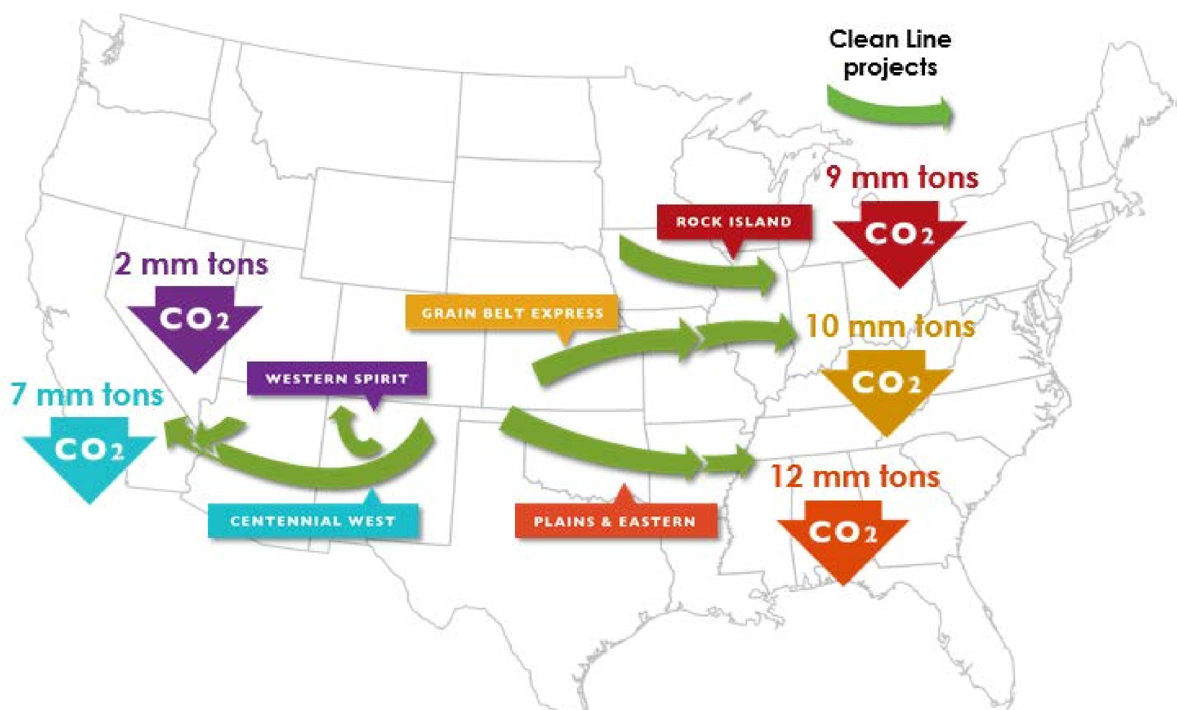
Date: September 8, 2014
To: U.S. Department of Energy (DOE) - Quadrennial Energy Review Task Force
From: Clean Line Energy Partners LLC
Subject: Comment on QER Public Meeting: Electricity Transmission and Distribution – East: Direct current transmission is a key enabler of a cleaner energy future

Clean Line Energy Partners LLC (Clean Line) appreciates the opportunity to provide comments to the Quadrennial Energy Review (QER) task force as it examines electric transmission infrastructure for our nation's energy future.

Clean Line is developing long-distance electric transmission lines to connect the nation's most affordable renewable energy resources with larger population centers to unlock development of our nation's highest capacity factor wind resources at greater scale and significantly reduce polluting emissions. Each of Clean Line's four high voltage direct current (HVDC) transmission projects will traverse over 500 miles and deliver 3,500 megawatts (MW) of low-cost wind power to markets that need it. Clean Line is also developing a roughly 200-mile alternating current (AC) transmission line that will facilitate 2,000 MW of new wind development. The wind energy delivered by each of Clean Line's projects will significantly reduce carbon dioxide emissions, as illustrated below.

Figure 1: Clean Line delivery of wind energy will significantly reduce CO_2 emissions[1]



[1] Carbon emission reductions shown are for the first year of operation, based on DNV GL studies of security constrained economic dispatch with and without each project.

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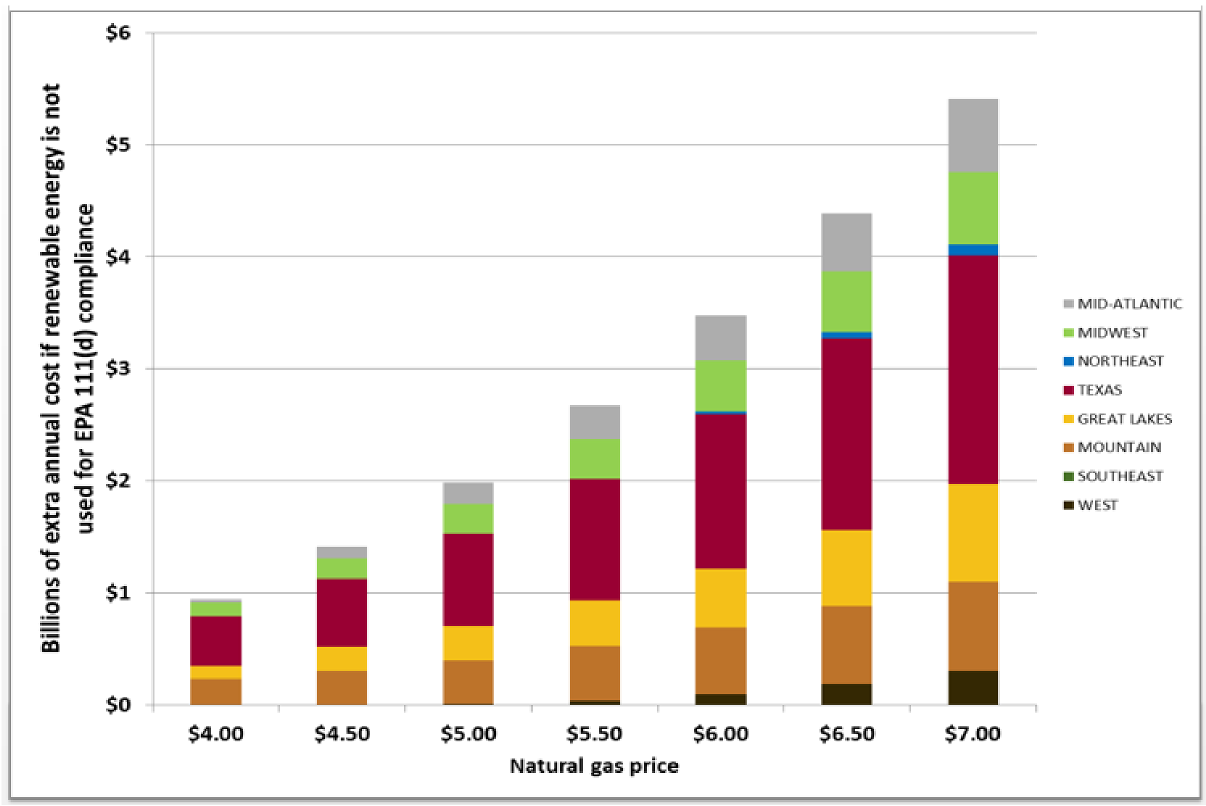
As recently reported by DOE, wind power prices are at all-time lows, and HVDC transmission is the ideal technology to deliver this mature and robust energy resource to distant markets at a highly competitive delivered cost of energy – under 5 cents per kilowatt-hour, fixed for 20-25 years. [2] Clean Line-delivered wind will provide states with a low-cost option to meet Renewable Portfolio Standards and emissions targets promulgated under the Clean Air Act. Clean Line-delivered wind will also provide a valuable hedge against more naturally volatile fossil fuel.

The American Wind Energy Association (AWEA) recently conducted analysis of various compliance strategies consistent with the proposed carbon dioxide emissions rule under section 111(d) of the Clean Air Act. As illustrated below, AWEA found that utilizing wind power saves consumers over a billion dollars annually, even with natural gas prices at $4.50 per million BTU.

Figure 2: Wind energy saves billions annually on 111(d) compliance cost[3]



Clean Line's transmission projects will provide distant markets with access to the lowest-cost renewable resources in the country, with minimal congestion risk. They are well aligned with the administration's national energy goals of enhancing economic competitiveness, environmental responsibility, and energy security, and they embody several of the desirable infrastructure characteristics identified by the QER

[2] Indicative cost for Plains & Eastern Clean Line delivered wind, including the Production Tax Credit.
[3] American Wind Energy Association analysis of wind deployment under proposed method of calculating renewable energy building block targets.

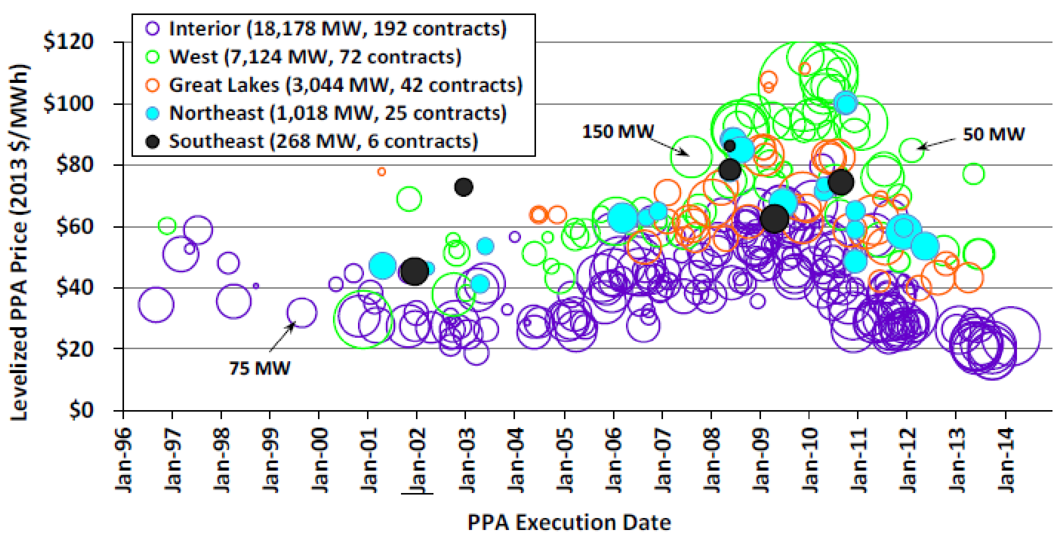
task force: Clean Line's projects will facilitate development and delivery of affordable clean energy, with minimal environmental footprint, in a robust and reliable manner.

By submitting these comments, Clean Line hopes to assist the QER task force in recognizing that HVDC transmission has a unique and essential role to play in unlocking our nation's lowest-cost renewable energy resources and advancing an affordable, cleaner energy future.

<u>Our nation's most affordable renewable energy resource is onshore wind in the Interior region,[4] but long-distance transmission is needed to provide more Americans access to this valuable resource.</u>

Onshore wind energy is not only the most affordable source of new renewable energy, but in some regions of the country, unsubsidized wind is also cost competitive with conventional generation, including combined cycle gas turbines.[5] As shown in Figure 3, wind power purchase agreement (PPA) prices reached all-time lows in 2013, and have shown a consistent downward trend since 2009. "This trend is particularly evident within the Interior region, which—as a result of its low average project costs and high average capacity factors…—also tends to be the lowest-priced region over time."[6]

Figure 3: Levelized Wind PPA prices by execution date and region (2013 $/Megawatt-hour)[7]



Note: Size of "bubble" is proportional to project nameplate capacity
Source: Berkeley Lab

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[4] The Interior region consists of the 13 states where average wind speeds are the highest: OK, KS, IA, NM, SD, NE, TX, MN, WY, CO, ND, MT, and MO.
[5] Lazard, Lazard's Levelized Cost of Energy Analysis – Version 7.0, August 2013, p. 2.
[6] U.S. DOE 2013 Wind Technologies Market Report, August 2014, p. 58.
[7] Ibid., p. 58.

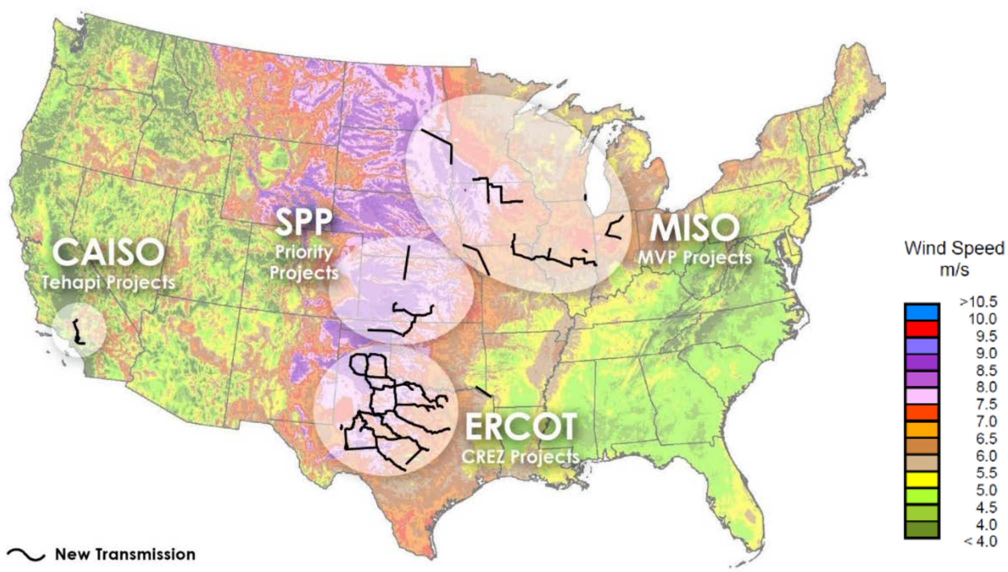
The Interior region saw average levelized PPA prices of just $22/Megawatt-hour in 2013.[8] Based on DOE's sample of wind projects built in 2013, installation costs per kilowatt were lowest in the Interior region, and wind PPA prices were most competitive with wholesale power prices in the Interior region.[9]

Despite the relative cost competitiveness of wind projects in the Interior region, DOE recently reported that transmission has been a limiting factor leading to a tendency to build new wind projects in lower-quality wind resource areas, particularly from 2009-2012.[10]

<u>To ensure that wind generation capacity installed in the U.S. results in the greatest amount of clean energy production and resulting displacement of polluting power generation, new infrastructure is needed to unlock the highest capacity factor wind resources at greater scale.</u>

Fortunately, the Electric Reliability Council of Texas (ERCOT), the Southwest Power Pool (SPP) and the Midcontinent Independent System Operator (MISO) have planned and approved the cost allocation of several new high voltage alternating current (AC) transmission lines, as illustrated in Figure 4, and billions of dollars of new investments in wind projects are coming online.

Figure 4: New transmission enabling wind energy development within grid regions



The Competitive Renewable Energy Zone (CREZ) transmission projects in Texas are proving that if you build transmission to connect wind resources to load centers, wind development will follow. Because of its CREZ lines, ERCOT reports that wind-related congestion between West Texas and other zones has largely disappeared. Moreover, ERCOT predicts that over 7,000 MW of new wind capacity will be installed in Texas by the end of 2015, with another 1,300 MW projected to come online in 2016.[11] However, Texas is unique in having superb wind resources, large load centers and its own grid operator

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[8] Ibid., p. 59.
[9] Ibid., p. ix.
[10] Ibid., p. 41.
[11] Ibid., p. 67.

within its borders. The Texas legislature approved and ERCOT implemented cost allocation of the transmission infrastructure to support wind development.

Several other states in the Interior region, within SPP for example, do not have large enough loads to facilitate significant amounts of wind development without access to larger markets. For example, the National Renewable Energy Laboratory estimates that Kansas' wind potential at 80-meter hub height is 952,371 MW – enough to supply over <u>90 times</u> the state's electricity needs.[12] With just 2,967 MW of wind generation installed in Kansas as of 2013, wind already provides close to 20 percent of the state's electricity consumption.[13]

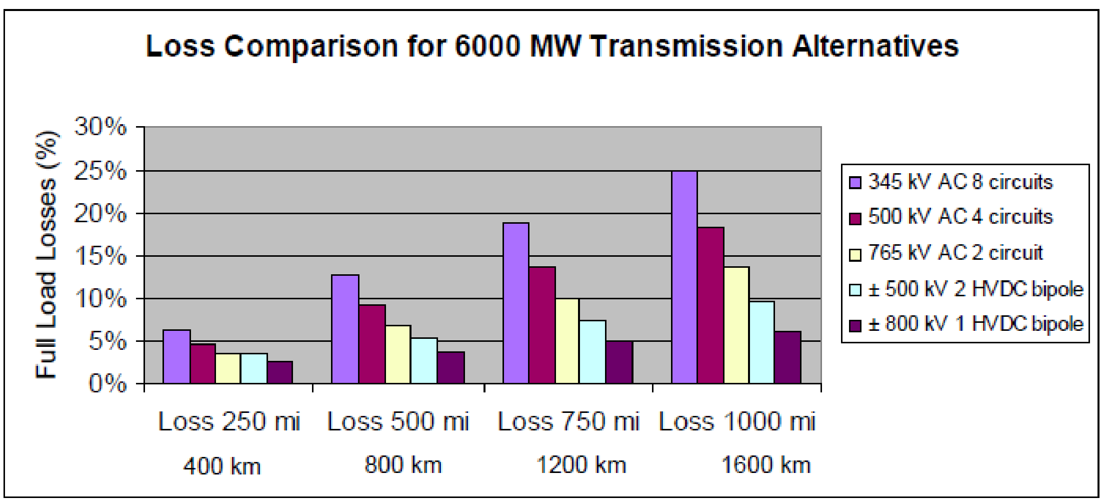
Tens of thousands of megawatts of additional wind farms are under development in states like Kansas and Oklahoma, but long-distance, interregional transmission lines are needed to connect these projects with larger markets and unlock our nation's most abundant, affordable, renewable energy resources at greater scale and to the benefit of more Americans.

<u>High voltage direct current (HVDC) transmission is ideal for reliably transferring large amounts of renewable power over long distances.</u>

As described below, HVDC transmission offers operational, reliability, cost and environmental benefits that can be particularly helpful for the application of linking variable, renewable resources to distant markets.

- HVDC lines can transfer significantly more power with lower line losses over longer distances than comparable AC lines, as illustrated in Figure 5.

Figure 5: Over long distances, AC lines lose significantly more power than DC lines[14]

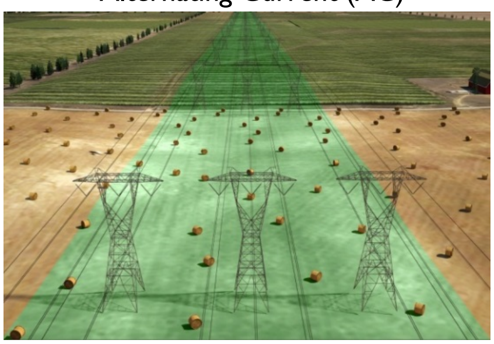


[12] AWEA, State Wind Energy Statistics: Kansas, www.awea.org/Resources/state.aspx?ItemNumber=5223
[13] Ibid.
[14] ABB, Michael Bahrman P.E., ABB Grid Systems, WECC Transmission Planning Seminar, February 2009, "HVDC Transmission: An economical complement to AC transmission," slide 18.

- HVDC technology gives grid operators direct control of energy flows, which makes HVDC particularly well-suited to managing the injection of variable wind generation.
- HVDC lines, unlike AC lines, will not become overloaded by unrelated outages, because the amount of power delivered is strictly limited by the DC converters at each end of the HVDC line, thereby reducing the likelihood that outages will propagate from one region to another.
- HVDC lines can dampen power oscillations in an AC grid through fast modulation of the AC-to-DC converter.
- HVDC lines utilize narrower rights-of-way, fewer conductors and less robust or fewer structures than comparable AC lines, thereby making more efficient use of transmission corridors and minimizing visual, land use, and environmental impacts, as illustrated below.

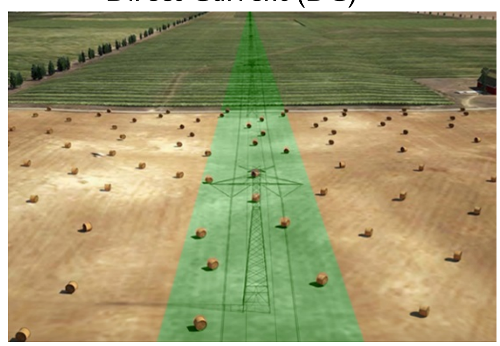
Figure 6: DC transmission systems for 3000-4000 megawatts of capacity have less impact on land use than comparable AC systems

Alternating Current (AC)



Three 500 kilovolt lines
600 foot right-of-way

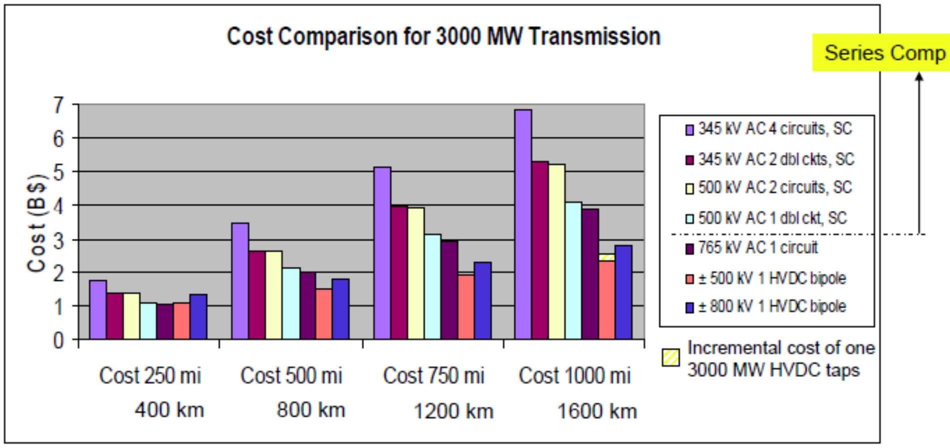
Direct Current (DC)



One +/- 500 kilovolt bipole
150-200 foot right-of-way

The need for fewer wires, structures and a narrower right-of-way result in a lower cost per mile for DC transmission. Further, AC transmission lines have diminishing capacity over long distances and require intermediate switching stations and series compensation every 200-250 miles, which also results in higher capital costs for long-distance AC lines than comparable DC systems, as illustrated in Figure 7.

Figure 7: Comparative capital costs for 3000 megawatt transmission (Intermediate switching stations and reactive compensation every 400 km for AC lines)[15]



While HVDC transmission lines require large investments in converter stations at each terminus in order to interconnect with the surrounding AC grid, savings per mile resulting from the efficiencies described above exceed the cost of converter stations at a distance around 300 miles and result in HVDC systems becoming the more cost-effective long-distance solution.

HVDC transmission is a well-established technology, but no overhead HVDC lines have been built in the U.S. since 1986. China is already many thousands of miles ahead in deploying this technology and has plans for 30 HVDC lines to be installed by 2020.

Recent studies in the U.S. have found that HVDC transmission lines are needed to reliably and cost-effectively export wind energy from the Interior region to other markets.

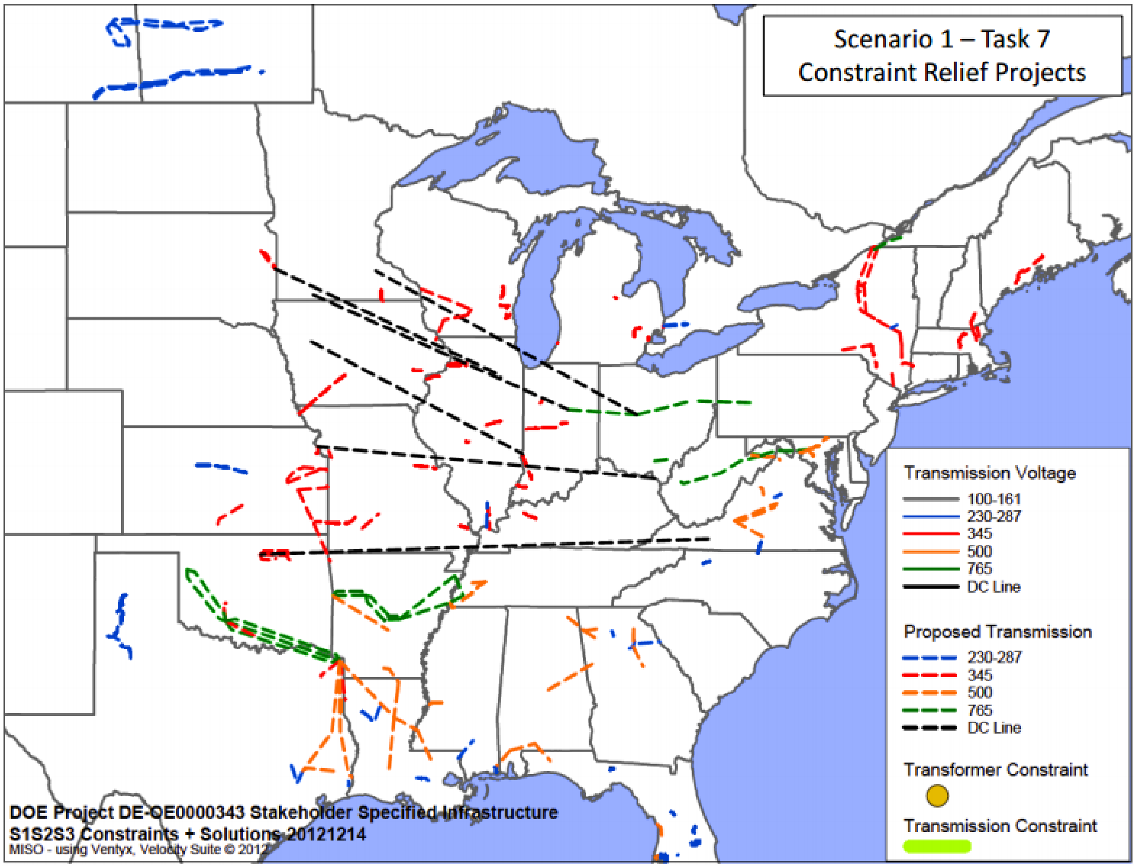
The DOE-funded Eastern Interconnection Planning Collaborative (EIPC) identified HVDC transmission as a critical enabler of a lower carbon grid. EIPC Phase 2 examined three stakeholder-selected future scenarios for which to plan necessary transmission expansions. Scenario 1 was a Nationally Implemented Federal Carbon Constraint with Increased Energy Efficiency/Demand Response. This future had a carbon reduction goal just 12% higher than the recently proposed EPA rule under Section 111(d) of the Clean Air Act.

The model output of this low-carbon scenario necessitated significant wind generation capacity additions in MISO and SPP. The capacity additions resulted in significant power flow constraints, which were alleviated by systematically adding transmission. In solving the constraints, EIPC Planning Authorities found that building a larger AC system would be insufficient. To move the large amounts of power from the Midwest over long distances to the East, HVDC lines were needed to avoid overloading lines and causing reliability violations.

Ultimately, it was determined that six +/- 500 kV HVDC lines, each capable of carrying 3,500 MW, were needed for a reliable system that alleviated all constraints, as illustrated below and on page 21 of the EIPC Phase 2 Report, published in January 2013.

[15] Ibid., slide 34.

Figure 8: EIPC Scenario 1 Task 7: Constraint Relief required 3,500 MW HVDC lines[16]



Also published in 2013 was the Southwest Power Pool 20-year Integrated Transmission Plan (ITP20), which studied a future scenario where SPP exported 10 gigawatts of wind power out of the SPP footprint to other regions (Future 3). SPP looked at AC-only and AC+HVDC solutions to accomplish the scenario's intent and estimated that the AC-only solution would cost $9 billion, while the AC+HVDC solution would cost $7.5 billion.[17]

[16] U.S. DOE, Phase 2 Report: Interregional Transmission Development and Analysis for Three Stakeholder Selected Scenarios, Draft - December 22, 2012, p. 21.
www.eipconline.com/uploads/20130103_Phase2Report_Part2_Final.pdf

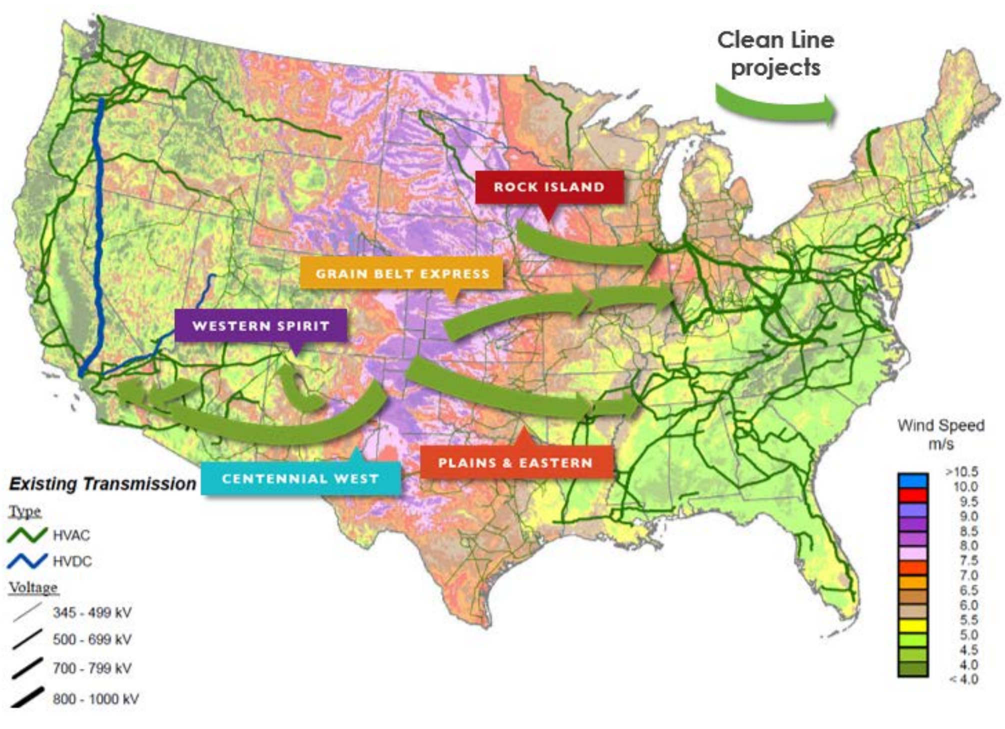
[17] Southwest Power Pool, 2013 Integrated Transmission Plan: 20-Year Assessment Report, July 30, 2013, p. 93.

Clean Line's transmission projects seek to connect the nation's lowest-cost wind resources to larger markets, utilizing the right technology for the task at hand.

Clean Line is developing transmission projects to connect the nation's highest-speed wind resources with larger markets and stronger points on the existing AC grid. Four of Clean Line's projects will utilize HVDC transmission, the most efficient means to transfer bulk amounts of electricity over distances beyond approximately 300 miles, as described above.[18] AWEA listed Clean Line's projects among near-term transmission projects that if completed could carry 14,000 MW of new wind capacity.[19]

Clean Line intends to privately finance its projects and recover costs through transmission service agreements with wind generators and/or load serving entities that purchase the wind power. This merchant or shipper-pays business model is facilitated by HVDC technology, which requires controllable converter stations at each terminus and interconnection with the AC grid.

Figure 7: Clean Line's transmission projects under development



Clean Line has been developing its projects since 2009, working with thousands of stakeholders in 11 states to seek the required regulatory approvals to permit construction and operation. Clean Line has enjoyed engaging thousands of landowners and representatives of conservation organizations, state and federal agencies, and a variety of other groups, while seeking input in identifying a proposed route for each project with the least impact to land use and natural and cultural resources.

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[18] Western Spirit Clean Line in New Mexico will utilize AC transmission to span roughly 200 miles.

[19] AWEA, DOE. 2013 Wind Technologies Market Report, p. 68.

Clean Line projects have obtained public utility status in Oklahoma, Kansas and Indiana, and similar regulatory proceedings are underway in Illinois, Missouri and Tennessee.

Clean Line is seeking the participation of DOE and Southwestern Power Administration, an existing federal utility in Arkansas, to construct the Plains & Eastern Clean Line under existing authorities enacted in Section 1222 of the Energy Policy Act of 2005.

In the meantime, Plains & Eastern Clean Line is advancing discussions with potential customers, consistent with negotiated rate authority granted by the Federal Energy Regulatory Commission. Plains & Eastern Clean Line recently launched an open solicitation and received transmission service requests from developers of wind projects with total capacity far exceeding the capacity of the transmission project. In advance of a similar open solicitation, Grain Belt Express Clean Line completed a request for information from wind generators in the western Kansas region, and over 13,000 MW of wind projects responded, again far exceeding the capacity of the transmission line.

The strong responses to Clean Line's open solicitation and requests for information confirmed an abundance of low-cost wind energy projects ready for construction if provided an efficient transmission path to market. Most of these projects have land leased for wind turbines from farmers seeking new sources of income, as drought has made their traditional farming livelihoods uncertain. Wind power represents new hope for drought-resistant income and economic development in regions of the country otherwise struggling with diminishing populations.

These wind projects and the consumer and environmental benefits they can provide Americans remain stranded in development without access to larger markets that need the low-cost clean energy. Clean Line's merchant HVDC transmission projects can provide that path to market, offering a total delivered price of wind energy, inclusive of transmission, that is competitive with any other source of new, local generation.

Clean Line's projects will support our nation's economic competiveness, leadership in environmental responsibility and energy security for decades to come. Clean Line appreciate DOE's consideration of our comments and would welcome continued engagement to support DOE's efforts on the Quadrennial Energy Review.