Variable Generation Integration Study (VIS) Phase 2 Scope

1. **Transient Stability Analysis for the Spring MDWG 2017 outlook for the 30%, 45%, and 60% wind cases.**

   A transient stability study will be performed to determine stability for the 45% and 60% wind penetration Spring MDWG 2017 base case. Two sets of models, a base planning case and a planning model with historical operations outages included will be analyzed. V&R Energy's Fast Fault Scan (FFS) tool will be used to determine the more severe N-2 fault locations in the SPP region for each case. These locations will be ranked according to critical clearing times. Stability analysis for disturbance events will be completed using DSATools TSAT for the FFS events with critical clearing times less than 9 cycles. During the stability simulations, monitored parameters will include rotor angle and speed, real and reactive power, bus voltages greater than 100kV in the disturbance area (more than one area may be monitored depending on proximity to the disturbance), transient voltage response, and machine rotor angle damping. Parameter values will be compared with the *SPP Disturbance Performance Requirements* criteria.

2. **Seasonal Voltage Stability Analysis 2017 and 2021 year outlook. Comparison between Thermal and Voltage to determine if Voltage Stability or Thermal limitations are the most limiting. Consider Operations vs Planning.**

   A voltage stability study will be performed to determine stability for the 45% and 60% wind penetration Spring MDWG 2017 and 2021 base cases (with and without ops outages). Two sets of models, a base planning case and a planning model with historical operations outages included will be analyzed. Single contingencies on all of the base models will include SPP lines and transformers above 100kV, interfaces, flowgates and circuits, per latest NERC event file. Monitored elements will include NERC event monitored elements and SPP thermal overloads due to transfers. Voltage instability prior to reaching thermal limits will be cause for redispatch to avoid voltage collapse. If local voltage stability or thermal limits are reached, a generation re-dispatch will be performed utilizing a block dispatch in the following order: 1st thermal units (except Nuclear)(Gas to pmin then offline and Coal to pmin then offline), 2nd DVERS (dispatchable variable energy resources)(Hydro/Wind/Solar), 3rd NDVERS (Non-dispatchable Variable Energy Resources)(Hydro/Wind), to remedy the violation. A 5% voltage stability margin will be reported for wind transfers, flowgate limits, and load increase limits. The base models will include SPP firm wind commitment to external areas. A total of 8 load pocket area shown below will be analyzed.

   ### Table 2: Load Pockets by area.

   Area 1: Eastern Nebraska (Lincoln, Omaha)
   Area 2: South Oklahoma
   Area 3: SPS – South
   Area 4: West Oklahoma (Woodward Area)

Area 5: South Central Westar (Wichita Load Area)
Area 6: Kansas City
Area 7: Oklahoma City
Area 8: Williston

Analysis will be performed by increasing load within the load pocket while increasing wind transfer to the load area. The transfer will be increased while under contingency until voltage collapse occurred on the transmission system. A 5% stability margin will be use for the transfer limit. Reactive reserves will be determined at the point of voltage collapse.

3. Frequency Response Analysis for the spring MDWG 2017 outlook for the 30%, 45% and 60% wind cases.

Significant deviations in frequency are often caused by the tripping of large generation units, which results in substantial real power imbalances. Should the frequency drop below acceptable levels, large blocks of load can be shed, leading to possible cascading outages. Higher levels of wind penetration in the SPP footprint displaces existing conventional generation, thereby changing the overall system inertia. This study will provide insight into the changing dynamics of frequency response due to larger levels of wind penetration.

Perform time domain simulation studies of the system frequency behavior following a sudden loss of selected large generating unit(s), with different amounts of wind generation and operating reserves. The studies will be performed using the 30%, 45%, and 60% wind penetration Spring MDWG 2017 base cases (ops outages included) and existing MDWG dynamics data for wind turbines. Frequency response will be examined and compared to existing under frequency load-shedding setpoints to determine if the inertial response, the frequency nadir, and the settled frequency following the generation loss event are acceptable. Frequency response analysis will be completed using DSATools TSAT.
A transient stability study will also be performed to determine stability for the 30%, 45%, and 60% wind penetration Spring MDWG 2017 base cases (ops outages included) for the generation loss event. Stability analysis will be completed using DSATools TSAT. During the stability simulations, monitored parameters will include rotor angle and speed, real and reactive power, bus voltages greater than 100kV in the disturbance area (more than one area may be monitored depending on proximity to the disturbance), transient voltage response, and machine rotor angle damping. Parameter values will be compared with the *SPP Disturbance Performance Requirements* criteria.

4. Targeted 5 Minute Analysis Future Ramping 5 Year Outlook.

Run scenarios with 5-minute granularity, designed to assess performance of the SPP system over varying ranges of ramping. These scenarios and ramping ranges are not finalized yet, but here are the initial proposals:

- Use existing market software (Market Clearing Engine for RTBM solution) to represent, based on current design and protocols, how SPP would operate across these ramping ranges
- Study four-hour horizons.
- Scenarios to simulate would be typical situations where we expect higher ramping needs. Because solar is not projected to have as large of an impact in the next five years as wind, this will mostly focus on times when load and wind are moving in opposite directions (Net Load increasing or decreasing quickly), such as

    - Summer load ramp, with wind dropping
    - Fall/Spring evening load drop, with wind increasing
    - Fall/Winter/Spring morning load increase, with wind decreasing
    - Etc.
- Wind/Solar ramping values to consider will be based on historical analysis, coupled with various capacity projections for five years out (using GI queue). We would take the same scenarios (like spring evening load drop with wind increasing) and simulate varying levels of wind/solar changes at the time (e.g. ramps of 4 GW, 8 GW, 12 GW… over the simulation period)
- With these studies, we will require some assumptions going into the simulation, like
    - current operating resource plan (which units are online at which time)
    - network model/topology and transmission constraints
    - accuracy of forecast assumed in studies leading up to the simulation (how well did our studies project the ramping and capacity obligations that we will experience in those simulations)

These studies should provide some results for analysis on SPP's future ramping capabilities and highlight any requirements. Because it will use the existing market software, we will also be able to look at data and performance that SPP is currently operating with for easy benchmarking (such as wind curtailments, pricing, product shortages, etc).

There will also be some analysis and reporting of forecast errors and risks associated with forecast errors, in relation to the ramping evaluated in the simulations.