Clean Line Energy

HVDC: The Key to the Continued Growth of the Wind Industry

MARC 2011

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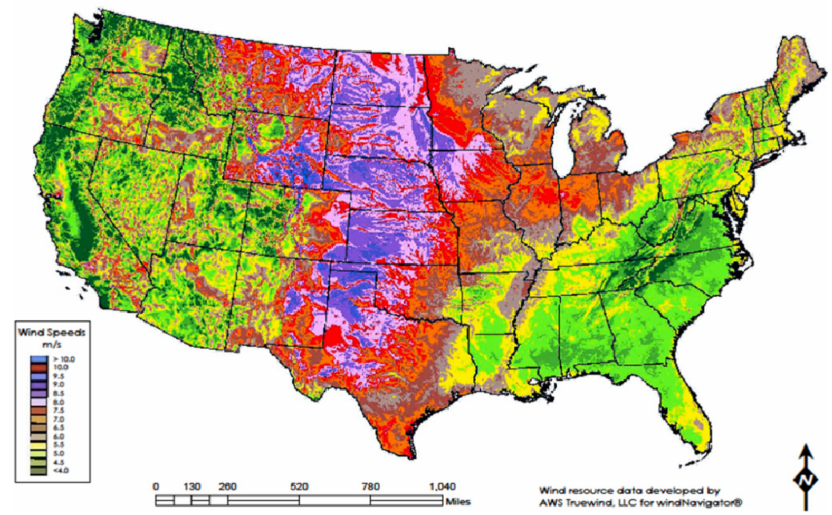
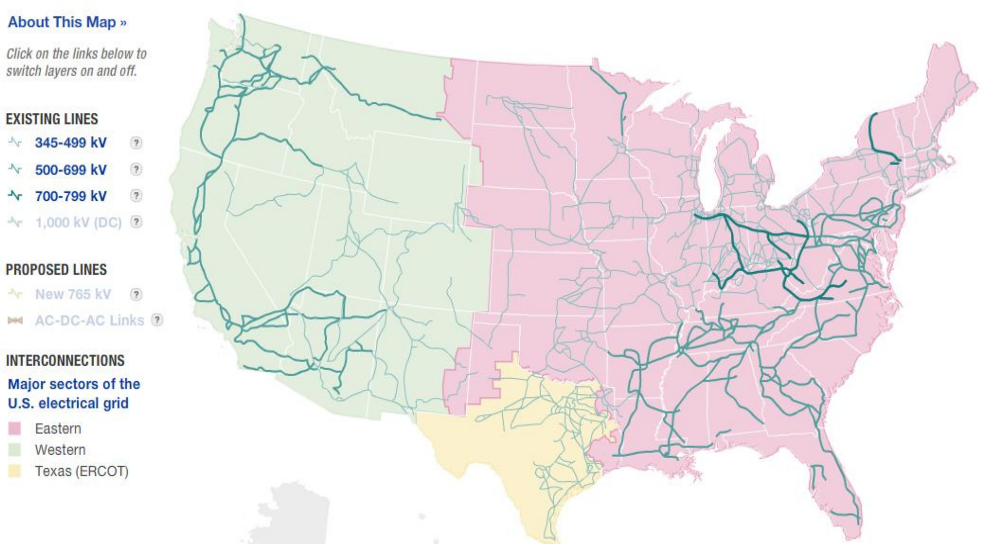
Why Do We Need HVDC Transmission?

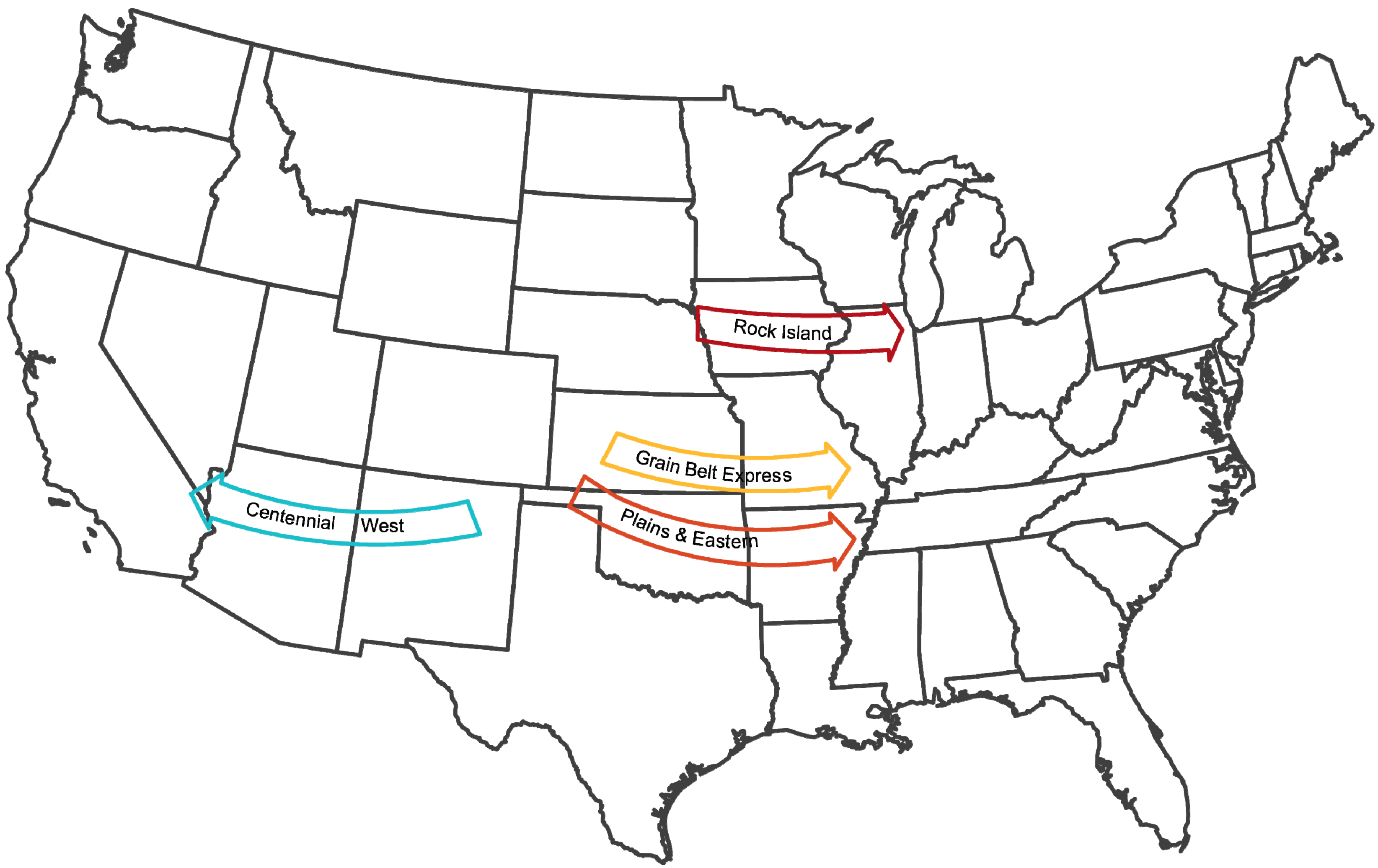
Best wind resources are in central spine of the United States away from distant population centers





…with limited access to robust transmission systems

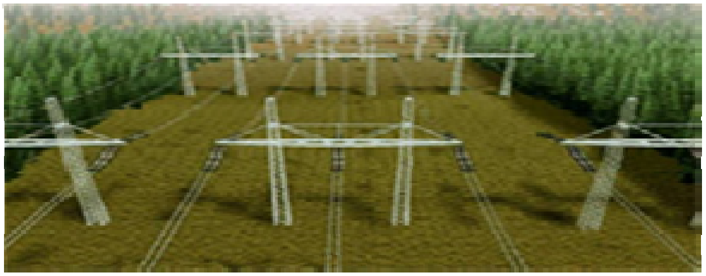
Clean Line is Developing HVDC Projects to Deliver Renewable Energy to Load Centers



Why HVDC?

- Efficient—Due to lower losses, DC is most efficient solution to move large volumes over long distances
- Smaller footprint—Less complex siting because DC requires narrower ROW and lower height than AC
- Improved reliablility—Enhances system stability, controls power flows, lowers integration costs in resource area

AC 3000-4000 MW Capacity DC



Three 500 kV lines

One ± 500kV bipole

Source: ABB

- Technological advances—Improved HVDC technology will help reduce costs over the long term
- Simpler commercial structure—HVDC enables "toll road" model, but also work in a world of cost-allocated transmission

Cost Competitiveness

Levelized Cost ($/MWh, nominal)

	Fixed Cost	***Fuel Cost***	***Total Cost***	***Comments***
Wind in high class II site	30-40	0	30-40	Typical resource in IA, OK, KS, TX, eastern NM
Wind in low class II site	50-60	0	50-60	Typical resource in IN, IL
Clean Line delivered product	55-70	0	55-70	Includes $25-30/MWh of transmission
Gas combined cycle	15	50	65	Based on 7,000 heat rate, $6/mmBTU real ($7 nominal)
Wind in class III site	65-75	0	70-80	Typical resource in OH, NY, CA
Nuclear	80-120	5	85-125	Costs are highly uncertain
Solar PV	110-130	0	110-130	Costs are declining, but have a long way to fall
Solar thermal	120-150	0	120-150	

Source: EIA, Clean Line

Integration Costs

- 3 scenarios:
  - Scenario 1: 7,000 MW delivered to TVA
  - Scenario 2: 3,500 MW delivered to TVA
  - Scenario 3: 3,500 MW to TVA; 3,500 MW to neighboring balancing areas (Southern Company, Duke Energy, Entergy)
- 3 times the standard deviation of the variations of net load (load minus wind) represents ramps occurring approximately 24 times every year

	Net Load 3 Sigma Variation (MW) w/o Wind	Net Load 3 Sigma Variation (MW) w/Wind	Additional Net Load Variation (MW)	Additional Net Load Variation (% of Peak Load)
Scenario 1	2326	3307	981	2.9%
Scenario 2	2326	2658	332	1.0%
Scenario 3	4989	5210	220	0.3%

Source: AWS

What's Working in Favor of HVDC

- WIND ECONOMICS
- PUBLIC ACCEPTANCE AT THE LOCAL LEVEL
- SUPPORT OF U.S MANUFACTURING BASE
- PROVEN TECHNOLOGY
- ADEQUATE WIND RESOURCES
- FERC'S NEGOTIATED RATE STRUCTURE
- NO CURTAILMENT DUE TO CONGESTION

Issues That Are a Challenge

- ANTIQUATED STATE SITING LAWS
- NO FEDERAL SITING LAWS
- 1222 PARTNETSHIP WITH DOE
- LACK OF RULES AROUND HVDC INTERCONNECTION
- INCUMBENTS SANDBOX
- INTEGRATION CONCERNS BY UTILITIES
- REGIONAL PLANNING LOOKS INWARD

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