AN EVOLUTIONARY APPROACH TO ADVANCING TECHNOLOGIES

How Southwest Power Pool is incorporating emerging technology to benefit our stakeholders and their customers

Published on January 16, 2018

By Operations Engineering

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
01/10/2018	Operations Engineering	Published	
1/16/2018	Operations Engineering	Revised SER section	

CONTENTS

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HOW SOUTHWEST POWER POOL IS INCORPORATING EMERGING TECHNOLOGY TO BENEFIT OUR STAKEHOLDERS AND THEIR CUSTOMERS

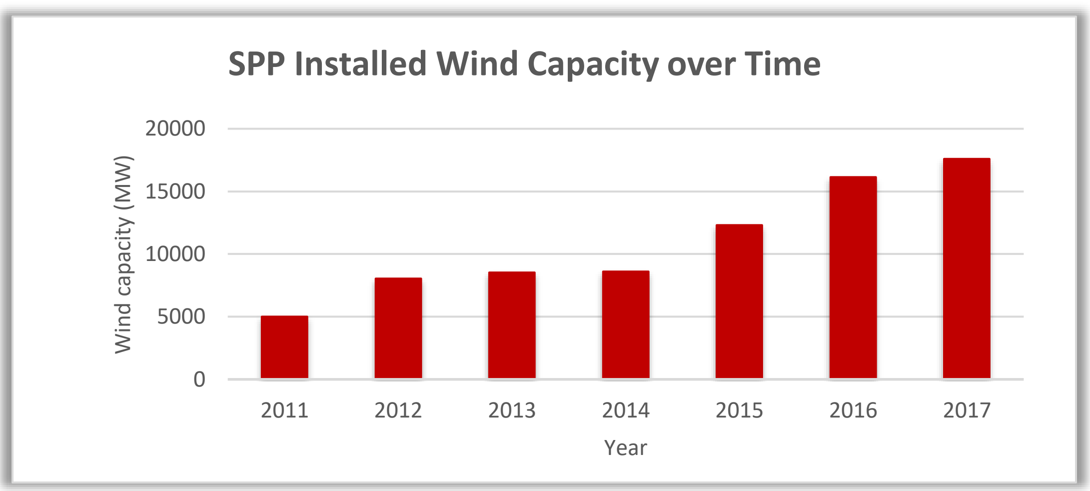
As technology and public policy advance at a rapid pace, SPP collaborates with its stakeholders to learn and understand their needs; apply our regional, member-driven strategic approach to the development of new policies, market practices and software applications; and advocate on their behalf throughout the industry.

Through our proven stakeholder process and thoughtful embrace of technology, we ensure electric reliability; hedge against bad investments; and facilitate collaborative, trusting relationships among our members and their customers.

This report provides insight into the SPP regional focus for advancing various technologies in the three-to-five-year horizon. This includes the following efforts: ramp product, forecasting improvements, stability assessments, energy storage, distributed energy, phasor measurement units, dynamic line ratings and topology control.

CHALLENGES OF A CHANGING FLEET

Year after year, SPP continues to serve an increasing percentage of our total load with wind generation. Installed wind-generation capacity is now over 17 gigawatts (GW) in our system. Such rapid and substantial integration of wind into our system comes with many challenges, including dramatic swings in wind output upward of 10 GW in less than 24 hours, as well as significant and sudden loss of wind generation due to icing and uncertainties inherent to wind forecasting. SPP also experienced an increase in congestion and congested flowgates with additional wind during the year: At high wind levels, the SPP transmission system experiences approximately double the number of congested flowgates compared to periods with moderate levels of wind.



To combat these challenges, SPP has implemented policies and market practices such as the dispatchable variable energy resource (DVER) to operate at these high penetration levels reliably. Learning from our experiences in the growth of wind-generation, SPP is preparing for large integrations of solar resources. Forecasting improvements, ramp products and stability assessments are a few of the tools that will ensure SPP continues reliable operations as the renewable generation numbers keep climbing.

FORECASTING IMPROVEMENTS

Better forecasts today ensure a more reliable and economic power system tomorrow.
Due to the ever-increasing amount of wind power within the SPP footprint, the importance of improving variable energy resource (VER) forecasting remains a top priority. The forecasting accuracy of SPP wind farms in particular is within industry norms, but there are still many opportunities for improvements. SPP's VER forecasting vendor is Energy and Meteo Systems based in Germany; the company is world-renown for its specialization in accurately forecasting VERs. Special challenges in forecasting wind can arise when there are large temperature or pressure changes that cause low-level jet streams. Other challenges in forecasting wind include reduced accuracy during icing events due to limited information concerning turbine blade response to ice buildup and forecasting wind farms installed over complex terrain that can experience turbulence.

SPP is working in close cooperation with Energy and Meteo Systems to improve the accuracy of wind and solar forecasts on many fronts. Wind-farm operators assisted with the procurement of wind-turbine-specific forecasts and turbine-level coordinates. Since wind farms can expand across large areas experiencing varying weather conditions, looking at individual turbines will be helpful in forecasting for the entire site. Energy and Meteo Systems also has rolled out new graphs that improve visibility of possible wind ramping scenarios that SPP may experience and enhance situational awareness.

In 2017, two revision requests to the SPP protocols were made to help improve the accuracy of the VER forecasts. In the future, SPP will continue to work with wind farms on the accuracy and dependability of critical Inter-Control Center Communications Protocol Supervisory Control and Data Acquisition (ICCP SCADA) data and work to obtain more data regarding specific turbines that will provide additional forecast granularity and help improve forecast for our growing VER fleet.

RAMP PRODUCT

With the growing integration of wind, solar and other VERs, the need to maintain a ramp capability has increased and will continue to increase in the foreseeable future. The ramping of most intermittent resources are very fast and are not systematically controlled, thus, place a heavy burden on the transmission, generation and other equipment tied to the interconnection. Although SPP may have enough available capacity to cover the generation difference, the market resources may be ramp constrained, forcing the use and depletion of the operating-reserve requirement. A ramp product in the SPP market will help ensure the ability to maintain the rampable capability to meet the challenge associated with the growing variability of the resource mix and rapid load fluctuation without depleting the operating reserve.

In the SPP marketplace:

- Security Constrained Economic Dispatch (SCED) dispatches inconsistently with how Security Constrained Unit Commitment (SCUC) dispatches
  - SCUC has look-ahead that can foresee future ramp needs
  - SCED does not have look-ahead capability to ensure enough ramp is available beyond the current interval
- Rampable headroom is not priced and settled in the market
- Currently, there is no economic transparency for the market value of ramp

SPP can design and implement a ramp product that:

- Creates economic market transparency as it related to the market value of ramp in SPP
- Provides a tool that is utilized based on economic incentives for the resource
- Help solve intrahour ramp problems while maintaining the operating reserve

What are the benefits?

- More available near-term ramp capability
  - Hold units back when required for future ramp needs
  - Reduce real-time price volatility caused by ramp shortage
  - Less frequent relaxation of operating-reserve requirement
- Production cost savings
  - Ability to use economical ramping units during sudden change in system requirements
  - Avoided cost of uneconomic commitments to provide ramp
  - Avoided cost of reserve shortage
- Transparent pricing for the supply of ramp capability
  - Resources are paid opportunity cost
- Long-term benefits of ramp product
  - Provide market incentives for participants to offer and develop improved resource flexibility

STABILITY TOOLS

SPP has been working to implement an online voltage stability assessment tool (VSAT) that will identify constraints on our system that real-time operators will be able to mitigate using current congestion management tools. Operational planning engineers will be able to perform stability studies in the course of outage coordination to prevent stability issues in real time. VSAT will provide a more in depth result to determine at what point voltage collapse will occur for defined contingencies. By doing so, SPP can make proactive decisions if studies indicate post-contingent voltage collapse could occur outside the threshold of current criteria.

SPP reliability coordination (RC) footprint is experiencing high penetration of wind generation. Wind generation has different characteristics than the conventional coal, gas and hydro generation (inertia, frequency response, voltage and reactive control, response to faults, etc.) Having a substantial part of the load covered with wind generation and less with traditional coal, gas and hydro changes the dynamic behavior of the bulk electric system (BES). Other contributing areas that create a more complex behavior of the BES: use of phase shifters, high-parallel flows from external regional transmission organizations, DC lines parallel to AC lines. This requires SPP to analyze more closely the dynamic behavior of the BES and VSAT, Transient Stability Assessment Tool (TSAT) and Small Signal Assessment Tool (SSAT) are the tools that are capable of analyzing the system for all possible events.

WHAT ABOUT ENERGY STORAGE?

The integration of energy storage is a prevalent issue concerning the future of the electric power industry. Renewable generation technologies such as wind and solar now provide an ever-increasing amount of energy to the power grid. One of the major challenges in incorporating these technologies into the grid pertains to the balancing of generation and load.

Traditional demand (load) fluctuations use energy stored in the magnetic fields of generators (inertia), which is very limited and causes impacts to system frequency. Resources respond to this using automated controls such a governors to increase or decrease speed in an attempt to maintain frequency at 60 hertz. Utilities respond to these fluctuations in demand and frequency using regulation (an amount of capacity set aside to respond to unplanned demand) to constantly adjust and balance the planned resource output with demand.

A stored energy resource (SER) is defined by the Federal Energy Regulatory Commission (FERC) as an electric storage resource capable of receiving electric energy from the grid and storing it for later injection of electricity back to the grid regardless of where the resource is located on the electrical system. These resources include all types of electric storage technologies, regardless of their size, storage medium (e.g., batteries, flywheels, compressed air, pumped-hydro, etc.), or whether located on the interstate grid or on a distribution system. SERs have the potential to reduce operational costs for the SPP market by using their rapid ramping rates to respond quickly to events for both regulation up and down. This fact highlights the importance of SERs as a resource with unique flexibility and varying functionality.

Stored energy resource design objectives:

- Enhance current market to allow for SERs to be incorporated in SPP footprint
- Leverage SERs unique characteristics to enhance SPP's available ramp for regulation and energy
- Manage the amount of system changes required for a proper design based on SPP needs
- Utilize this emerging technology to reduce set point oscillations on conventional resources during transient Area Control Error (ACE) excursions
- Maximize SER capabilities and reduce regulation capacity required due to increased ramp capability
- Create a mechanism for energy shifting in the market

DISTRIBUTED ENERGY RESOURCES

Operating reliably with an increasingly distributed electric system

As distributed energy resource (DER) amounts continue to grow, it's imperative that SPP is well-prepared for the resulting impacts. Fortunately, DERs have captured the attention of the national organizations and SPP's peers who are already dealing with higher capacity levels. In the near term, SPP's primary objective will be visibility, while long-term efforts may focus on increased control through market participation.

Visibility into the distribution system is the starting point for reliable and effective integration of DERs. It's important to gain a clear picture of what is installed to understand fully the potential impacts to the BES. To gain visibility, it is good to understand the barriers. Jurisdictional issues due to the many layers between the DER and SPP results in an insufficient amount of high-quality data at the national or regional level. Also, varying practices at the installation level may fail to capture site-specific information.

How do we plan to use the data?

Determining the ultimate plan for DER data usage will define what information is needed:

- Modeling
    - Per North American Electric Reliability Corporation's (NERC) Distributed Energy Resource Task Force, "Based on reliability considerations for modeling purposes, generation from DERs should not be netted with load as penetration increases. Load and DERs should be explicitly modeled in (a) steady-state power flow and short-circuit studies and (b) dynamic disturbance ride-through studies and transient stability studies for Bulk Power System (BPS) planning with a level of detail that is appropriate to represent the aggregate impact of DERs on the modeling results over a five-to-10-year planning horizon. A modular approach to represent DERs in BPS studies, with some level of data validation, is recommended to ensure accurate representation of the resources for the specific BPS study type."
- Forecasting
    - The system operator's visibility into DERs directly impacts their ability to forecast accurately and reliably control the system.
    - Traditional load-forecasting mechanisms don't account for the increased variability that high-DER penetrations may create.

How do we get the data?

Understanding that modeling and forecasting are the primary use cases for building the data specifications, the next step is to determine the mechanisms that enable SPP to get the data:

- Public data — Most public data sources are often informal and the quality is questionable. It seems like the data sets are often incomplete as well since some entities tend to focus on certain technology types and not others. Nevertheless, SPP will continue to advocate for greater data gathering efforts in this area.
- SPP policy — This area can be broken down into two separate efforts:
    - SPP's Supply Adequacy Working Group (SAWG) has a robust reporting structure in place for load-responsible entities (LRE) that may provide an avenue for collecting more granular data for distributed generation that has historically been captured in net load forecasts.
    - A recent FERC Notice of Proposed Rulemaking (NOPR) may provide increased opportunities for DERs to participate at the wholesale market level. The hope is that the participation would also lead to detailed data requirements and a means to harness DER capabilities.

- NERC Standards – IRO-010 and TOP-003 regarding data specification and collection at the RC, TOP and balancing authority level include the distribution provider (DP) as an applicable entity creating a mechanism for the RC/TOP/BA to request necessary data. Changes to MOD-032 to include the DP as well should be beneficial in acquiring the needed modeling data.

Moving forward

In the near term, we've identified visibility as the primary objective to operating reliably with DERs. To gain that visibility, SPP must create a comprehensive collection of data specifications and implement the policies or processes to gather the data on a continuous basis. Developing a centralized repository for DER information will assist SPP in integrating the data into defined use cases such as modeling and forecasting. SPP still has unanswered questions in moving forward:

Which stakeholder groups should lead the effort?

What processes will ensure the highest quality?

How to address state policy variances?

Governing language changes?

In the longer term SPP must be prepared to transition from the primary objective of visibility to an objective of control. As always, SPP will learn from our peers who are already experiencing higher levels of DERs. There may be a need to build relationships across different jurisdictional layers to form policies at the distribution level that support reliable operation on the BES. Additionally, participation in wholesale markets presents challenges of creating the proper incentives that also take advantage of the capabilities that DERs bring to the table.

SITUATIONAL AWARENESS

Using synchrophasors at SPP

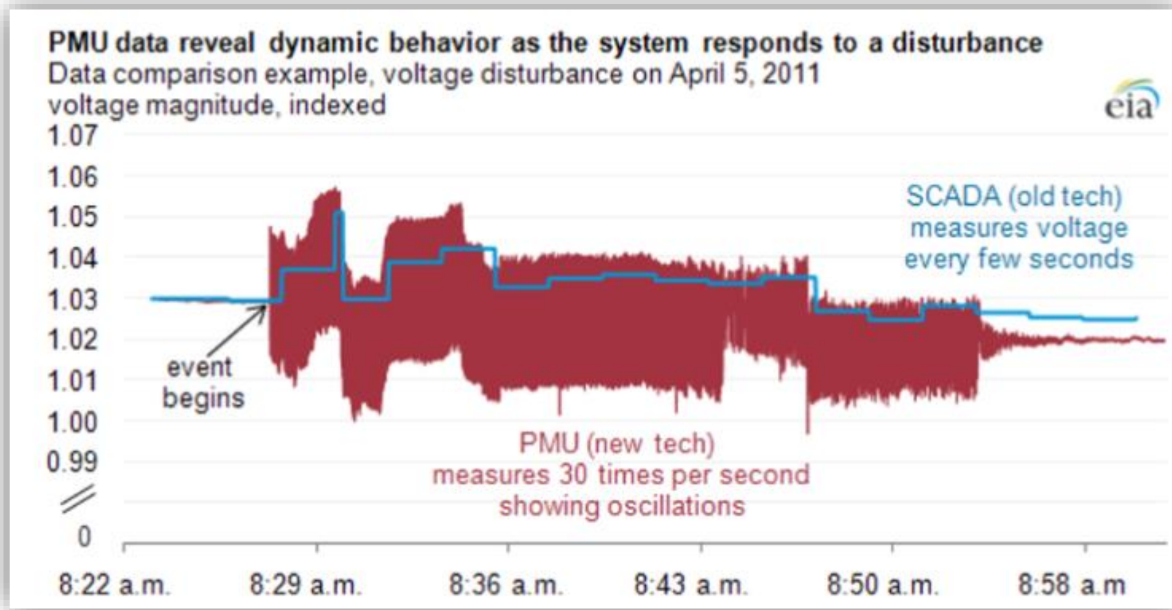
Synchrophasors are precise grid measurements available from monitors called phasor measurement units (PMUs). PMU measurements are taken at high speed (typically 30 observations per second, more than 100 times faster than conventional supervisory control and data acquisition (SCADA) technology). Each measurement is time-stamped according to a common time reference such as GPS. Time-stamping allows measurements from different locations and utilities to be time-aligned (synchronized) and combined providing a precise and comprehensive view of the entire interconnection, as defined by the North American SynchroPhasor Initiative (NASPI).

SPP roadmap

At SPP, we are focused on leveraging existing PMU data with both open-source and vendor-supplied software to leverage the value this technology can bring in support of SPP's goal of region-wide reliability.

SPP's first PMU project will equip us with a mission-supported PMU system focused on enhancing current operations, after-the-fact event analysis and improving system-model validation efforts.

This new PMU system will provide enhanced real-time situational awareness with measurement-based dynamic voltage stability monitoring, new insight into the detection of oscillatory modes and real-time tracking of phase angles to assess the overall stress of the grid.



These new and enhanced abilities will enable SPP to manage the transmission grid more efficiently, better accommodate significant variable generation, detect and identify potential undesirable conditions on the grid and, one day, enable SPP operators to make adjustments to resolve these conditions.

Member engagement

To maximize the value and minimize the effort required to adopt PMU technology, it is important for transmission and generation owners to collaborate and share ideas, use cases and successes along the way. Sharing actual PMU data, training and analysis results helps increase member's understanding and adoption of the technology. The Synchrophasor Strike Team is focused on promoting this collaboration among SPP members while also determining the optimal placement of new PMU devices with a goal of minimizing costs and maximizing value.

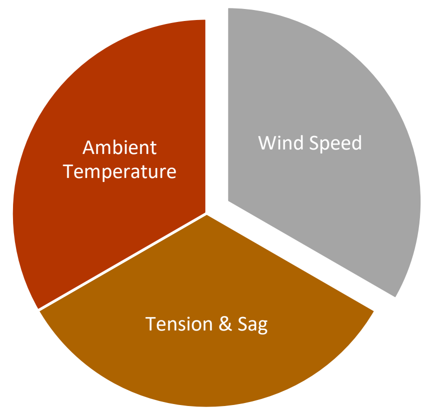
TRANSMISSION SYSTEM OPTIMIZATION

How current and forecasted conditions can define a more efficient and reliable power grid

With improved technology and grid operations, SPP is looking for ways to realize a more efficient and reliable power system today. Exploring the use of dynamic line ratings and transmission topology control may be an avenue for SPP members to optimize the use of their transmission assets. These tools will enable SPP to manage real-time and forecasted conditions more efficiently.

DYNAMIC LINE RATINGS

Traditionally, transmission system equipment has been controlled to static ratings provided by the facility owners. The use of these static ratings can sometimes be overly conservative for certain types of equipment, as ambient conditions vary drastically within a particular season. To ensure optimal usage of transmission capacity, SPP is working to help members integrate the use of dynamic line ratings. Benefits of using dynamic line ratings include: congestion relief, economic savings, improved transmission life, improved grid reliability and grid optimization.



Considerations for dynamic line ratings

TOPOLOGY CONTROL

The integration of large amounts of wind generation into the SPP footprint has led to new constraints and an ever-increasing amount of congestion across the transmission system. As transmission outages are taken to upgrade and maintain system equipment, deliverability issues can arise with large amounts of renewable generation.

One step SPP is looking at to aid in managing congestion on the transmission system is topology optimization. Through topology optimization SPP will be able to look quickly for transmission reconfiguration options that will mitigate system constraints and help to alleviate market congestion. Traditionally, engineers have manually run powerflow studies to evaluate individual reconfiguration plans. This tool will allow operations planning engineers to rapidly identify solutions that will help protect the integrity of the transmission system while reducing congestion costs.

SUMMARY

It’s no secret that technology advancements have played a huge part in shaping SPP’s business. It’s also apparent that technology continues to drive change at a swift pace. SPP’s relationship-based and member-driven approach to solving complex issues helps its members evolve in a reliable and economic manner. With this ever-changing industry, SPP embraces the challenges and opportunities ahead as we continue our mission of helping our members work together to keep the lights on … today and in the future.