SEVENTY-FIVE YEARS OF RELIABILITY THROUGH RELATIONSHIPS
Wind Capacity Installed by Year

![Wind Capacity Installed by Year](image-url)
Current MWs By Fuel Type

- Wind Totals 12,400 MWs
  - NDVer 6,634 MWs
  - DVer 5,766 MWs
- Solar 50 MWs
- Nuclear 2,635 MWs
- Natural Gas 35,692 MWs
- Coal 28,916 MWs
  - Generic Coal 21,368 MWs
  - Lignite Coal 2,899 MWs
  - Subbituminous 4,649 MWs
- Hydro 3,427 MWs
- Other Fuel Types (Oil, Agricultural Byproducts, Municipal Solid Waste) 1,659 MWs
Renewables impacts to SPP

• Peak Wind Penetration level: **45.1%**  March 7, 2016

• Peak instantaneous Wind output: **10,738 MW** (36.9% pen.)

• High impact on congestion and loading of the transmission system

• Wind can cause capacity issues by
  • Not showing up during times of high demand, contributing to capacity shortages
  • Showing up too high during times of low demand, contributing to “Min Gen” issues

• Short-term, intra-hour changes in wind also require reserves to maintain balance between generation and obligations

• Wind forecast is crucial for SPP to have the right generation online at the right time, while maintaining the reliability and economic efficiency of the regional transmission grid.
Operational Planning

- **Multi-Day Reliability Unit Commitment (RUC) studies starting 7 days out**
  - Identify potential capacity or transmission issues that may need to be mitigated days in advance of the Operating Day

- **Day-Ahead RUC**
  - Run after Day Ahead Market (financial) results are posted
  - Ensures adequate resource capacity for the Operating Day

- **Intra-Day RUC (same function as Day-Ahead RUC)**
  - Begin running the night before and throughout the Operating Day
  - Run at least every four hours, usually more frequently

- **NEW** Short-Term RUC
  - Run every 15 minutes, provides more granular look at ramping obligations and transmission requirements
Wind Forecast in SPP

- Multi-Day RUC studies, utilizing Long- and Mid-Term wind forecast
- Short-term wind forecast used in Pre-RTBM and RTBM; estimates uncurtained potential
- Operating Day Real-Time
  - Day Ahead RUC, run after Day Ahead Market results posted
  - Intra-Day and Short-Term RUCs
High wind/low load capacity

At times we are using DVER wind to meet down-ramping obligation
RTBM redispatch of wind during down-ramping periods

Market dispatches more wind down after evening load peak, when system load is dropping and we need to ramp down.
Real-time usage of wind

- SPP implements a controlled release of DVERs after curtailment
  - Ramp constraint provides controlled release
  - Allows the market to reevaluate before full release
  - Provides a safety net for wind forecast error
  - Optimize the reliable and economic solution with many resources at once

- DVERs can offer in to clear down-regulation service
  - Only a handful of DVERs have cleared Reg Down in the past
  - Allows wind farms to provide products other than energy
  - Helpful when system wind is increasing, load is decreasing and we are constrained on down ramp for conventional fuel resources
2015 Average Regulation Requirement contributors (Up direction)

“Wind Variability” component creates higher requirement on average during morning hours, as wind is typically ramping down during this time (expected use of Regulation Up during this time)
November 26-28, 2015
Extreme Weather Event
Timeline of Events Overview

- Operations Impacts Beginning at Approx. 4:30 on 11/26
  - Cold conditions and icing begin affecting wind resources
  - Footprint wide output of wind resources begins to come up significantly short of forecasted output
  - Excess Capacity Reduced System Wide

- Early Morning into Midday 11/27
  - Difference between 24 Hour Ahead Forecast and Actual Wind Output greater than 6000 MW
  - Significant Increase in Number of Self, IDRUC, and QS Unit Commitments
  - Limited Additional Capacity Available

- Reduced Operational Impacts Continue on 11/28
Impact on SPP’s Wind Forecast

Wind vs Forecast

- Forecast 24 hours out
- Forecast 4 hours out
- Forecast 8 hours out
- Actual Wind

Storm moving in late Thursday 11/26
WF Outages/Derates in CROW

OOS Derate
Managing the Event

• SPP Operators Adjusted for Loss of Resources/Capacity Efficiently

• SPP RUC Operators Committed Additional Resources Appropriately Given Information Available as Events Unfolded

• WF Operators Informed SPP of Resource Status
Lessons Learned and Potential Improvements Identified from Event

• Potential Icing Impacts as a Component of SPP’s Wind Forecast

• Improving the Timeliness and Accuracy of WF Availability Information in CROW

• Anticipating Capacity Needs in Preparation for Similar Events
  • Day-Ahead Preparations
  • Balancing Economic and Reliability Considerations
SPP Wind Integration Summary

• Market is adjusting to high levels of wind  
  • Some LMP prices driven negative  
  • Wind farms voluntarily curtailing due to price

• Operations responding to wind impacts  
  • Forecasting continues to improve  
  • SPP is blessed with large number of quick start units  
  • DVER policies and experience from EIS market greatly helped in Integrated Marketplace

• Wind futures…  
  • Wind capacity continues to increase, expect another 4,000 MW within 2 years  
  • Expect to hit >50% penetration level in April 2016  
  • Studying higher wind penetration level impacts to maintain reliable operations
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