Infrastructure investment to deliver low cost clean energy

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Clean Line’s projects connect the lowest-cost wind resources to major demand centers.
Plains & Eastern links transmission-constrained, best-in-country wind resources to Southeastern markets

- Oklahoma converter station connects to up to **4,550 MW** new wind generation (geographically in SPP).
- The Arkansas converter station interconnects with **MISO**, delivers **500 MW**.
- The Tennessee converter station interconnects with **TVA**, deliver **3,500 MW**, some of which is wheeled to neighboring utilities.
9 m/s wind speed sites are abundant in the Oklahoma Panhandle

Oklahoma Panhandle wind seasonal profile
Average monthly capacity factor vs month

Oklahoma Panhandle wind diurnal profile
Average hourly capacity factor vs hour

9 m/s sites are abundant in the 100x100 mile area around the Plains & Eastern Clean Line converter station

Plains & Eastern will unlock a wind resource with average capacity factors of approximately 55%

1. Plains & Eastern generation profile is derived from 3Tier simulated wind speed data in the Oklahoma Panhandle applied to Vestas V110-2.0, V126-3.3, and GE2.0-116 turbine power curves
Multiple factors contribute to the Mid-South and Southeast’s strong demand for renewable energy

**BROAD BASE OF POTENTIAL CUSTOMERS**
In addition to TVA, Duke, Entergy and Southern Company, P&E’s delivery points provide access to munis, coops and other wholesale load including C&I.

**WIND AS A PORTFOLIO STAPLE**
Utilities will add wind to generation portfolios if below avoided cost; robust resource makes low delivered cost possible and provides hedge against gas volatility.

**COAL PLANT RETIREMENTS**
46 GW of coal plant retirements have been announced to date, further retirements expected.

**MEETING CPP AND RPS REQUIREMENTS**
SE states have limited low-cost renewable options to comply with CPP requirements; can address PJM states’ RPS with wind delivered through P&E and TVA.

**Existing wind capacity by state (AWEA)**

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Direct current transmission is the right answer to tap distant renewable resources and deliver across regions.

- **Cost**: For large volumes at distances over ~400 miles, direct current results in lower delivered energy cost.
- **Reliability**: DC, unlike AC, allows complete control of power flow and prevents cascading outages.
- **Efficiency**: Over long distances, DC transfers more energy with lower line losses and less infrastructure than comparable AC lines.
- **Smaller footprint**: DC requires narrower right-of-way than equivalent AC configuration, resulting in lower land use impact.

**3000-4000 MW Capacity**

- Three 500 kV AC lines
- One ± 500kV DC bipole

**Cost**

- Project Cost for 6,000 MW Capacity

**Converter stations function as on- and off-ramps; generators connect to the on-ramp and load-serving entities receive low-cost wind power at off-ramps.**

**Clean Line will sell transmission service to shippers via long term transmission contracts - Those who use the line, pay for it.**
Market simulations show substantial benefits to consumers

Results of Production Modeling Analysis of TVA Benefits to Power Systems
Estimated Year 1 impacts

- Production cost savings to Tennessee: $137 mm
- Average marginal energy price reduction for TVA system: $1.44/MWh
- Production cost savings to Arkansas: $65 mm
- Average LMP reduction for Entergy system: $0.14/MWh
- Production cost savings to rest of Eastern Interconnect: $540 mm

ENVIRONMENTAL BENEFITS

- 13 million tons carbon dioxide reduced
- 11 thousand tons sulfur dioxide reduced
- 5 thousand tons nitrogen oxide reduced
- 194 pounds mercury reduced
- 3.4 billion gallons saved

Source: Leidos, 2015.
Plains & Eastern delivered wind is cost effective and provides additional sources of value – TVA example

The different sources of value that the Plains & Eastern project brings to the TVA system are quantified in this graph.

The levelized value over 25 years of 1000 MW of Plains & Eastern wind delivered to TVA could total between $50-69/MWh. That is equivalent to approximately $310 million in savings from avoided costs each year assuming 5 million MWh are delivered every year.

The declining cost of wind and direct transmission to TVA help so that the delivered product is lower cost than the value the energy provides.

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1. Levelized value is established over a 25 year time period using an 8% discount rate. Further details on assumptions and calculation methodology behind the sources of value are provide on the following slides.
Plains & Eastern can transport market power when the wind is not blowing

Frequency distribution of wind utilization rate
Percentage of time vs. line utilization

1. Plains & Eastern generation profile is derived from 3Tier simulated wind speed data in the Oklahoma Panhandle applied to Vestas V110-2.0, V126-3.3, and GE2.0-116 turbine power curves, assumes 105% overbuild

- Line is 5% filled all the time
- Average line utilization rate: 60%
- Line is completely filled ~29% of the time

Average line utilization from wind power will be around 60%

Remaining capacity available for SPP market power delivery to MISO or PJM

Possible use of unused capacity:
- Solar
- Arbitrage opportunities

Oklahoma Panhandle has some of best solar resources in Eastern Interconnection

Source: NREL
Plains & Eastern Clean Line means economic development and jobs

- **OVER $2 BILLION PROJECT INVESTMENT**
- **OVER $6 BILLION OF NEW WIND FARM INVESTMENTS**
- **THOUSANDS OF CONSTRUCTION JOBS**
- **OVER 1 MILLION HOMES POWERED PER YEAR**
- **MILLIONS IN ANNUAL REVENUES TO SUPPORT LOCAL COMMUNITIES**
- **INCREASED MARKET COMPETITION BENEFITS ELECTRICITY CONSUMERS**

**CLEAN LINE ENERGY PARTNERS**
Plains & Eastern Clean Line: largest wind/solar project in US and one of the largest “power plants” of any kind

### Top 10 Largest Power Plants in US
**Nameplate Capacity (MW)**

<table>
<thead>
<tr>
<th>Plant</th>
<th>State</th>
<th>Fuel</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Coulee</td>
<td>WA</td>
<td>Hydro</td>
<td>6,809</td>
</tr>
<tr>
<td>Plains &amp; Eastern*</td>
<td>OK/AR/TN</td>
<td>Wind</td>
<td>4,376</td>
</tr>
<tr>
<td>Martin</td>
<td>FL</td>
<td>Natural Gas</td>
<td>4,318</td>
</tr>
<tr>
<td>West County Energy Center</td>
<td>FL</td>
<td>Natural Gas</td>
<td>4,263</td>
</tr>
<tr>
<td>Palo Verde</td>
<td>AZ</td>
<td>Nuclear</td>
<td>4,210</td>
</tr>
<tr>
<td>W A Parish</td>
<td>TX</td>
<td>Natural Gas</td>
<td>4,008</td>
</tr>
<tr>
<td>Turkey Point</td>
<td>FL</td>
<td>Nuclear/Natural Gas</td>
<td>3,665</td>
</tr>
<tr>
<td>Scherer</td>
<td>GA</td>
<td>Coal</td>
<td>3,564</td>
</tr>
<tr>
<td>Bowen</td>
<td>GA</td>
<td>Coal</td>
<td>3,499</td>
</tr>
<tr>
<td>Browns Ferry</td>
<td>AL</td>
<td>Nuclear</td>
<td>3,494</td>
</tr>
</tbody>
</table>

* Minimum MW for a fully subscribed line. Does not include economic overbuilding to lower delivered costs.

### Top 10 Largest Plants in US
**2015 Energy Production (MWh)**

<table>
<thead>
<tr>
<th>Plant</th>
<th>State</th>
<th>Fuel</th>
<th>Generation (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palo Verde</td>
<td>AZ</td>
<td>Nuclear</td>
<td>32,525,595</td>
</tr>
<tr>
<td>Browns Ferry</td>
<td>AL</td>
<td>Nuclear</td>
<td>27,669,694</td>
</tr>
<tr>
<td>Oconee</td>
<td>SC</td>
<td>Nuclear</td>
<td>21,939,740</td>
</tr>
<tr>
<td>Plains &amp; Eastern*</td>
<td>OK/AR/TN</td>
<td>Wind</td>
<td>21,100,000</td>
</tr>
<tr>
<td>TalenEnergy Susquehanna</td>
<td>PA</td>
<td>Nuclear</td>
<td>20,591,260</td>
</tr>
<tr>
<td>West County Energy Center</td>
<td>FL</td>
<td>Natural Gas</td>
<td>20,428,360</td>
</tr>
<tr>
<td>Turkey Point</td>
<td>FL</td>
<td>Nuclear/Natural Gas</td>
<td>20,337,856</td>
</tr>
<tr>
<td>Comanche Peak</td>
<td>TX</td>
<td>Nuclear</td>
<td>19,954,124</td>
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<tr>
<td>Peach Bottom</td>
<td>PA</td>
<td>Nuclear</td>
<td>19,858,302</td>
</tr>
<tr>
<td>Braidwood Generation Station</td>
<td>IL</td>
<td>Nuclear</td>
<td>19,710,011</td>
</tr>
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</table>

* Wind generation for 4,376 MW with a 55% NCF. Does not include economic overbuilding to lower delivered costs.

Source: EIA Form 860 and 923 2015
Transmission expansion has met regional renewables demand; a need for interregional transmission remains

**SPP Priority Projects**
- 3-5 GW capacity

**MISO MVP Projects**
- 15 GW capacity

**CAISO Tehachapi Projects**
- 4.5 GW capacity

**ERCOT CREZ Projects**
- 18.5 GW capacity

Studies point to need for more inter-regional projects to increase wind energy in a cost effective way.
Internationally, HVDC is the proven solution to connect large amounts of power to load centers

China has completed thousands of miles of HVDC transmission lines in the last decade

The last long distance HVDC transmission line in the United States was completed in 1989
Wind energy prices continue to decrease, particularly in the windiest part of the country.

Levelized Wind PPA prices by PPA execution date
2015 $/MWh

The “Interior” region consists of the 13 states where the wind resource is the strongest:
OK, KS, IA, NM, SD, NE, TX, MN, WY, CO, ND, MT, and MO.

Similarly, utility-scale solar price decreases have been consistent and tied to regions.

Levelized Solar PPA prices by PPA execution date
2015 $/MWh

Sample includes 136 contracts totaling 9.1 MWAC

4 of 5 regions now have PPA prices <$50/MWh (Midwest <$60/MWh)

Source: LBNL Utility-Scale Solar report 2015; published August 2016
Wind energy cost is very attractive compared with other sources of new generation

**Levelized Cost of Energy**

<table>
<thead>
<tr>
<th>Source</th>
<th>Levelized Cost of Energy ($ / MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind with the PTC</td>
<td>39</td>
</tr>
<tr>
<td>Wind without the PTC</td>
<td>14</td>
</tr>
<tr>
<td>Solar PV Utility Scale</td>
<td>55</td>
</tr>
<tr>
<td>Combined Cycle Gas Turbine</td>
<td>65</td>
</tr>
<tr>
<td>Coal</td>
<td>108</td>
</tr>
<tr>
<td>Nuclear</td>
<td>117</td>
</tr>
<tr>
<td>Solar Thermal with Storage</td>
<td>150</td>
</tr>
</tbody>
</table>

1. Cost of generation based on mid-point of Lazard’s LCOE estimates. Unless noted, costs shown are unsubsidized.
2. High capacity factor wind cost uses low-end Lazard estimates for which the capacity factor is 55% and capital cost is $1,250/kW.
3. Assumes $3.45/MMBtu gas price.

Source: Lazard’s 2016 Levelized Cost of Energy Analysis
Panhandle solar is best in the Eastern Interconnection and has better time-of-day than local solar

Summer (June-Sept) Solar Diurnal Profile\(^1\) Comparison vs 2013 Southeastern Summer Load\(^2\)

The Panhandle has one of the highest levels of irradiance in the Eastern Interconnect resulting in around 15-20% more energy from solar compared to Southeast solar.

Oklahoma solar delivered by P&E will still generate power when local Southeastern solar powers down.

1. 2013 TVA Load Data from FERC Form 714
2. Global Horizontal Irradiance (GHI) blended data for Memphis, TN and Savannah, GA and data for Guymon, OK from NREL Solar Prospector
A combination of solar and wind delivered by Plains & Eastern complements Southeastern load

At a small premium, Plains & Eastern can be used to deliver a combined wind and solar product that increases line utilization (i.e. more energy delivery for the same delivered MW) and improves the generation time-of-day profile that Southeastern utilities find more attractive.

1. 2013 TVA Load Data from FERC Form 714
2. Plains & Eastern generation profile is derived from 3Tier simulated wind speed data in the Oklahoma Panhandle applied to Vestas V110-2.0, V126-3.3, and GE2.0-116 turbine power curves, combined with solar production profiles simulated in NREL’s System Advisor Model using Mono-c-Si (SunPower panel) on a one-axis tracking system near Guymon, OK
Market power price differentials create opportunities for arbitrage through Plains & Eastern

Frequency distribution of market power price differentials
Percentage of time vs. difference in market power prices

Arbitrage opportunities exist between RTOs that are connected through P&E even when including additional transmission service

Utilizing unused capacity to take advantage of these arbitrage opportunities create additional value to the owner of the transmission capacity

Market power arbitrage could yield up to $60 million a year, assuming perfect execution on unused capacity up to 1000 MW of OK-TN service and 500 MW of OK-AR service over the entire project

Note: Frequency distribution bin size is $5/MWh.

2. Positive market power price differentials are valuable when delivering SPP power to PJM or MISO, whichever is higher priced, including non-firm transmission costs and losses, and negative differentials are valuable when delivering PJM or MISO power, whichever is lower priced, to SPP including non-firm transmission costs and losses

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A minimum generation event arises when a transmission system experiences a surplus of non-dispatchable or low fuel-cost generation relative to load.

Based on the data available to Clean Line, TVA can purchase up to 3,500 MW of wind delivered by Plains & Eastern without significant minimum generation issues.

A historical analysis of TVA’s previous years’ demand results in curtailment of a little less than 0.4% of total wind energy delivered with 3,500 MW delivery capacity.

An analysis using projected load for 2019 results in curtailment of less than 0.1% of total wind energy delivered with 3,500 MW delivery capacity.

Sources: TVA load data from FERC Form 714 2008-2013, Ventyx nuclear and coal generation and load forecasts for 2019, P&E Wind production data from 3Tier Modeled data as referenced in report, Existing wind contracts production data based on the Eastern Wind Integration and Transmission Study dataset.
Utilities and states are already reliably integrating wind at high penetration levels.

Adding wind to the resource mix offers reliability benefits for utilities. Wind has increased system reliability during extreme weather events in Texas and PJM.
Plains & Eastern Clean Line can help Southeastern states meet their carbon reduction targets

Annual CO₂ emissions reductions (million tons) for Southeast states

- **CO₂ emissions reductions from Plains & Eastern**
- **CO₂ emissions reductions required by Clean Power Plan**

<table>
<thead>
<tr>
<th>State</th>
<th>CO₂ emissions reductions (million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KY</td>
<td>28</td>
</tr>
<tr>
<td>AL</td>
<td>17</td>
</tr>
<tr>
<td>GA</td>
<td>13</td>
</tr>
<tr>
<td>FL</td>
<td>13</td>
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<td>TN</td>
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<tr>
<td>SC</td>
<td>10</td>
</tr>
<tr>
<td>AR</td>
<td>7</td>
</tr>
<tr>
<td>NC</td>
<td>116</td>
</tr>
<tr>
<td>SE States</td>
<td>9 – 23</td>
</tr>
</tbody>
</table>

4,000 MW of wind delivered by Plains & Eastern can make a significant impact on CO₂ emissions in Southeast states, reducing between **9 million** and **23 million tons** of CO₂ depending on the generation source displaced.

Note: Mass-based CO₂ emission reductions based on EPA calculations for 2012 and 2030 targets for each state. Plains & Eastern displacements are calculated using the average coal and gas emission rates for Southeastern states as defined in the EPA Clean Power Plan and assumes a 60% utilization rate of the Plains & Eastern line.

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