09.14.09 DRAFT

NREL SUBCONTRACT NUMBER (AAM-9-89030-01)

NEBRASKA STATEWIDE WIND INTEGRATION STUDY

SUMMARY of Technical Review Committee Meeting #6

August 11, 2009 – 10:00 AM to 2:00 PM (Central Time)- Ventyx WebEx tele-web conference

Reference Documents - Email to TRC and Observers dated 08.04.09 from Doug Kallesen (for Clint Johannes) containing three attachments: the meeting Agenda, TRC Meeting #5 Summary, and Roster, some of them having been updated from previous distributions. The EnerNex and Ventyx presentation files were provided in separate emails on 08.10.09 and then the finalized presentation files were emailed on 08.17.09, and including some subsequent additions and corrections.

TRC Members Participating:

Utility- Clint Johannes, Dave Rich, Doug Kallesen, David Ried, Marc Nichols, Jon Iverson, Bruce Merrill, Billy Cutsor.
Consultants- Bob Zavadil, Jack King, Tom Mousseau, Gary Moland, Rick Hunt, Barbara Coley.
Technical Experts and Stakeholders- Michael Milligan, Laverne Kyriss, Jay Caspary, Neil Moseman, Bruce Hauschild, John Hansen, Tim Texel, Michael Goggin, Steve Eveans.

Observers Participating:

Utility- Randy Lindstrom, Jim Fehr, Rocky Plettner, Ron Thompson, Tim Owens, Mike Matheson, Frank Thompson, John Richards, Max VanSkiver.
Technical Experts and Stakeholders – Mark Ahlstrom.

Overview of Meeting and Summary:

The complete agenda was covered and the general purposes achieved, that being to review new results, discuss and make decisions about future work including case definition and assumptions as well as work and meeting schedules.

This summary is intended to document key points of the discussion. *Questions and comments from the audience are usually identified in italics* and plain type is intended to indicate statements by the presenter at the time. Usually the person involved will be clear, but not always. [Followup is usually shown in brackets].

Afterthoughts and suggestions can be emailed at any time to Doug Kallesen, drkalle@nppd.com, 402-563-5274, and they will get "logged" into the study process, or to Clint Johannes, Chair of the TRC, cjohannes@neb.rr.com, 402-910-1856.

Key Points of the Discussion:

1. Rick Hunt, Ventyx, welcomed all and took roll call.

2. Clint Johannes, Chair of the Technical Review Committee (TRC) and Chair of the NPA Joint Planning Subcommittee (JPS):

    a. Welcomed all and provided an overview of the meeting purpose.

b. Asked for any additional comments to the TRC 5 Meeting Summary dated and distributed 08.04.09. No comments offered.

3. Bob Zavadil, study technical manager, EnerNex, proceeded into the EnerNex presentation with some more background on meeting objectives and general work status.

4. Tom Mousseau continued the EnerNex presentation (slide numbers listed below refer to the finalized presentation sent to the TRC on 08. 17.09).

   a. Slide 4: MAE refers to Mean of the Absolute Error of the forecast and is referenced to the nameplate generation capacity of the wind plant (slides 15-16) – so that, all the ± errors are considered as positive (absolute value), then the average (mean) of all the resulting absolute hourly errors is 10MW for a 10% MAE on a 100 MW wind plant.

   b. Slide 4: DA refers to "day-ahead" forecast of wind generation, which for the NREL data being used means the forecast was made 18 hours before the start of the next day (slide 14).

   c. Slides 6-13: EnerNex indicated they would supplement these with some maximum ramp-up and ramp-down data to see how much greater than the max is than the 98th percentile.

   d. Slides 15-16: MAE will decrease with aggregation due to occasional cancellation of errors; *however not much of a decrease shows up from 10% to 40% penetrations– perhaps because the 10% siting is diverse and already contains much of the aggregation decrease (apparently).* Comment was made that individual sites, as we have seen previously, have MAE of approximately 15%, whereas these aggregated values are around 10%. Persistence forecast is simply forecasting that the next hour's wind generation is expected to be the same as the current hour.

   e. Slides 17-21: (April 4 charts were corrected subsequent to the meeting and the April 5 charts were dropped). Nameplate wind capacity for Nebraska at 20% penetration is 2,488 MW. These slides show a spring day where the down ramp of wind from midnight to mid-day goes from approximately 87% of nameplate wind to near zero wind, and thereby adds to the load ramp burden throughout the morning. This causes the Nebraska coal units to go from min to max yet still not be able to handle the full up ramp of load net wind; the coal units can only handle about 60% of the wind generation ramp range, and the reduction in export must handle the other 40% of the ramp range. As clarification on slide 21, the export amount is the difference between the two lines labeled "NPA Gen" and "Export".

   f. Slides 22-30: these are charts of various hourly data for SPP including NPA for weeks of winter low wind, winter high wind, spring low wind, spring high wind, summer low wind, summer high wind, fall low wind, and fall high wind. *Michael Milligan asked how do these selections compare to the April 4 day shown in slides 17-21?* EnerNex will try to line them up and maybe do some more extreme and typical charts like these slides for

the final report. Tom indicated EnerNex will also be doing some of these hourly data charts when Ventyx provides data for NPA only.

5. Rick Hunt began the Ventyx presentation (slide numbers listed below refer to the finalized presentation sent to the TRC on 08.17.09).

    a. *Dave Ried brought up that the SPP WITF has found that the 40% penetration case will not solve and have dropped study of it.* Reply that our understanding is that they are not including the overlay that we are (using a more near-term model) and they are also doing a more comprehensive technical study using complete load flow and stability tools.

    b. *Slide 5 table discussion about no curtailment in Nebraska but some in SPP.* Rick replied that 17 constraints are being modeled for Nebraska. These are not causing curtailment because PROMOD is always able to redispatch, with the LMPs not being below the $-40/MWh cost of wind.

    c. *Slide 5 Jim Fehr asked what is the typical ratio between incremental reserves and nameplate wind for the SPP part of the model, including Nebraska.* Answer:
    10% penetration: nameplate = 12,541 MW, incremental res = 852 max, ratio = 6.8%
    20% penetration: nameplate = 23,856 MW, incremental res = 1,542 max, ratio = 6.5%
    40% penetration: nameplate = 49,699 MW, incremental res = 3,034 max, ratio = 6.1%
    Rick will add an average incremental reserves line to the slide 5 table reporting for the final report.

    d. Slide 8 identifies that the APC is $462 million less with the 765kV overlay. It is intended for the final report to identify the sources of these benefits. Probably half is from more wind generation (less wind curtailment) and then to identify the other efficiencies.

    e. Slides 10 and 11 are both labeled for use in the "flat block" sensitivity case explanation, with the flat (daily) block being the red line on slide 10. Here is a bit of explanation to help understand the PROMOD analytical process that develops the wind integration cost:

        i. Slide 10: The Flat Block "proxy" resource contains the same amount of energy as does the actual wind generation, with the daily value being the average for the day. The integration costs are developed as the difference between an "ideal" run and an "actual" run. Using the flat block profile for the ideal run, the daily block is used for PROMOD's day-ahead commitment and day-of dispatch decisions. For the actual run, the forecast wind generation is used for commitment and the actual wind generation is used for dispatch. The concerns with the flat block are the possibility of shifting some of the wind generation from off-peak periods into the more valuable on-peak periods, and also for high penetrations the potential large midnight ramps as the block changes level.

ii. Slide 11: The Shaped Wind "proxy" resource also contains the same amount of energy as does the actual wind generation. In the shaped ideal run, the actual wind generation is used for both the commitment and dispatch decisions. For the actual run, the forecast wind generation is used for commitment and the actual wind is used for dispatch.

f. Slide 12 shows wind integration cost for 10% penetration, 2006 pattern, SPP market of $1.74/MWh for the shaped proxy increases to $12.56 MWh [as updated after the meeting] for the daily block wind proxy resource ($2018). For EWITS, done at 7% penetration the result for the daily block was $8.15/MWh ($2024).

g. Slides 13-14 show that combined cycle generation increases both for use of the shaped proxy (over the flat block), and for actual wind case compared to the ideal wind given the shaped proxy. In relative terms the combined cycles generally increase three times as much to deal with the actual wind (given shaped proxy) than with the ideal shaped proxy itself (over flat block). Two possible factors are involved: flexibility is needed on both accounts, and exports are increasing on both accounts. However, it is noted that the Neb combined cycles actually reduced for the shaped proxy in slide 13, opposite in movement to the combined cycles of the rest of SPP.

h. Slide 17 shows $120/ton CO2 price created a reduction of 19% in CO2 emissions from the $0/ton run for the 20% penetration; however this still may not meet cap limits currently under discussion for reductions from the 2005 emission level. More work to relate these emission levels to regulatory discussions is intended.

i. Slide 20 shows SPP pumped storage generation significantly decreasing as CO2 price increases. This is logical given that the increasing CO2 price tends to close the gap between coal and gas production cost, which tends to close the gap on pricing between on- and off peak periods, taking away a big reason for pumped storage generation to occur.

j. Slide 24 shows the 345kV Neb-only (765kV for the rest of SPP) overlay case as having a slightly higher APC than for the all-765kV overlay [this relationship is updated since the meeting].

k. Slide 30 shows the generation for SPP, including Nebraska, decreases 5.8 % (=-16.6 TWh/287.7 TWh) as the hurdle rate for SPP is increased from $5/MWh to $20/MWh. Its effect on exports is to reduce them perhaps by 61% (= -16.6 TWh /27.13 TWh). APC only increases by $152 million, or only $9.17/MWh of export lost. Amount of wind generation is unchanged. No significant change in wind integration cost – actually it is lowered some.

l. Slide 35 on WAPA hydro mitigation sensitivity discussion. One idea would be to schedule the transactions based on the load net wind instead of load only, keeping energy deliveries unchanged, and minimally shifted time-wise. EnerNex and Ventyx are now into analysis and data development needed for case setup. NPA desires to have

some run scope reserved for a follow-on (second WAPA case) if the first case warrants a second, supplementary view.

m. Slide 36 on third proxy represents a sub-period block proxy where the wind proxy uses separate flat blocks for the on-and off peak periods on a daily basis. One of the issues this is intended to address would be the shifting of wind energy from off-peak to on-peak (creating an optimistic assumption) that occurs with the daily block assumption. Maybe this result would be in between the results for the shaped and block proxies. TRC agreed to do this case. [In a subsequent phone call on Aug 17, the consultants and utilities agreed to modify this plan to instead consider a rolling window assumption for the wind pattern to try to separate wind shape costs from operating costs. This may take two case slots to "iterate" to the right window length].

n. Along with the discussion about the sub-period proxy assumption option, Michael Milligan offered up, and sent to the project team, a link to a recent paper entitled "Calculating Wind Integration Costs: Separating Wind Energy Value from Integration Cost Impacts", by Brendan Kirby and Michael Milligan, available at (link was sent to the TRC on 08.11.09) http://www.nrel.gov/docs/fy09osti/46275.pdf .

o. Slide 37 shows a potential methodology of peak shaving / valley filling modification to hourly load as a sample sensitivity on demand side modification as a potential linking of off-peak wind energy to supply plug-in hybrid charging load. Some other source of demand reduction would need to be found for the on peak load shaving. There was discussion about western interconnection studies along these lines that apparently justify some of these looks based on addressing unserved energy in production runs. In our runs we have minimal unserved energy. Because all of the integration costs using the shaped proxy are coming in consistently low, we would not expect to see much new information using that metric on a load modification case. Lacking a clear basis, metric, and methodology for pursuing this case, the TRC has tentatively decided not to pursue this sensitivity any further. We believe that in the above possibilities and run ideas (proxy and/or WAPA), there will be more useful applications of the study resources.

p. *Michael Milligan suggested an alternative to running PROMOD against a modified load shape, but instead looking at the load and wind data in conjunction, like the 98% data tables, to examine some extreme operating conditions. Then see what load modification capability might be able to accomplish, and what other useful information might be available, irrespective of PROMOD costing*.

6. The discussion on wrap-up and final case planning is summarized as:

a. Doug Kallesen indicated some ideas for additional sensitivity runs.

i. **Third proxy** with sub-period blocks. This is discussed more fully as item 5.m above, indicating that the **TRC agreed to pursue this case**, which is probably going to modified a bit per 5.m, but is considered quite important to the study.

ii. Given that the 345kV Nebraska-only overlay case results turned out quite interesting, run another transmission-related case. After discussion, the **TRC decided to run the 345kV Neb-only overlay case against the 40% penetration** to see how it might handle the doubled wind energy. [One further modification to this was identified later to rate the line capacity at 3,000 amps consistent with current SPP design practice to give the 345kV a "fair shot". The 20% case was run with 2,000 amp capacity]. Also Rick Hunt will do some further review of the comparison of the Neb 345 and 765kV overlay cases to learn why the 345kV performs so well and what is its potential for handling a 40% wind penetration.

iii. This leaves yet one undefined sensitivity case, to be held until some further results are available for review (for example, possibly indicating more to do on proxy resource or on the study of WAPA mitigation potential).

b. Next Doug Kallesen described a methodology for estimating a total SPP cost for each of the cases, which in summary form includes:

i. Estimating an average 2007 retail rate for the SPP footprint based on DOE-EIA data, then projecting this rate at an assumed escalation rate to 2018, then multiplying by the assumed number of 2018 retail KWh in the SPP footprint to get a total retail revenue requirements reference value that is assigned to the existing wind case, without CO2 costs included.

ii. Available wind (beyond existing wind and before curtailment) is priced at a typical developer sale price, and the incremental revenue requirement is factored into each case varying for each penetration.

iii. Local transmission is estimated as an adder to the wind cost in ii above, and factored in as incremental revenue requirement.

iv. EHV overlay transmission line cost is estimated based on mileage and voltage level, with associated substation cost being an adder, and both are factored in as incremental revenue requirement.

v. All transmission costs are annualized for 2018.

vi. Adjusted Production Cost is factored in as a delta from the APC for the reference case (existing wind).

vii. CO2 cost, being shown by PROMOD as a tax, is adjusted to a cap-and-trade scheme with some of the allowances being granted free of charge to the SPP utilities.

viii. Also the $120/ton CO2 cost for the CO2 emission reduction case is factored back to $50/ton, as the $120 was used simply to "force" an emission reduction.

ix. Taking the reference cost and adding all the incremental cost effects described in ii through viii above, results in the overall total SPP cost estimate for each of the cases.

c. Discussion was held on how best to portray total cost, especially the cost differences between cases and whether Nebraska only vs. SPP-wide. It was left that the utilities will work more on this and further develop and check the methodology, assumptions, and presentation approach, but using something along these lines generally.

d. Billy Cutsor indicated that he and Ron Steinbach were nearing completion of a draft appendix addressing the western interconnection issues relative to Nebraska, including the results of the WAPA mini-analysis. A draft will be shared with the study team by the end of the month.

e. Detailed scheduling and case definition of the final runs will be discussed by the study team on its Monday phone call. We intend to get the main report to the TRC one week prior to the **final September 23 face-to-face meeting in Omaha (set for 9:00 AM Central).** [Subsequently the TRC and observers were notified by email on August 26 that "*We do not expect to have the final written report completed in time for you to review prior to the meeting, but would intend to provide it shortly thereafter, and including consideration of suggestions/comments at the meeting. We do expect to have all the cases run and analyzed for the meeting, together with presentation of findings for group discussion."]*

f. Bob Zavadil indicated that we are on the UWIG agenda for its fall meeting to be held October 7-8 in Cedar Rapids, Iowa.

By Doug Kallesen, NPPD (for NPA)