



White Paper

Wind in SPP is Not So Simple

By Himali Parmar and Shankar Chandramowli, ICF

Shareables

- With Federal tax credits for new wind developments expiring soon, SPP is a compelling market to invest since studies have shown that it can reliably accommodate up to 60% wind penetration levels.
- With the increasing pace of wind developments in the region, there is also a risk of local generation curtailment and power price depression unless critical transmission improvements are implemented by SPP.
- Changes to market operational practices, especially in the ancillary services market product, and expanding the customer base beyond SPP is expected to favor wind in the region.

The Southwest Power Pool (SPP) is emerging as the next market leader in wind development after ERCOT, but it must promote sound transmission policy to avoid too much of a good thing. Recent estimates have shown that nearly 16 GW of wind is in operation in SPP with an additional 37 GW in different stages of development.¹ SPP became the first system operator in North America to serve more than 50% percent of its load at a given time using wind energy alone (54.2% on March 19, 2017). Transmission bottlenecks during high wind output have already begun pushing nodal prices into negative territory. Potential expansion of SPP through transmission projects to evacuate local wind generation and integration of new load areas would further SPP's prowess. Looking at the successful wind integration so far provides a platform for an examination of the current market issues that could stifle, or sustain, further wind development.

¹ SPP Generation Interconnection Queue (as of March 2017)





Wind Penetration in select ISO/RTOs

ISO/RTOs	Highest Hourly Wind Penetration	Annual Average Wind Penetration
SPP	54%	18%
CAISO	~25%	9%
ERCOT	50%	11%

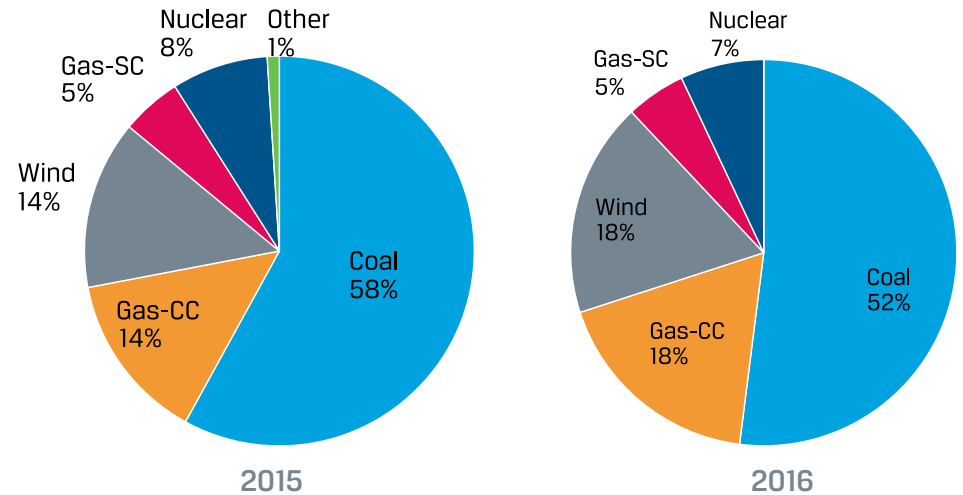
Note: Wind penetration is the percentage of system demand met by wind generation in a given time period. For California, the maximum renewable penetration (primarily wind and solar) was estimated to be 54%, with solar alone accounting for 29%.

Source: SNL

SPP is uniquely positioned for wind

SPP covers some of the best wind resource sites in the country today with wind energy accounting for 20% of the total generation and 15% of the total installed capacity in 2016. In fact, wind is the only resource type with an increasing share relative to total SPP-wide generation. Wind was 14% of total generation in 2015, increasing to 18% in 2016, and 26% in the first quarter of 2017. In contrast roughly 52% of generation in SPP was sourced from coal based power plants in 2016, down from 58% in 2015. As coal continues to decline in SPP's generation portfolio mix, wind is ready to fill the gap.

Annual generation by fuel type in SPP



Source: SPP Quarterly and Annual State of the Market reports

EXHIBIT 1. LEGENED

Kansas

Existing Wind: 5.1 GW
 Planned Wind addition: 7.2 GW
 Approved IA: 0.4 GW

Oklahoma

Existing Wind: 7.2 GW
 Planned Wind addition: 14.6 GW
 Approved IA: 1.5 GW

Texas

Existing Wind: 1.8 GW (SPP only)
 Planned Wind addition: 3.9 GW
 Approved IA: 1 GW

Transmission Lines Projects

Plant Development Event

- Announced
- Early Development
- Construction Begun
- Advanced Development
- Terminated
- Postponed
- Retired

Transmission Lines Operating

Voltage (kV)

- 1 - 138
- 138 - 230
- 230 - 345
- 345 - 500
- 500 - 1,000
- NA

Power Plants

Operating Status

- Operating
- Planned
- Operating & Planned

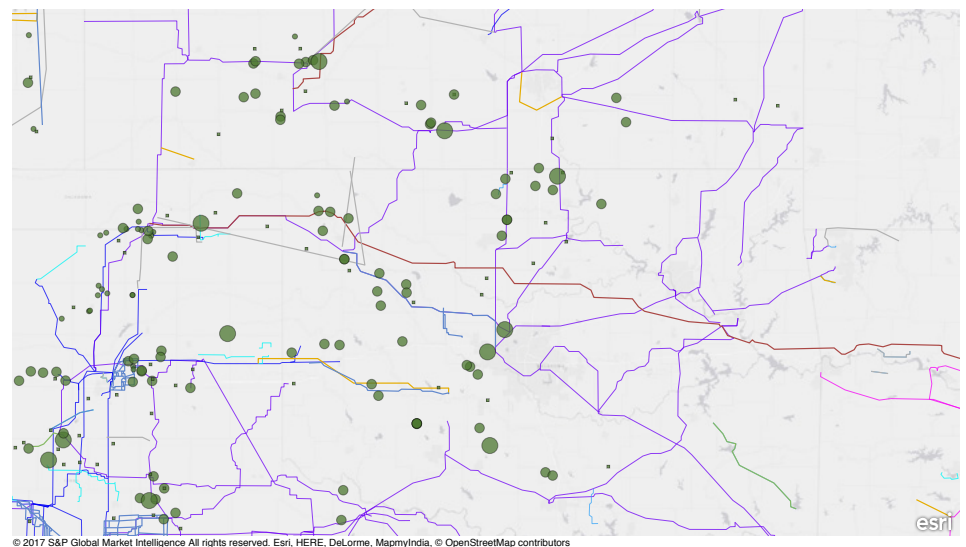
Fuel Type

- Wind

Too Much of a Good Thing in "Wind Alley"?

There is a significant amount of wind generation in the area known as "wind alley", the western Kansas, western Oklahoma, and Texas Panhandle areas in SPP. The wind alley has consistently high wind speeds, and is home to nearly 88% of existing wind capacity in SPP. As of March, 2017, SPP had approximately 37 GW of wind projects in various stages of development, with nearly 15 GW seeking interconnection in the wind alley region of Oklahoma alone. With the amount of wind developed, and the number of projects currently underway, there is a risk of further congestion and transmission issues.

EXHIBIT 1. MAP OF EXISTING UNITS AND PROPOSED WIND PROJECTS IN "WIND ALLEY" REGION OF SPP



Source: Planned additions are based on SPP Interconnection Queue (March 2017) (rounded to nearest whole number). Congested lines are shown in red.

Because of limited local demand and sparse transmission for power exports from local wind generation, severe transmission congestion is already affecting the performance of some of the generation resources in the wind alley. One of the most constrained transmission lines is the 138 kV Woodward to FPL Switch line, which limits the transactions in the day-ahead market 70% of the time in 2016.² Transmission improvements will be required to avoid exacerbating the problem as new wind generation is added in the region.

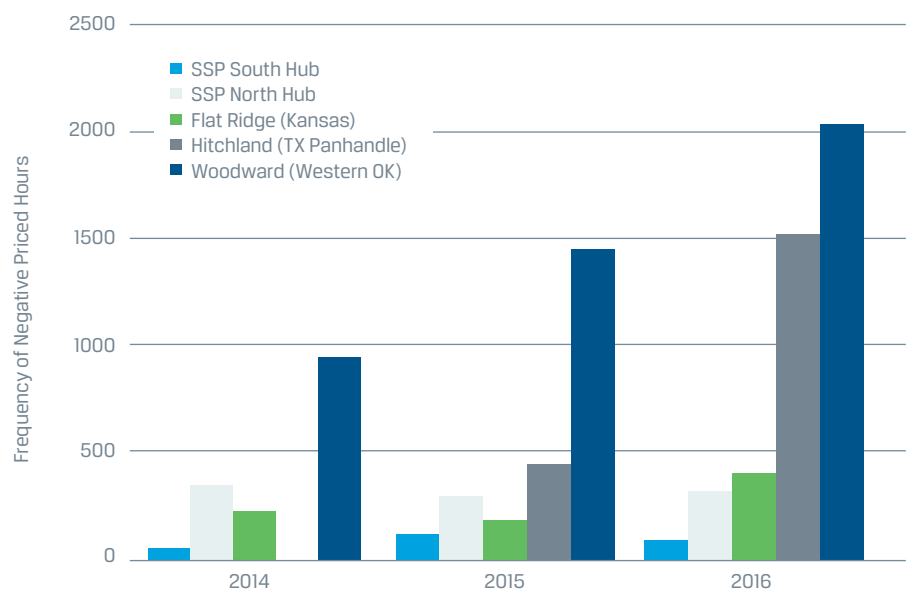
² See recent SPP State of Market Reports. e.g. https://www.spp.org/documents/48857/qsom_2017winter.pdf

Congestion has begun to affect pricing

Transmission congestion, inflexible generation and relatively low demand in some hours have resulted in negative prices in the SPP market. When transmission is congested or there is an over-supply of generation it is not uncommon for wind resources to offer their generation into the market at a cost below zero to ensure they are dispatched. Any losses would be offset by the Production Tax Credits (PTC) they would earn when they operate. Conventional generation may also make low or even negative bids to avoid high startup and shutdown costs. When units with low bids are on the margin, they set low or even negative prices in the market. With increasing wind penetration, SPP is observing higher frequency of intervals when wind is acting as a marginal source of electricity. In 2016, wind was the marginal fuel in SPP for about 10% of the hours. Given that wind offers are typically at or below zero, suggests market clearing prices could be at sub-zero levels for about 10% of the hours. In 2016, negative prices in the real-time market were observed for less than 5% of the hours at the two major trading hubs in SPP. In spite of significant increase in wind generation over the last 2-3 years, negative pricing at the trading hub has remained relatively flat.

Exhibit 4 shows the number of hours in the year that prices at selected locations in SPP went below zero. The incidences of negative prices have been increasing at some of these locations. At the 345 kV Woodward substation prices were negative for approximately 2,000 hours, or 20% of the time, in 2016, compared to 1,400 hours in 2015. At the 345 kV Hitchland substation the number of hours of negative prices more than tripled, from approximately 450 in 2015 to 1,500 in 2016.

EXHIBIT 4. FREQUENCY OF NEGATIVE PRICES

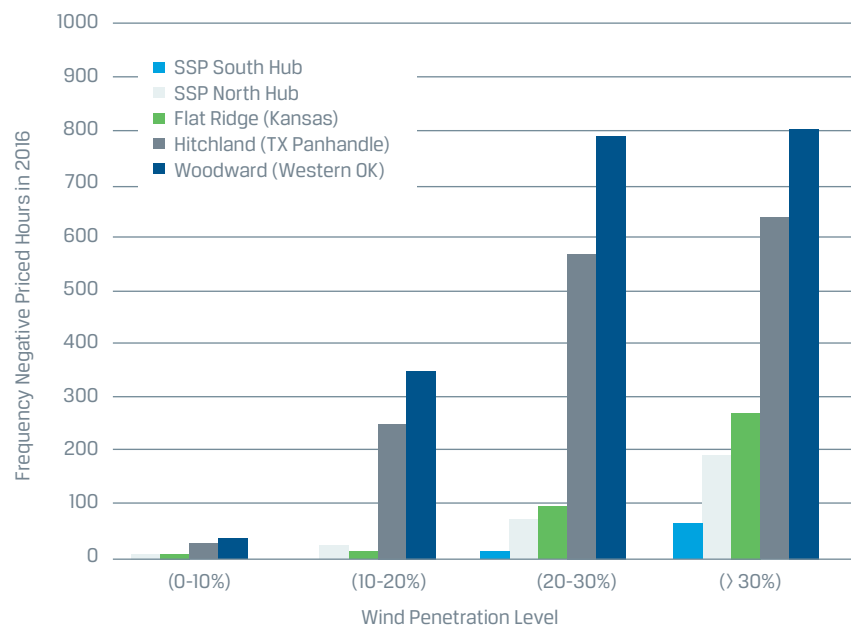


Source: SPP OASIS - <https://marketplace.spp.org/web/guest/operational-data>

Note: Real-time energy prices are represented here.

The occurrence of negative pricing is strongly correlated to wind penetration.³ Exhibit 5 shows the link between wind penetration and negative prices. It shows a strong correlation between wind penetration and the occurrence of negative prices. The frequency of hours with negative prices increase noticeably starting from a 10-20% penetration level. Both Exhibits 4 and 5 also show that the impact on the hub prices can be much lower than the nodal prices. This indicates that the problem is due to local transmission bottlenecks. These may be resolved by transmission improvements targeted at the constrained areas. The location of a wind generator can therefore make a big difference in its performance in the market.

EXHIBIT 5. NEGATIVE PRICES AND WIND OUTPUT ARE HIGHLY CO-RELATED



Source: Based on SPP's Real-time pricing and dispatch data

Proactive market policies and investments by SPP are crucial to sustain this wind growth story

Today, SPP is in a position to reap the benefits of wind integration due to the significant transmission investments, regional cost allocation⁴ for high voltage transmission lines, proactive wind policies and strategies adopted in the past.

- Over the last five years (2012-2016), SPP has completed approximately \$5 billion worth of transmission upgrades. Significant portion of this investment was made under SPP's Balanced Portfolio and Priority Projects-series of new, high voltage transmission lines developed to connect higher quality wind resources to load centers in SPP. These transmission lines helped in spurring the wind projects in the "wind alley" region.

³ In this context, wind penetration is calculated based on SPP's actual 5 minute dispatch by fuel type data. It is calculated as the ratio of hourly wind and total SPP-wide generation.

⁴ According to SPP's Highway/Byway approach, costs for projects 300 kV and above are regionally allocated.

- Transition to SPP's Integrated Marketplace in March, 2014 introduced rules so that wind resources could be dispatched down based on offers in a manner similar to other dispatchable resources as opposed to being subjected to curtailment based on the impacts to system constraints and transmission service priority. These resources, known as dispatchable variable energy resources (DVER), follow the dispatch instructions issued by SPP as part of its security constrained economic dispatch (SCED) framework.
- Installed DVER capacity was 28% of all wind capacity at the start of the Integrated Marketplace in March, 2014, increasing to 46% by the end of 2015. With increasing levels of wind output being bid as dispatchable, SPP has greater flexibility in congestion management and is able to re-dispatch wind generation closer to a transmission constraint, rather than curtailing larger amounts of generation located further away from the constraint.
- Short term reliability unit commitment (ST-RUC) introduced in March, 2016 which is run every 15 minutes, provides more granular look at ramping obligations, transmission requirements and also enables quicker response to system deviations
- Starting in March 2015, SPP implemented its Regulation Compensation market design in compliance with FERC Order No. 755. The revised design includes additional payment to market participants based on changes in energy output for regulation deployment in real time markets. Equipped with ability to respond quickly to any deviations in demand and supply, SPP can accommodate even higher penetration of wind resources and also stay committed to serve load reliably.

Cumulatively, changes in market structure and proactive transmission policies have enabled SPP to successfully increase the level of wind penetration in its footprint.

Way Forward- Risks and Opportunities

Over the next few years, several factors are expected to affect the outlook for wind generation in SPP. We strongly believe that stakeholders should consider the following factors when executing development decisions of wind projects in SPP.

- Planned transmission upgrades with regional cost allocation- Quite a few approved transmission projects are currently under development. Some of these projects will relieve congestion in the wind alley and could improve the performance of some of the generation discussed earlier. These include the second circuit of the 345 kV line from Matthewson to Tatonga line and the Woodward EHV Phase Shifting Transformer. Additionally, SPP is planning to invest close to \$5.5 billion over the next five years for transmission upgrades under different initiatives High Priority and Integrated Transmission Planning projects.⁵

⁵ See https://www.spp.org/documents/47494/2017_spp_transmission_expansion_plan_report_1-31-17_spp_bod_approved.pdf

These upgrades are expected to improve the deliverability of upcoming wind projects and remedy congestion issues in the "wind alley" region.

- Merchant transmission projects- Merchant projects such as the proposed 4,000 MW Plains and Eastern Clean Line HVDC transmission project³ could play a significant role in sustaining wind development in the region but these projects face financial and regulatory uncertainties.⁶ In addition to regionally cost allocated transmission projects, wind developers should consider economic viability of an existing or new wind investment with a sponsored transmission upgrade.⁷
- Changes in Operational Dispatch Practices – The provision of mileage-based regulation compensation is expected to incentivize faster response resources to participate in the ancillary services market which could improve the scope for further wind penetration increases. SPP is also considering changes to operational dispatch which could enable up to 60% wind penetration.⁸
- NDVER to DVER- SPP recently amended its transmission tariff requiring all future non-wind NDVERs⁹ to register as DVERs. Although the proposed changes is not applicable for wind resources for now, SPP is looking to actively bring more legacy NDVERs into the DVER fleet. SPP anticipates increased transition of legacy NDVER resources (incl. wind) to DVERs in the future through stakeholder processes and future filings with FERC. Approximately 50% of existing wind in SPP is non dispatchable. This transition is expected to give system operators more flexibility to integrate wind resources in the future.
- New Ramping Product- SPP is also considering adding a new ramping product to the current ancillary services which could further improve wind integration. Ramp rates play a crucial role in market operations because they place limits on how quickly a system operator can respond to changes in system load.
- Expanding geographic load footprint for SPP - Another promising development for existing and new wind resources is the potential for serving more demand with integration of Mountain West Transmission Group¹⁰ into SPP.

⁶ The project received Department of Energy (DOE) approval early last year and construction is said to commence later this year. http://www.cleanlineenergy.com/sites/cleanline/media/news/Clean_Line_Energy_ROD_National_Press_Release_FINAL_Web.pdf

⁷ Cost of the sponsored transmission upgrade is fully borne by the requesting entity

⁸ In their 2016 Wind Integration report, SPP recommended installing voltage reactive support capabilities for existing wind farms, accelerating certain transmission projects and enhancing operations and utilizing real-time monitoring tools to achieve sustained higher wind penetration levels.

⁹ Non- Dispatchable Variable Energy Resources

¹⁰ Mountain West Transmission Group is an informal collaboration of utilities based in Colorado, Wyoming and parts of Montana, Arizona and New Mexico. The group is currently evaluating options like joining SPP or forming an independent system operator group to adapt to the changing market and industry dynamics. See <https://www.wapa.gov/newsroom/NewsReleases/2017/Pages/Mountain-West-explores-RT0-options.aspx>

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A surge in wind development in the next couple of years to avail federal PTC opportunities could lead to further increases in transmission congestion and negative pricing.

However, developer friendly transmission policies and several key initiatives that are currently underway, create a favorable environment for wind projects in SPP. Investment in wind assets in SPP should take due consideration of all the listed factors, and look into local congestion and transmission issues. Given the nodal nature of the SPP market, some locations could experience stronger effects (both up and down) compared to others.

About the Authors



Himali Parmar joined ICF in 2002 and is a Project Manager in the Transmission and Ancillary Services Group of the Wholesale Power Practice. Ms. Parmar has 15 years of experience in power systems analysis and modeling. Her focus areas include production cost modeling, power system reliability and risk assessments, forecasting transmission congestion and losses and their effect on locational power prices and plant dispatch, asset valuation and due diligence. Ms. Parmar has provided due diligence support in development of several wind and solar facilities including assessing curtailment and congestion risk assessment.



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