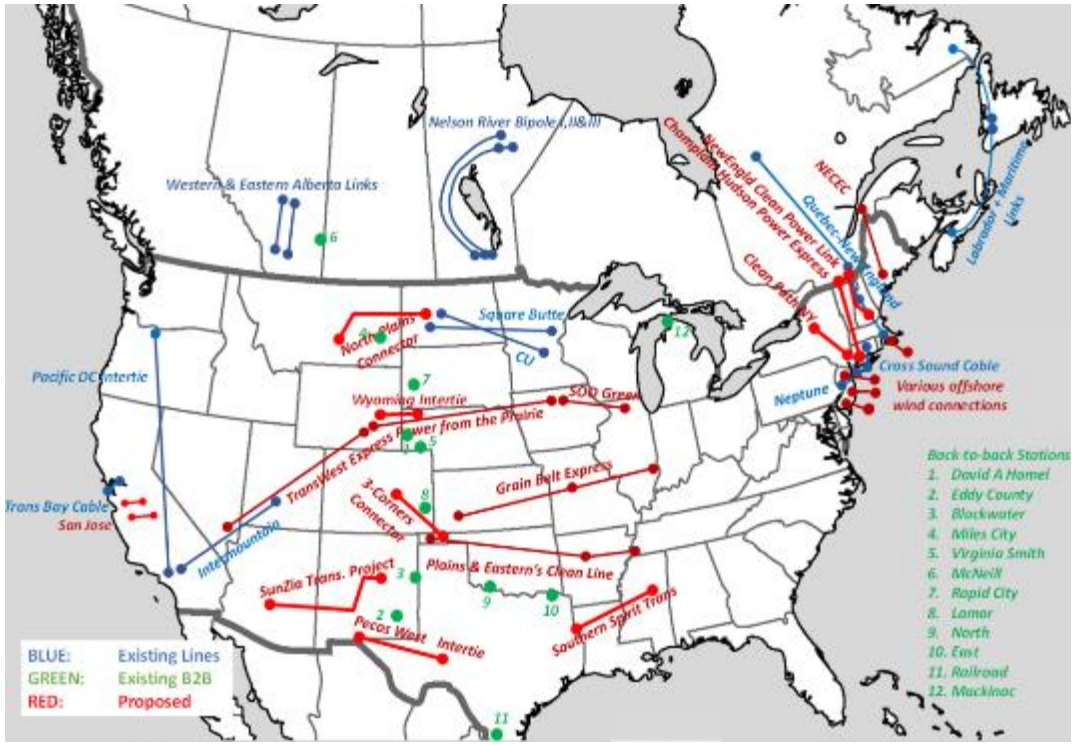
Cost Allocation of Network Upgrades

- Typically subject to generator interconnection cost allocation methods
- Particularly high costs assigned to HVDC due to gigawatt scale
- *Need to discuss reasonable cost allocation mechanisms for merchant HVDC*

Interregional transmission = more AC interconnections = more complexity caused by the above

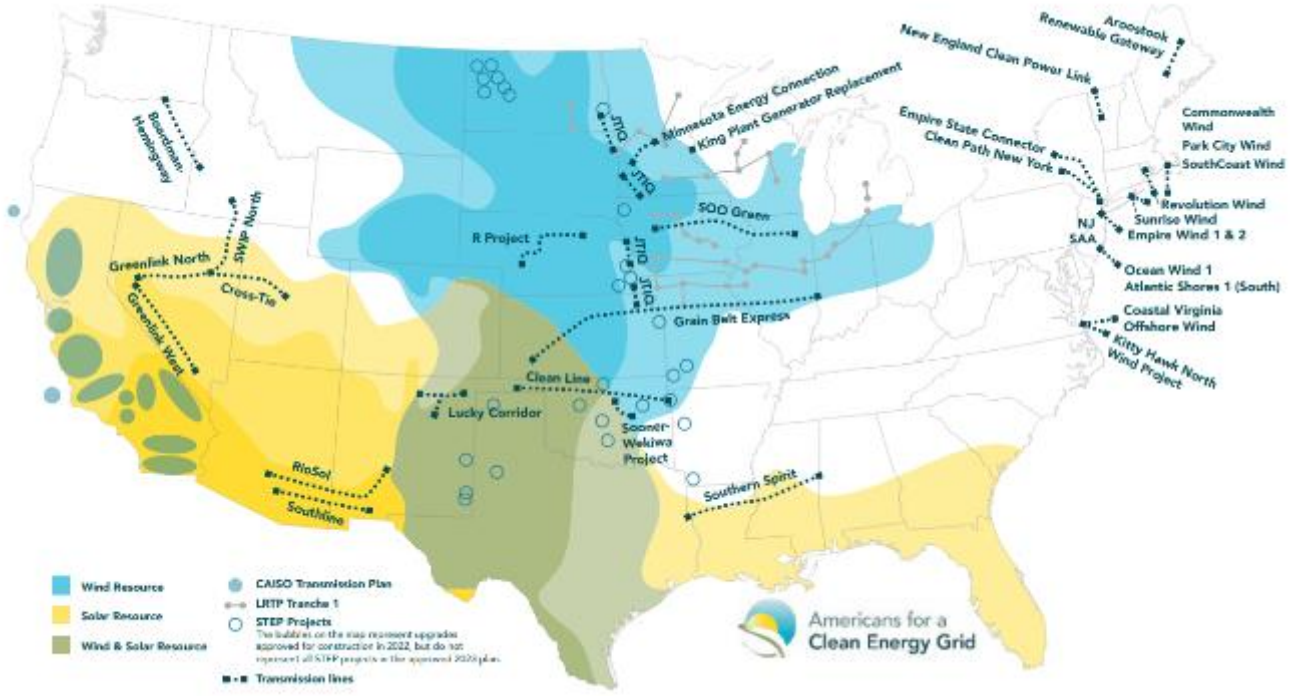
Ongoing Work

HVDC Projects in North America



Jim McCalley, Iowa State University

Shovel-Ready Transmission Projects



ACEG Transmission Projects Ready-to-Go, Sep. 2023

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Case Study: Grain Belt Express

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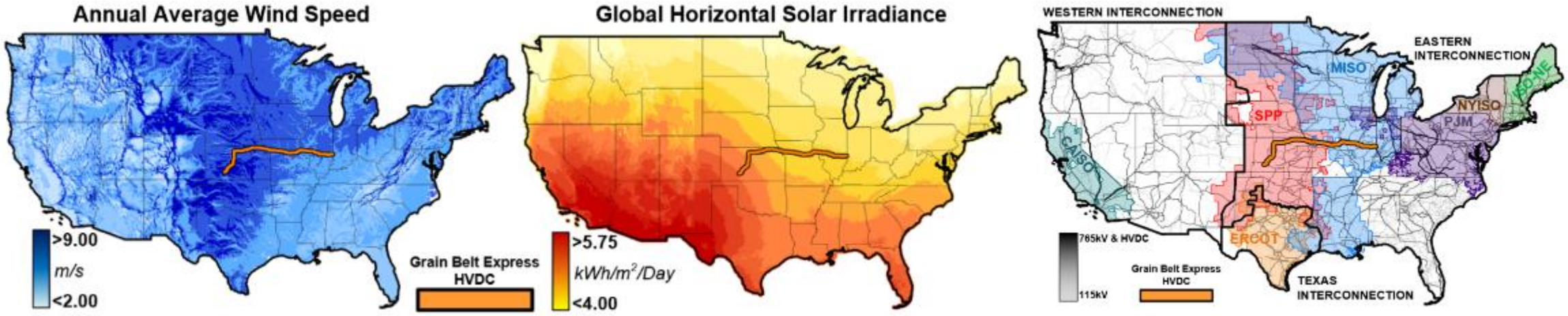
Grain Belt Express – Fundamentals

1. Access to low-cost, high capacity factor wind and solar resource
2. Generation uncorrelated to local resource
3. Interregional transfer capability – bidirectional power flow, system restoration



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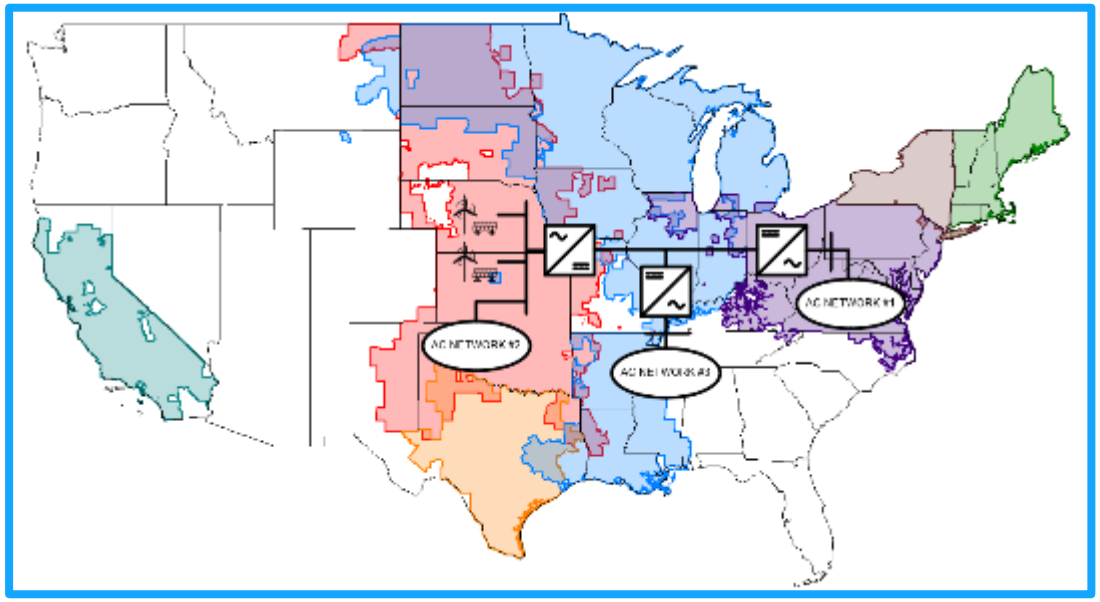
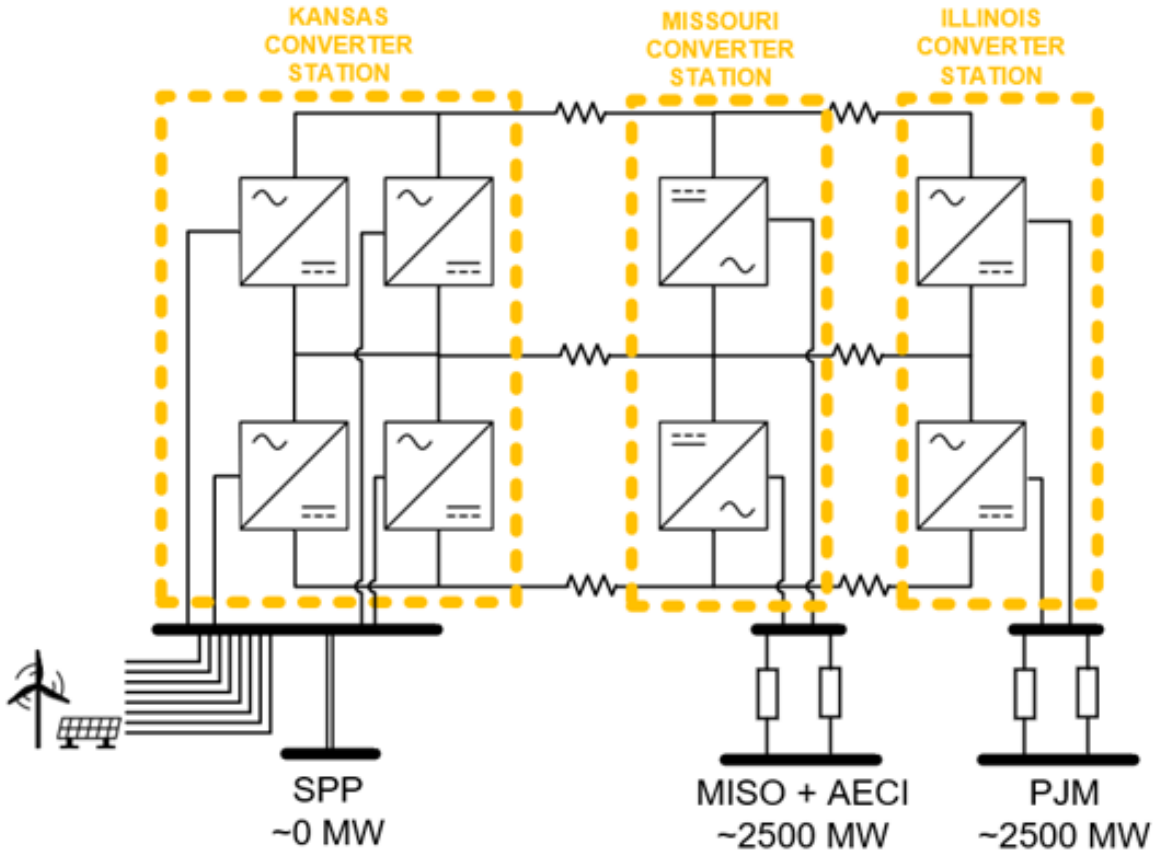
Interregional Transfer Capability





Grain Belt Express – Project Design

Key Design Parameters	
Nominal DC Voltage	±600 kV
Nominal AC Voltage	345 kV
Delivered Power	5,000 MW
Converter Topology	Bipole with DMR
Converter Type	VSC

Key Advancements in Technology:

- Power and voltage ratings of VSC-HVDC
- Multiterminal HVDC grid control
- VSC-HVDC DC fault response
- Integration of renewables with VSC-HVDC

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Summary

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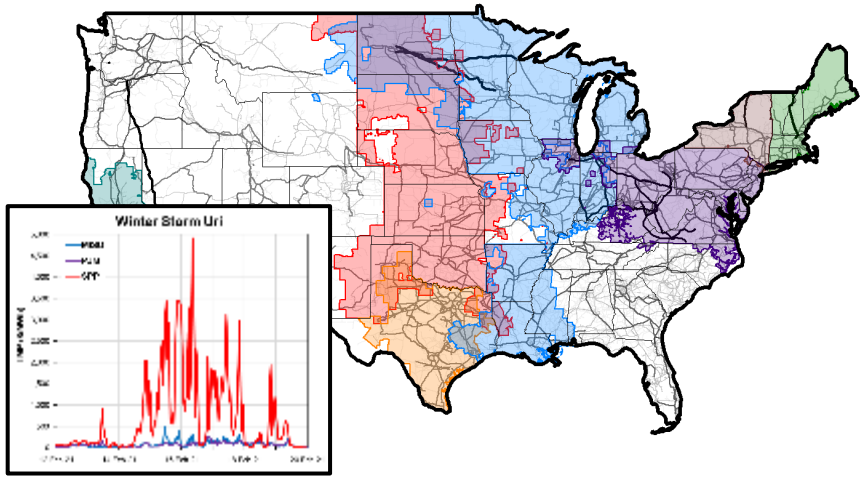
Conclusions

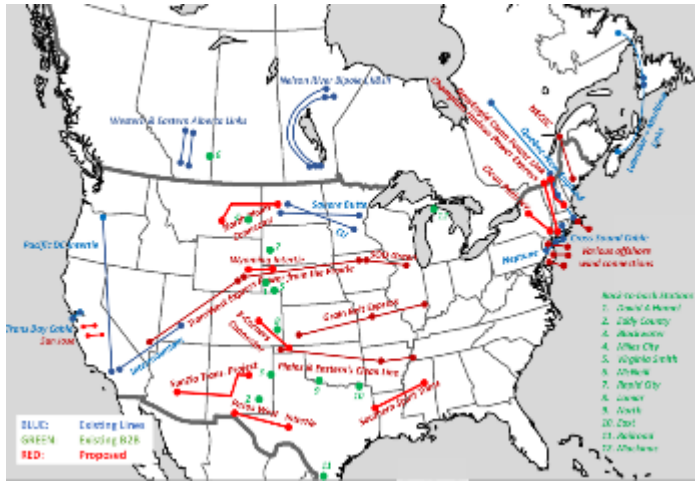
1

There is a tremendous need for interregional transmission



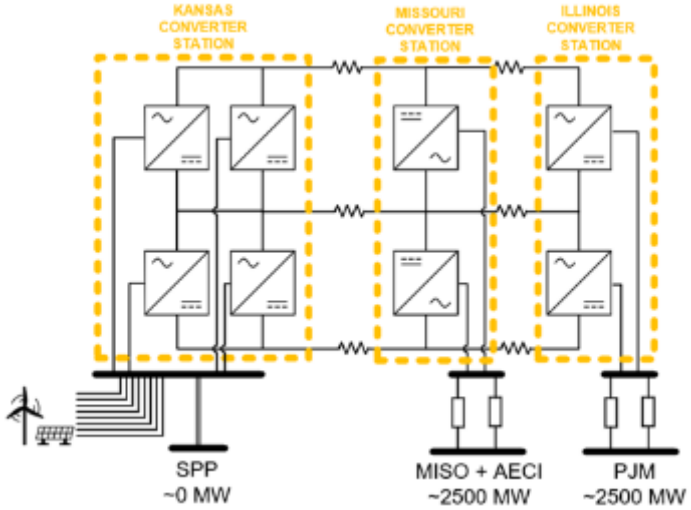
2

HVDC interconnectors are being developed to support



3

Technology is capable and actively being implemented



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Questions?

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