



OCTOBER 24, 2023

HVDC Transmission: Case Study

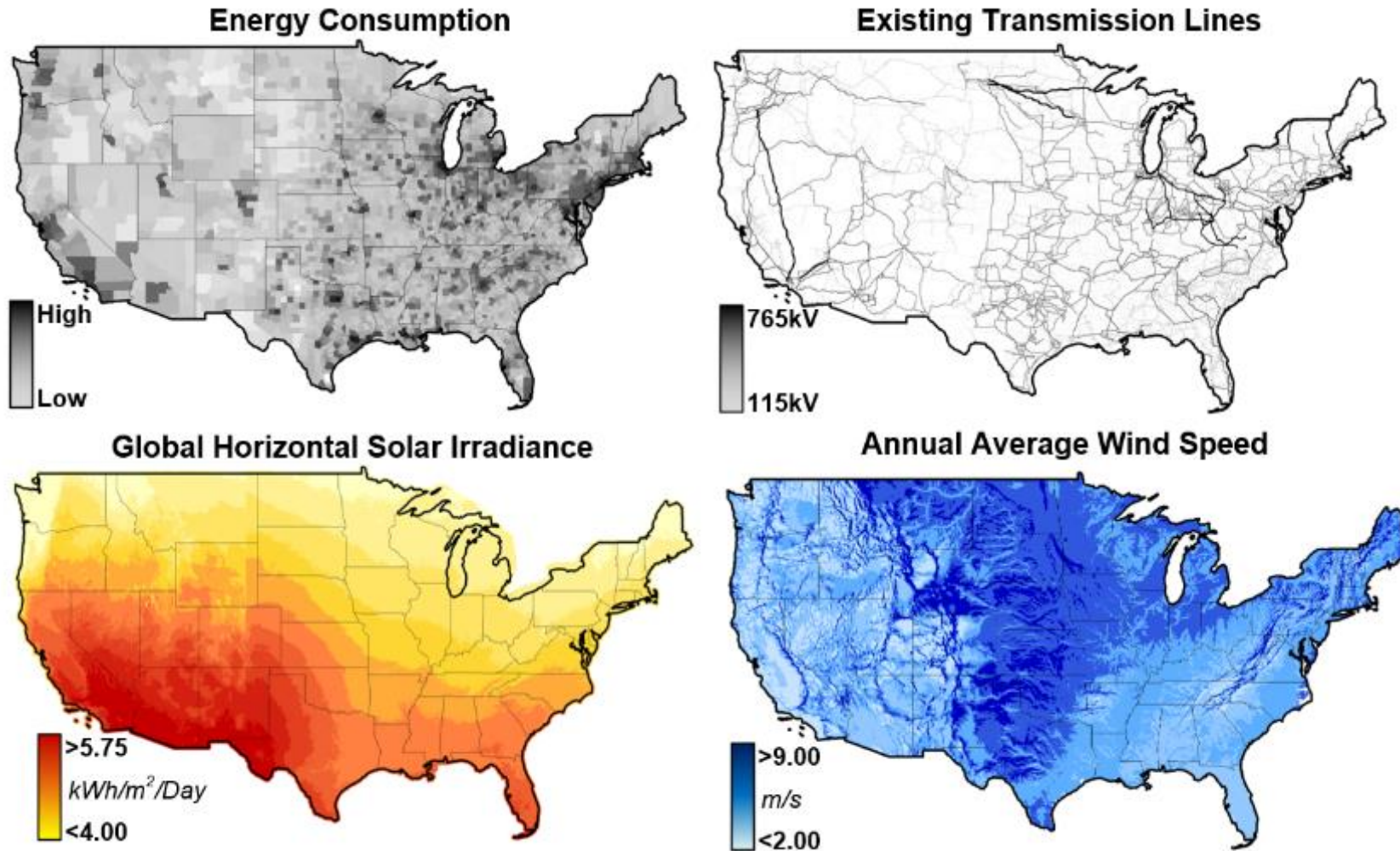
Henry Abrams, Rajat Majumder

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The Energy Transition

Renewable Resource vs. Infrastructure

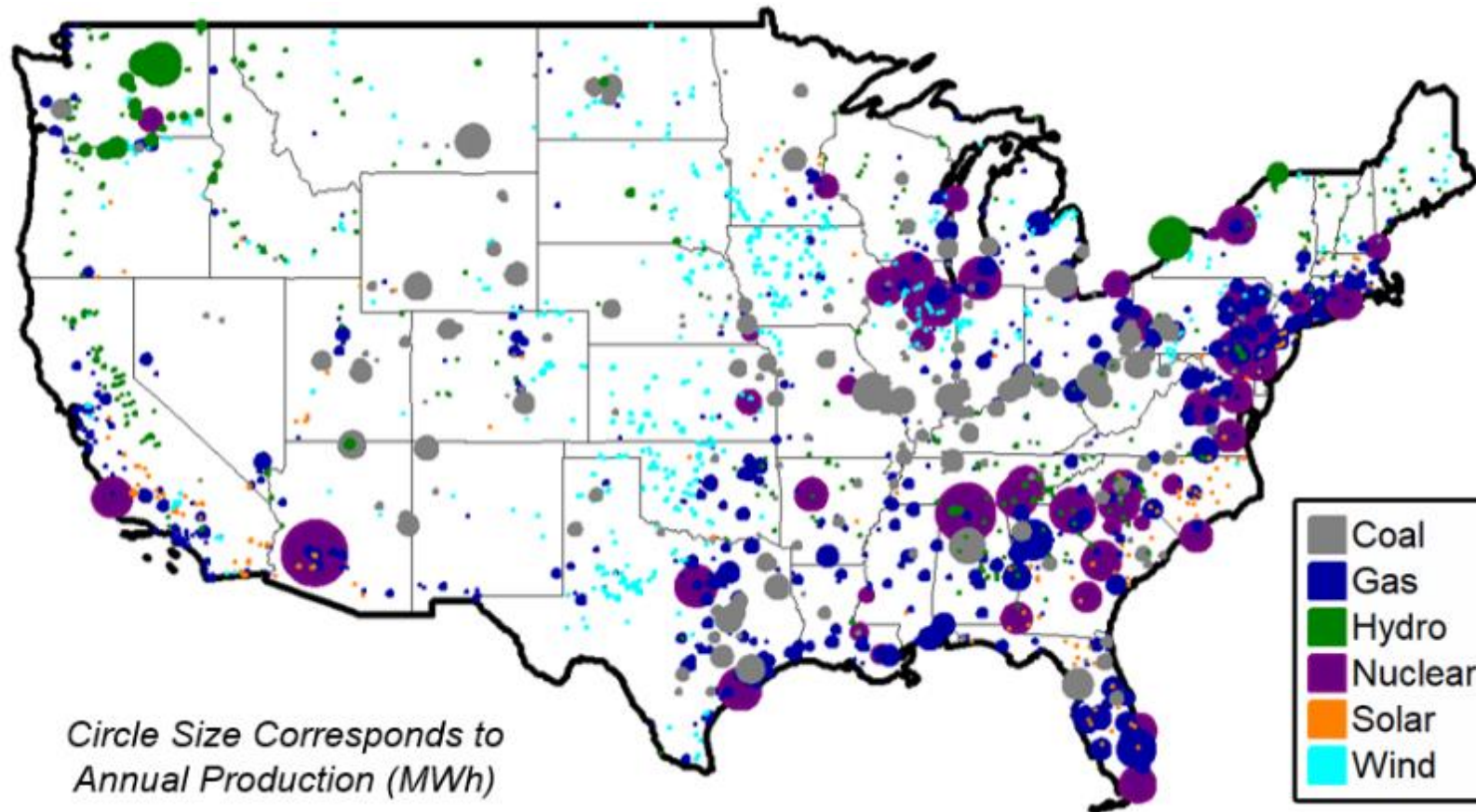


Origins as a regional network of thermal generation and nearby load

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

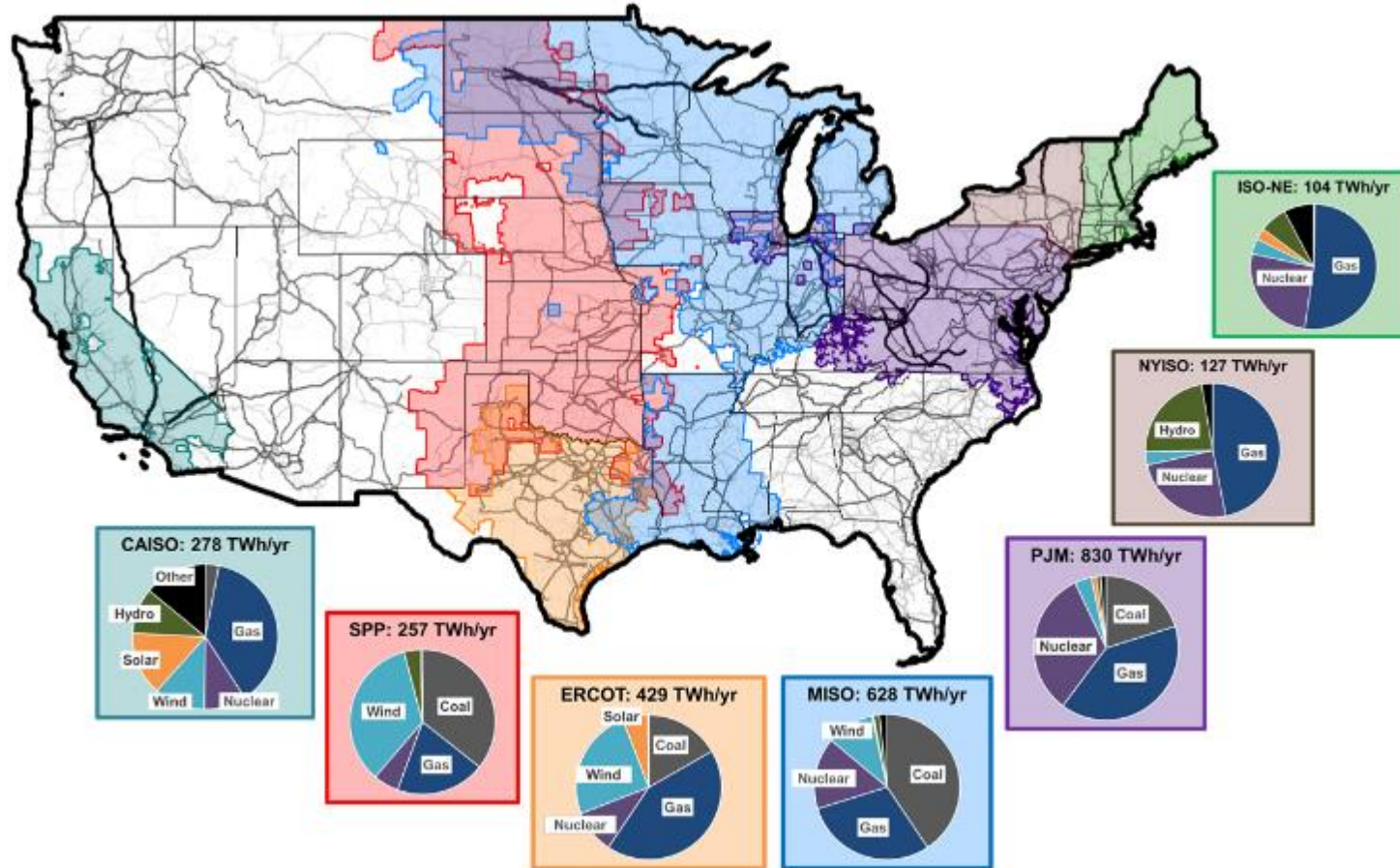
U.S. Generation, 2022

Renewable generation is concentrated in areas with high resource efficiency



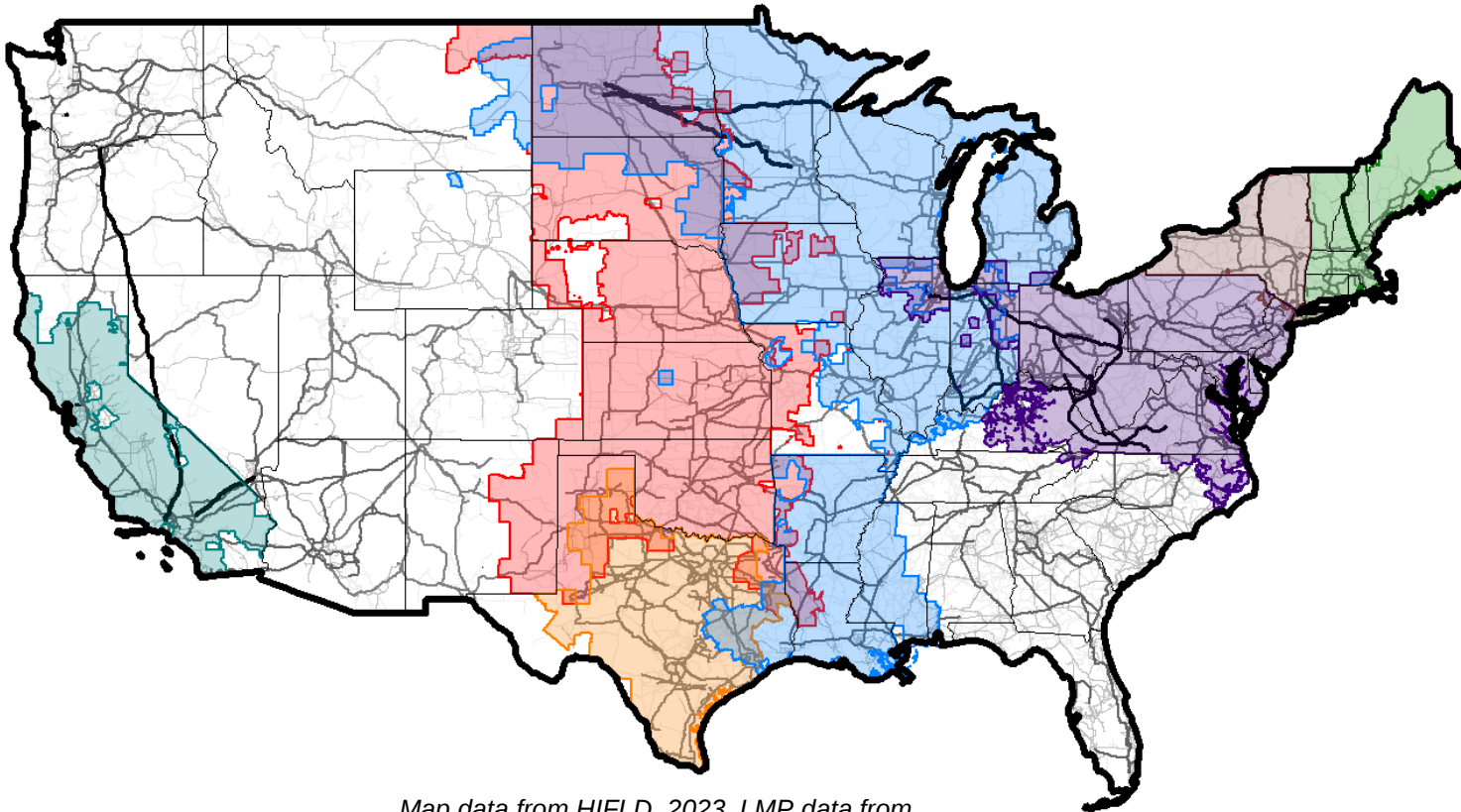
Limited Interregional Transmission

Interregional transmission is necessary to extend reach of best renewable resource

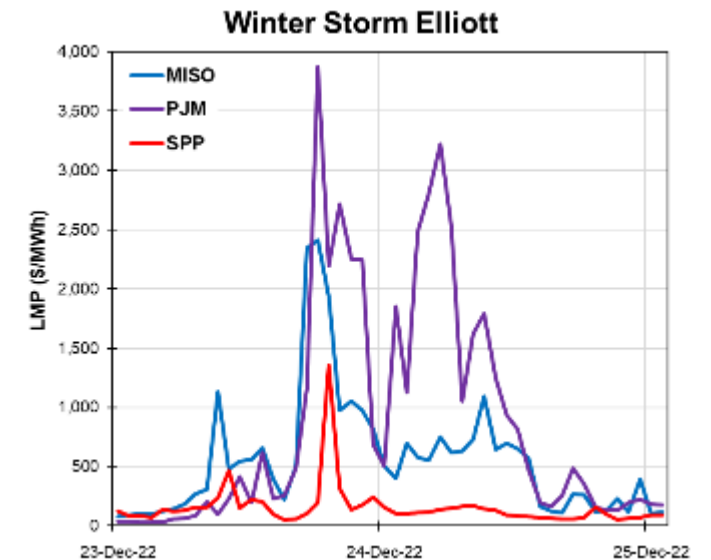
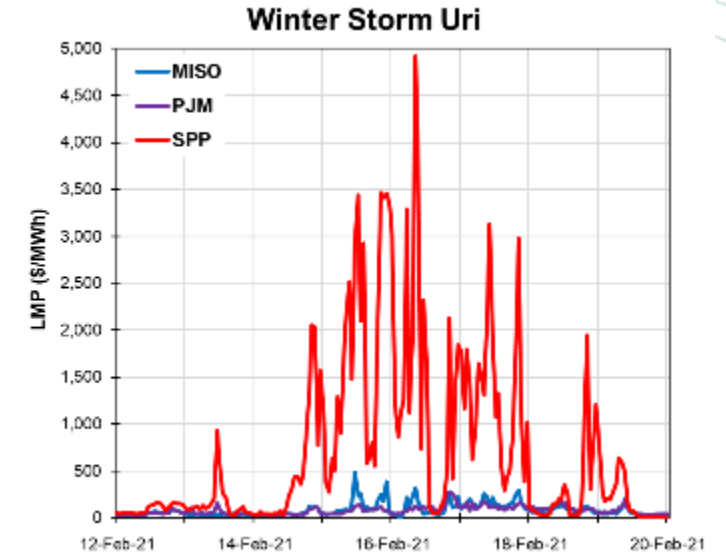


Limited Interregional Transmission

Interregional transmission would provide support in extreme weather events



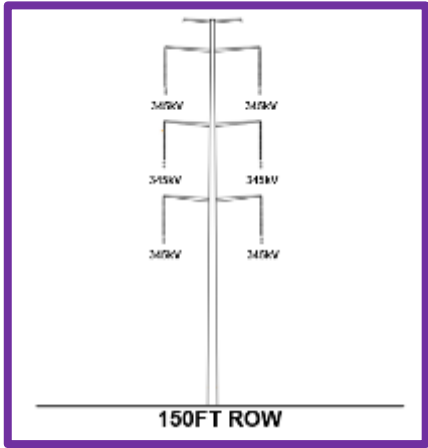
Map data from HIFLD, 2023. LMP data from Hitachi Energy Velocity Suite



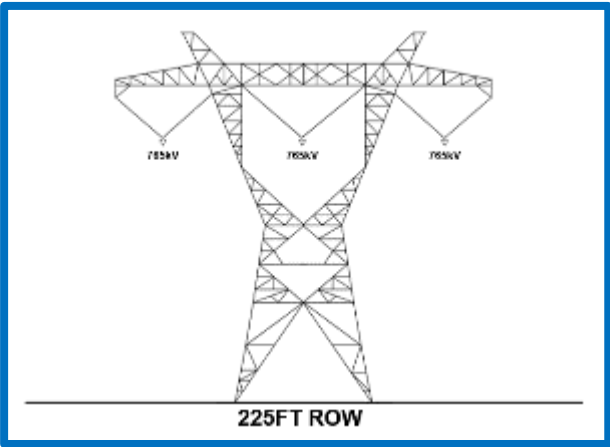
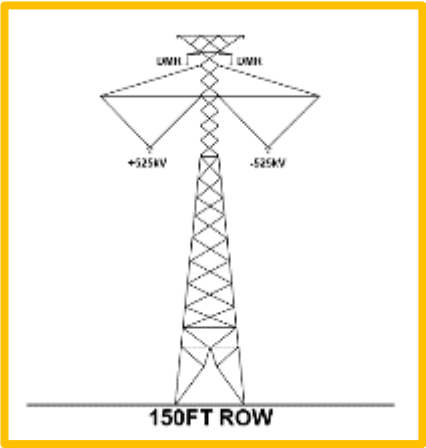
HVDC as a Solution

Potential Solutions

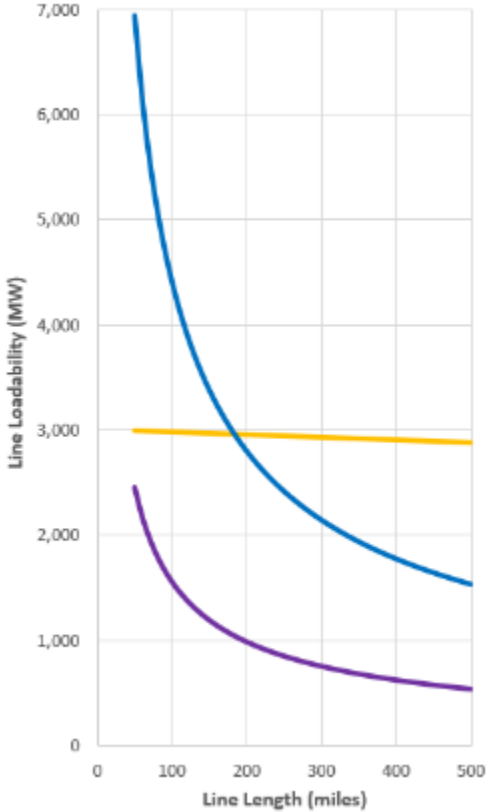
Double Ckt. 345kV



HVDC Bipole

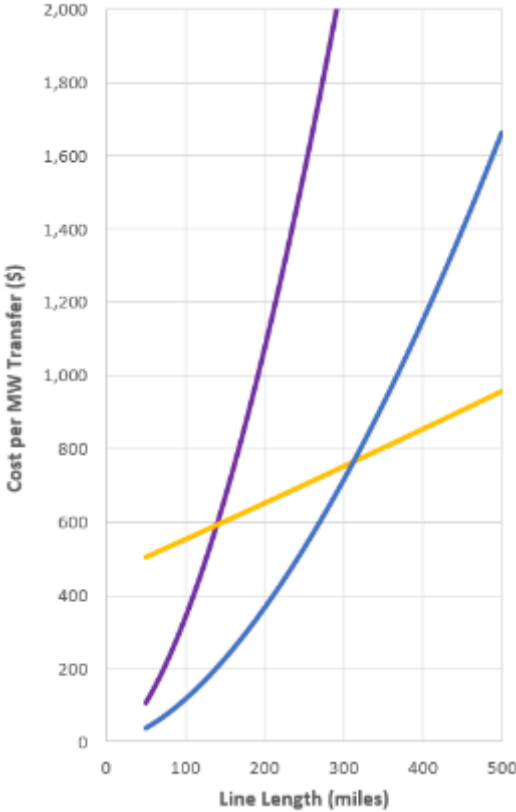


Power Transfer Capability*



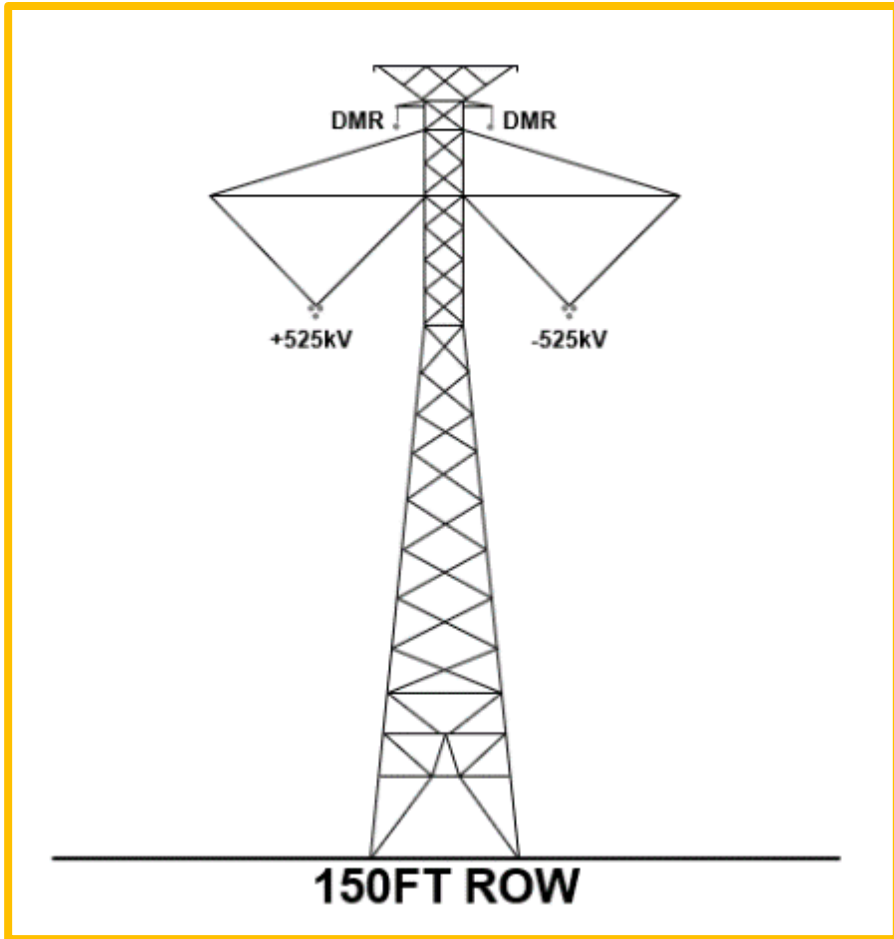
*without series compensation

Cost of Power Transfer**



** estimates per 2023 MISO Cost Estimation Guide

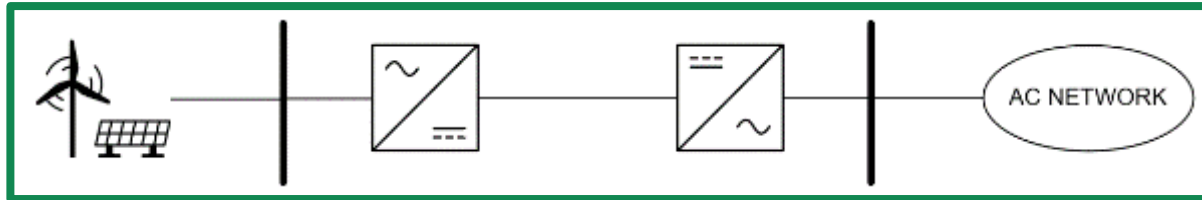
HVDC for Interregional Transmission



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

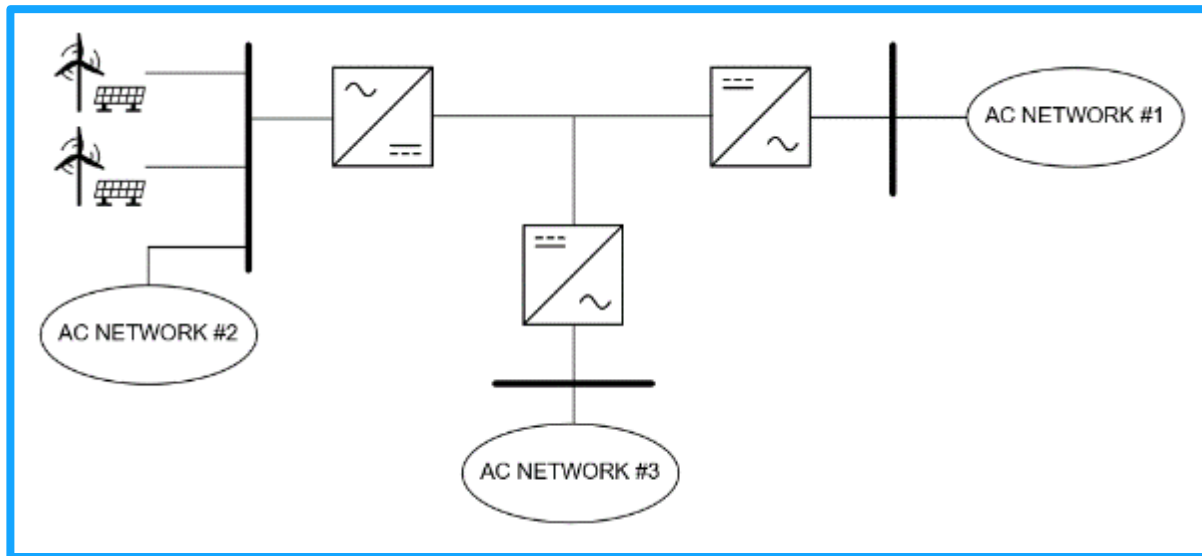
- Greater electrical efficiency
- Smaller rights of way
- Improved system stability and control
- Less conductor cross section
- Avoids AC compensation
- Connections between weak AC systems
- Connections between asynchronous interconnections

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

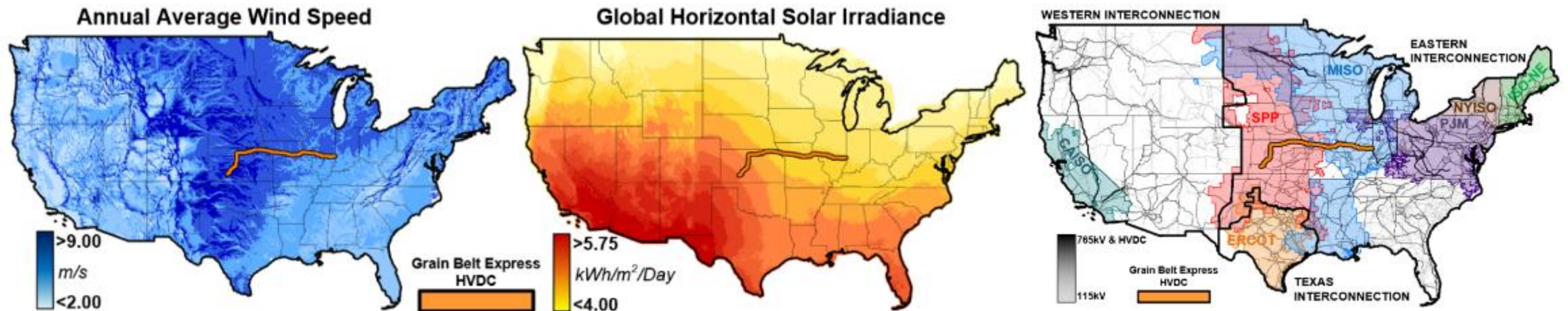
Jim McCalley, Iowa State University

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

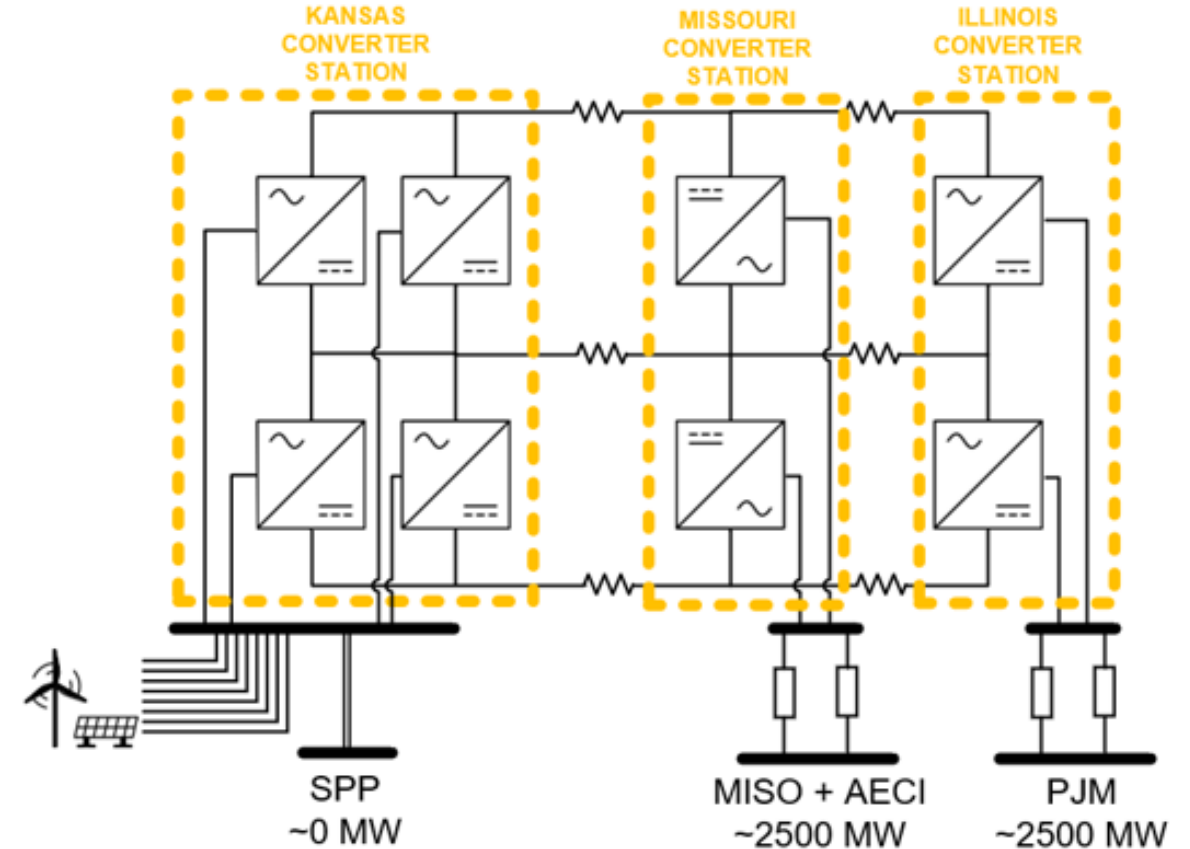
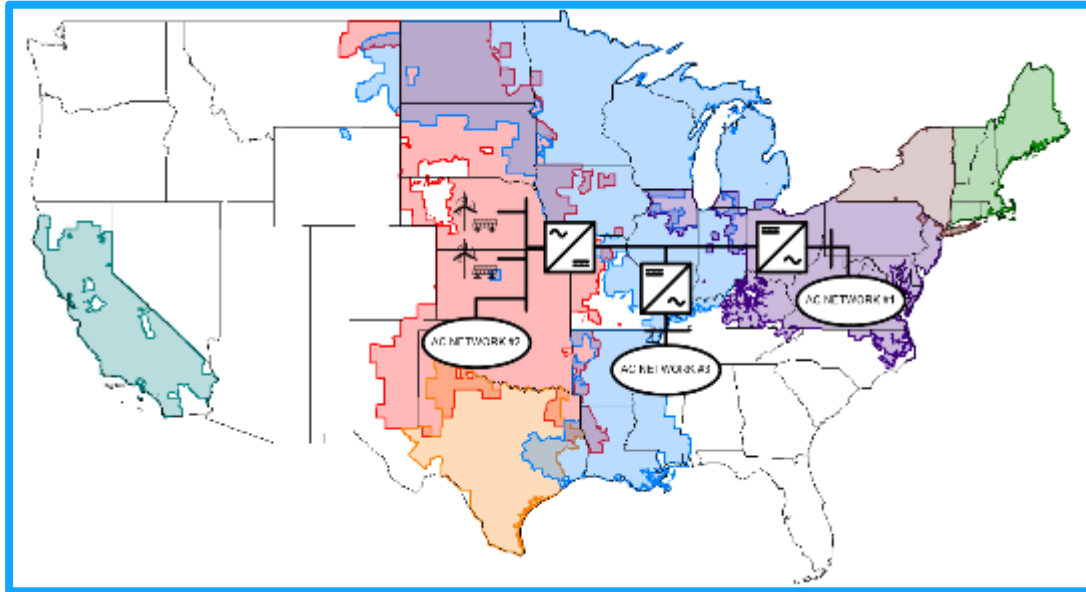
Case Study: Grain Belt Express

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



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

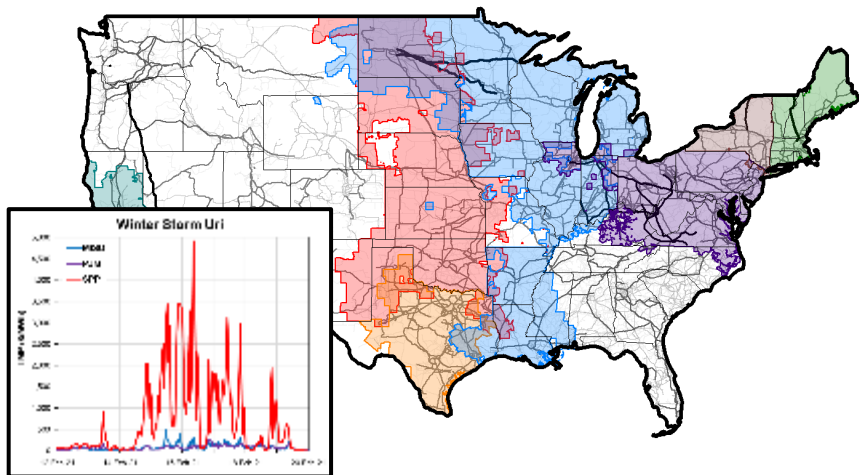


Summary

Conclusions

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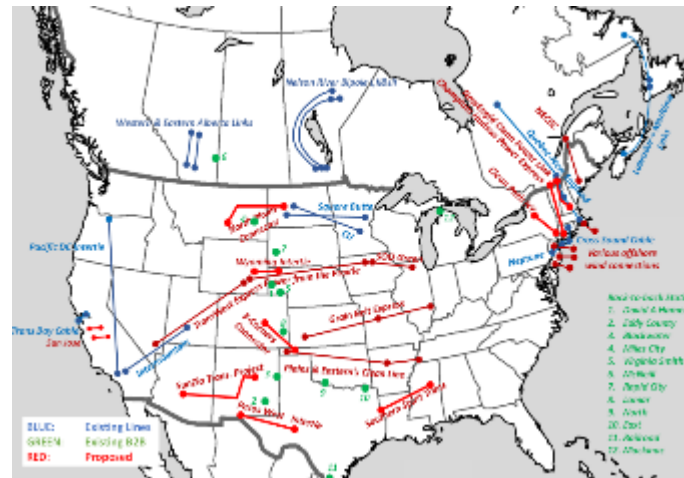
There is a tremendous need for interregional transmission



Invenenergy

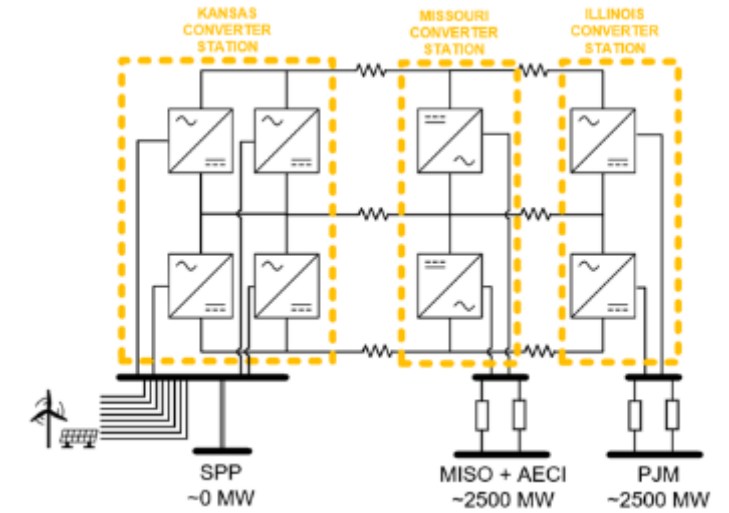
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HVDC interconnectors are being developed to support



3

Technology is capable and actively being implemented



Questions?

