SOO Green HVDC Link

PJM MRC Special Session

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SOO Green Project Overview

SOO Green HVDC Link

- Direct Connect Development Company is pioneering a new model to build High Voltage Direct Current (HVDC) transmission underground along existing rail rights of way, eliminating visual, environmental and land use impacts, and providing resiliency and system reliability benefits.
- The SOO Green HVDC Link, our flagship project, is a 350-mile, 2,100 MW, 525 kV underground HVDC transmission line from Iowa to Illinois, linking low-cost, utility-scale renewable generation in MISO with customers in PJM.
- SOO Green is the first major transmission project to cross the seam between MISO and PJM.

MISO Terminal (Killdeer Substation)	345 kV MISO Zone 3
PJM Terminal (Plano Substation)	765 kV PJM ComEd Zone
HVDC Converter Technology	Siemens 525kV VSC
Cable Technology	525 kV XLPE
Transmitted Power / Net of losses	2100 MW / 2035 MW
Route Distance	350 miles
Development Financial Close	Q4 2018
Initial Subscription	Q4 2020
Construction Financial Close	Q4 2021
Target NTP	Q1 2022
Target COD	Q4 2024

Click here to watch a two-minute video overview of the SOO Green HVDC Link project.

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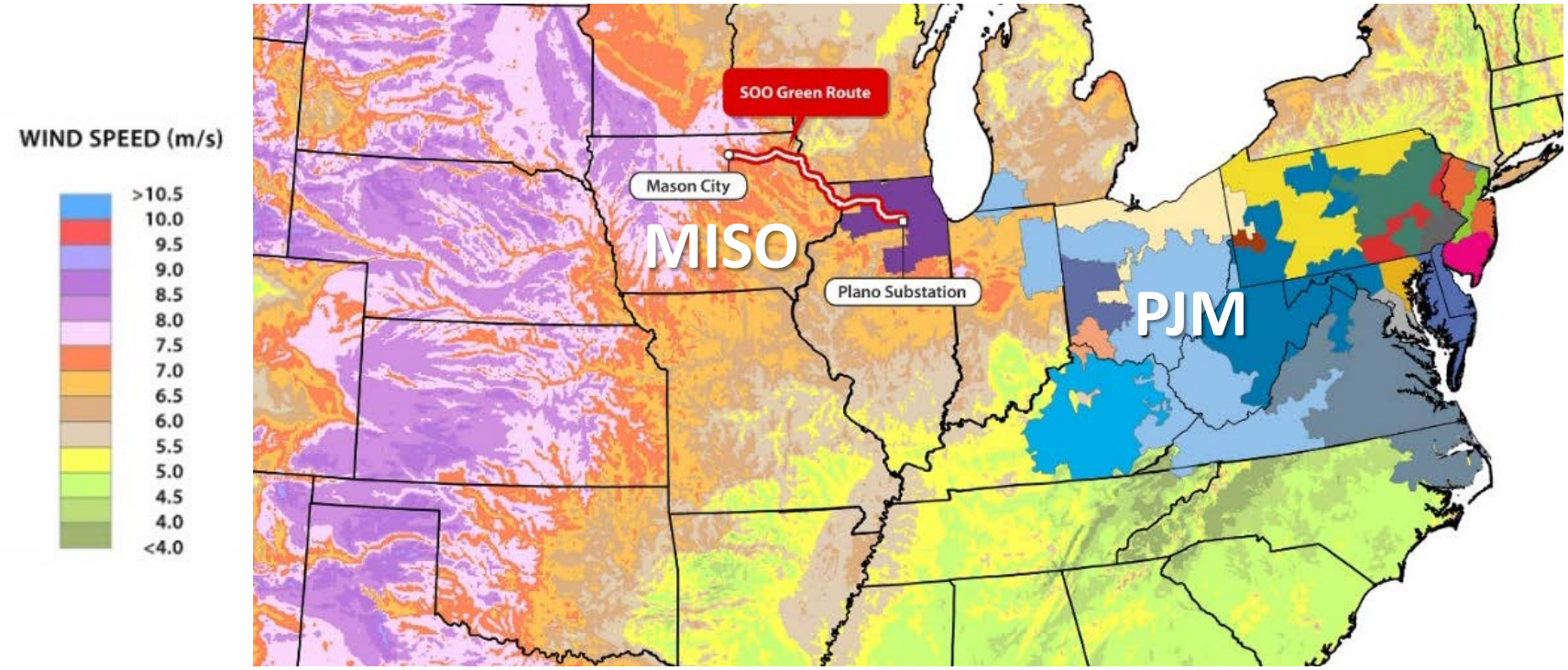
Motivations for the SOO Green Project

- Unlock high-quality energy resources needing a path to market
- Deliver large-scale, dispatchable renewable energy
- Demonstrate a lower-risk merchant transmission development model that:
  - Does not rely on eminent domain to secure right of way
  - Builds on the railroad co-location model successfully used for the national fiber optic network buildout
  - Reduces environmental impacts by installing HVDC cable underground

SOO Green: An Inter-Regional Merchant Transmission Solution



- Relieves congestion and reduces market inefficiencies
- Connects sellers and buyers
- Enhances inter-regional reliability and resiliency

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Modernizing the Grid with Advanced HVDC Technology

Siemens 2000 MW Voltage Sourced Converter Station Technology

- VSCs boost grid reliability by providing extremely responsive utility-scale reactive power, black start and other ancillary services historically provided by centralized fossil-fueled generators
- VSCs strengthen grid resiliency by accurately controlling power dispatch, avoiding cascading outages and improving power quality via dynamic voltage, frequency and reactive power control
- XLPE cables enable long-distance delivery of renewable energy with little line loss and allow for simpler and less expensive installation with high-power transfer capability

SOO Green will use state-of-the-art Voltage Sourced Converter (VSC) stations and Cross Link Polyethylene Cables (XLPE) to bring transmission into the digital age

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SOO Green Commercial Structure & HVDC Capacity Market Participation

SOO Green: Connecting Markets and Market Participants

- SOO Green will provide direct access for buyers in PJM to diverse and large-scale wholesale energy products
- The abundant supply of renewable generation in MISO will result in competitive pricing for SOO Green Shippers and Buyers

Suppliers can own, control or contract for output from one or more generation resources

Shippers can purchase transmission capacity (and may want to be paired with Suppliers/Buyers)

Buyers can contract with counterparties to purchase wholesale and retail products delivered by SOO Green

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SOO Green's Contractual Structure for Market Participation

- SOO Green will enter into long-term transmission capacity contracts with Shippers
- Shippers will enter into long-term contracts with Suppliers for bundled energy and capacity, creating a portfolio of dedicated generating resources
- SOO Green's Open Solicitation process will match Shippers, Suppliers and Buyers to allocate transmission capacity in a non-discriminatory and non-preferential manner
- SOO Green's converter station as the capacity resource would be internal to PJM and would participate in PJM's RPM
- SOO Green will operate the line, subject to NERC reliability and RTO dispatch instructions

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Review Tariff Provisions and Compare Contractual and Operational Attributes of Capacity Resources

Definition of Capacity Resources

RAA Article 1 (Definition)

"Capacity Resources" shall mean megawatts of:

(i) net capacity from Existing Generation Capacity Resources or Planned Generation Capacity Resources meeting the requirements of the [RAA], Schedules 9 and [RAA], Schedule 10 that are or will be owned by or contracted to a Party and that are or will be committed to satisfy that Party's obligations under the [RAA], or to satisfy the reliability requirements of the PJM Region, for a Delivery Year;

(ii) net capacity from Existing Generation Capacity Resources or Planned Generation Capacity Resources not owned or contracted for by a Party which are accredited to the PJM Region pursuant to the procedures set forth in such Schedules 9 and 10; or

(iii) load reduction capability provided by Demand Resources or Energy Efficiency Resources that are accredited to the PJM Region pursuant to the procedures set forth in the [RAA], Schedule 6.

PJM OATT, Attachment DD § 5.5A(a):

Subject to 5.5A(a)(i)-(ii), the following types of Capacity Resources are eligible to submit a Sell Offer as a Capacity Performance Resource: internal or external Generation Capacity Resources; Annual Demand Resources; Capacity Storage Resources; Annual Energy Efficiency Resources; and Qualifying Transmission Upgrades.

These capacity resource definitions do not include HVDC converters.

Comparing HVDC Converter & Combined Cycle Generator Contractual Structures

Gas Supply

Firm/Non-firm Supply

Compressor Station

Gas Pipeline

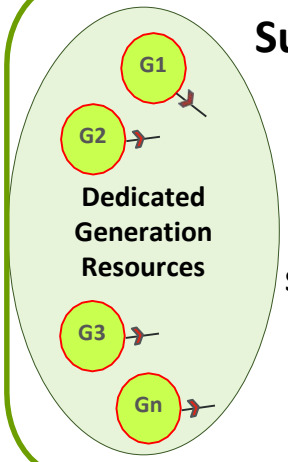
CCGT Generator Station may or may not rely on firm supply and transportation contracts

CCGT Generator Station

Firm/Non-firm Transportation

Inter-connecting Substation (PJM)

Suppliers



Firm Supply

Firm Out-Service

HVDC Line

HVDC Converter Station will rely on firm supply and transmission contracts

HVDC Converter Station

Firm Transmission

Plano Substation (PJM)

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Attributes of HVDC Converters and Conventional Generation

- An HVDC converter connected to PJM would be capable of performing operationally like other generating resources on the PJM system
- Below is a comparison between an HVDC Converter and a Combined Cycle Gas Turbine generator

Attributes	HVDC+VSC Converter Station	CCGT Generator Station (1300 MW)
Dispatchability	Fully dispatchable with bi-directional continuous power transfer, no minimum dispatch limitation, instantaneous start-up and control	Fully dispatchable with approx. 10-20 minutes of start-up time
Availability	Fully available based up to its contracted capacity	Dependent on fuel supply. Firm gas supply would ensure greater operational availability
Reactive Power	Can meet +/- 0.95 power factor requirement at interconnection point with continuous control (at least +/-690 MVAR of reactive support assuming 2100 MW)	Can meet +/- 0.95 power factor requirement at interconnection point (+/-429 MVAR of reactive support assuming 1300 MW)
Frequency Regulation	Can provide instantaneous and long-term response to PJM's operational requirements (Reg A or Reg D)	Can provide slower response to PJM's regulation requirements
Black Start Capability	Can support system restoration after blackouts and energize an islanded network providing up to 1,500 MW of power while operating to control voltage and frequency independent of local generation	Only certain types of combustion turbines and battery-storage enabled CCGTs can provide black start capability
Congestion Management	Available to PJM operators for regional and local congestion management	Available for local congestion management

Participation of HVDC Converter Stations and CCGT

- Though HVDC Converter Stations and CCGTs can deliver the same services and can functionally participate in the markets in the same way, the existing tariff does not allow participation of HVDC Converter Stations in PJM markets

Market Participation Opportunities	HVDC Converter Stations	Generic CCGT Generators
Interconnection Rights	Cannot obtain Capacity Interconnection Rights	Can obtain Capacity Interconnection Rights
Capacity Markets	Not Eligible	Eligible
Energy Markets	Cannot Participate	Can participate in Day Ahead and Real Time markets
Ancillary Services	Cannot Participate	Can participate in Regulation, Black Start, Reserves, Reactive Power and other ancillary service markets

Pseudo-Tie Rules are not Applicable to an Internal Converter Station

Pseudo-tie rules are in place for external resources to provide capacity to PJM.

Existing Pseudo-tie Rules:

- Electrical distance and deliverability requirements
- Market-to-Market Flowgate Coordination
- External resources must be dispatchable by PJM

These pseudo tie requirements were designed to accommodate individual external resources, not HVDC converter stations internal to PJM.

However, HVDC converter stations like SOO Green can satisfy PJM's underlying requirements of deliverability and dispatchability because...

- shippers will contract with dedicated generating resources
- the converter station will be located inside PJM's footprint (Plano substation), eliminating the requirement for Market to Market Flowgate Coordination
- the HVDC line operator will obtain firm transmission out-service at the withdrawal point
- the converter station will be fully dispatchable by PJM

SOO Green is Not Relying on a Slice of System Agreement

RAA Schedule 8.1D(4)

A Capacity Resource submitted in an FRR Capacity Plan must be on a unit-specific basis, and may not include "slice of system" or similar agreements that are not unit specific.

- SOO Green is not relying on a “slice of system” agreement because the converter station, located internally to PJM, will deliver energy and capacity using supply contracted with specific generating units in MISO.

SOO Green Proposal on HVDC Converters as Capacity Resources

Proposal for HVDC Converter Station Capacity Resource

- SOO Green Converter Station would be an internal capacity resource
- SOO Green (or a subsidiary entity) would be PJM market participant and receive capacity obligation through the RPM
- Shippers would have contractual rights and obligations with the market participant
- Each Shipper would contract with dedicated resources (Suppliers)
- As discussed on Slide #15, by injecting directly into PJM at the Converter Station point of interconnection, the SOO Green Converter Station is a capacity resource within PJM; the pseudo-tie requirements would not apply
- As discussed on Slide #16, this model meets its obligations from dedicated resources; this model is not slice-of-system

Integration of HVDC Converter as a New Type of Capacity Resource

Problem / Opportunity Statement

PJM's existing Tariff (Reliability Assurance Agreement/RAA and OATT) and manuals allow dispatchable generation resources, intermittent resources and energy storage resources to participate in PJM's Reliability Pricing Model (RPM) capacity market. High Voltage Direct Current (HVDC) transmission lines that have a converter station directly connected to the PJM system, that can follow PJM dispatch instructions and that are backed by a portfolio of firm generation supply are similarly situated to these other capacity resources and can provide reliability benefits to PJM. However, current PJM Tariffs do not allow such HVDC converters to participate in the RPM market—presenting a market barrier to merchant resources seeking to sell bundled energy and capacity in the PJM market.

An HVDC converter station connected to PJM would be capable of performing like any other generating resource on the PJM system. It could contract for firm "fuel" (generation) supply, enabling it to be fully dispatchable with high availability. In fact, HVDC converter stations utilizing modern Voltage Source Conversion (VSC) technology have a demonstrated ability to respond to dispatch instructions quickly. Such stations can provide substantial amounts of reactive power at the point of interconnection, independent of the amount of real power requested. If connected to the PJM grid, such a station could enhance PJM grid stability by mimicking rotating inertia and could provide voltage and frequency support. An HVDC converter could undergo the interconnection process in accordance with PJM Manual 14 like any other generator. Furthermore, the ability to respond to dispatch signals from the PJM system operator would allow an HVDC converter to operate with the same or better responsiveness as other PJM dispatchable generating resources. Finally, in the same way that generating resources can contract for firm fuel supply, shippers on an HVDC facility could secure firm generation supply.

Any other similarly interconnected resource in PJM with the technical capabilities and firm fuel contracts analogous to the technical capabilities and firm supply described above would be eligible to participate in the RPM. However, PJM's existing Tariff (Reliability Assurance Agreement/RAA and OATT) and manuals preclude RPM participation to existing or new generating resources, intermittent resources, and energy storage resources. Given the essential similarities described above, an HVDC converter station located in PJM, delivering generation from another RTO, with the necessary interconnection and shipper arrangements, should be eligible to provide capacity through the RPM.

We would like to work with PJM and its stakeholders to develop a mechanism that would allow HVDC converter stations configured as described above to participate directly in the PJM capacity market. By providing for the integration of merchant inter-RTO HVDC connections into the capacity market, PJM and its customers would benefit from increased competition, greater geographic and technological generation diversity, and the additional instantaneous control offered by dispatchable HVDC facilities.

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