Nebraska Statewide Wind Integration Study
Report Appendix Section 8.2 – Part 1

Prepared for:

Nebraska Power Association (NPA)

Subcontractor to:

The National Renewable Energy Laboratory

A national laboratory of the U.S. Department of Energy
Subcontract Number (AAM-9-89030-01)

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Date:

December 31, 2009

NEBRASKA POWER ASSOCIATION

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Section 8.2 Additional Wind and System Generation Characteristics and Scenario Information

This document is a part of the work performed by EnerNex for the Nebraska Statewide Wind Integration Study and is the appendix to this study final report. Ventyx provided the output results from PROMOD runs used to create the charts provided in Section 8.2.4.2 (Part 2 of Section 8.2).

The objective of this section of the appendix is to document the wind profile data from the mesoscale database developed for National Renewable Energy Laboratory (NREL) by AWS Truewind as it is used in the Nebraska Statewide Wind Integration Study. Load profile data obtained from NPA is also reported, including its correlation to wind generation. The focus is on the data for Nebraska and the rest of the Southwest Power Pool (unless otherwise noted herein "SPP" is used to refer to the non-Nebraska portion of the Southwest Power Pool, even though most Nebraska utilities are members of SPP). Data used in the model is also reported for other portions of the Eastern Interconnection of the U.S. power grid.

Because of the very significant volume of data, for both the database as a whole and the scenarios defined and developed for use in the study, the documentation is necessarily in the form of summary charts, graphs, and tables that depict relevant characteristics of the time series data.

The analyses conducted conform to the structure defined in the project scope, which consists of the following five items for the data included in this appendix, Section 8.2.

- *Group wind sites into regions.*
- *Conduct statistical analysis with spatial and temporal slices, to examine resource correlation across the region and wind/load correlation over time.*
- *Examine the energy production value of wind sites.*
- *Develop three scenarios with 10%, 20% and 40% wind energy penetration in the SPP portion of the study footprint based on these analyses, and with a goal of low cost of energy and low integration costs.*
- *Conduct statistical analysis on these three scenarios to examine the feasibility of integrating these levels of resources into the individual balancing areas, or authorities.*

The raw data used in this work can be accessed and downloaded from NREL's website at http://wind.nrel.gov/public/EWITS/. Before downloading, it is suggested that one review the FAQ webpage referenced there for direction.

Section 8.2.1 of this appendix focuses on the mesoscale data as a whole. The database for 34 states in the Eastern Interconnection contains 1,325 separate "plants" – which are aggregations of nearby data points corresponding to a 2 km grid – and a total installed capacity of 580 GW, see Table 1, Table 2, and Table 3.

Section 8.2.2 of the report documents the process used to define the study scenarios being evaluated, as well as several charts and tables of the site-specific and aggregated wind

generation characteristics in terms of capacity and energy, capacity factor, capacity value (in SPP), diversity/correlation, variability, and uncertainty .

Section 8.2.3 provides:

- charts and tables showing relationships between NPA and SPP loads and wind site generation for the selected sites.
- NPA and WAPA wind diversification for combined forecast reduction.

Section 8.2.4 displays weekly details for the year's time for each of the NPA and for the rest of SPP in how wind generation reduces the net load and how the remainder of the generation system responds to the wind generation characteristics as determined by PROMOD.

Section 8.2.1 Characterization of NREL Meso-Scale Data

The NREL meso-scale wind database for the Eastern Interconnection, developed by AWS Truewind, is the source for all wind generation data in this study. The data is available for selective download at http://wind.nrel.gov/public/EWITS/.

Characteristics of the NREL meso-scale database, which represents 580 GW of total nameplate capacity, are presented in this section, along with characteristics of wind generation profiles by the operating footprints defined for this study.

Table 1: Counts of Plants by Size

Plant Size (MW)	Number of Plants in Database
0 -150	265
150 - 250	155
250 - 350	214
350 - 450	194
450 - 550	146
550 - 650	95
650 - 750	52
750 - 850	38
850 - 950	11
950 - 1050	57
1050 - 1150	54
1150 - 1250	29
1250 - 1350	12
1350 - 1450	3
Total	1325

Table 2: Wind Plants by State and Size

State	0 - 150	150 - 250	250 - 350	350 - 450	450 - 550	550 - 650	650 - 750	750 - 850	850 - 950	950 - 1050	1050 - 1150	1150 - 1250	1250 - 1350	1350 - 1450
Arkansas	11	6	2							1				
Colorado			2	3	1		1	1						
Connecticut	6	2												
Delaware	6		1											
Illinois		5	19	23	6	5	2	5	2	6	4	1	1	
Indiana		5	17	12	9	6	3	1		3	4	1		
Iowa		7	13	17	17	13	6	6	1	4	1	2	4	1
Kansas			6	12	10	10	5	3	1	1	11	5	2	
Kentucky	3		1	1	1									
Maine	37	4									1			
Maryland	7	2												
Massachusetts	18	1												
Michigan	9	13	12	5	5	1	3	1	1	3	1	2		1
Minnesota	1	9	33	22	22	13		4	1	4	7	4	1	
Missouri		1	4	4	2	5			1	1	1			
Montana	2	2	2	2	1				1	1				1
Nebraska		8	16	17	13	9	8	3		10	4	1		
New	20	1												
New Jersey	5	2		1										
New Mexico	2	5	4	3	5		2		1	1	1			
New York	25	26	5	5	1		2	1			1			
North Carolina	6	2		1	1									
North Dakota		6	13	10	10	6	3	2		5	3	2		
Ohio		4	9	4	4	2	6	1		1	2	1		
Oklahoma	4	9	14	21	11	7		5		5	4	1	1	
Pennsylvania	48	7	1											
Rhode Island	4	3												
South Dakota	2	9	14	18	13	13	6	2	2	5	4	2	1	
Tennessee	7	1												
Texas			11	8	6	4	3	1	1	2	4	6	2	
Vermont	14	3												
Virginia	13	1	2											
West Virginia	15	2		1										
Wisconsin		8	14	4	8	1	2	1		4	1	1		

Table 3:Installed Capacity by State and Size of Plant

State	0 - 150	150 - 250	250 - 350	350 - 450	450 - 550	550 - 650	650 - 750	750 - 850	850 - 950	950 - 1050	1050 - 1150	1150 - 1250	1250 - 1350	1350 - 1450	Total - GW
Arkansas	1342	1101	557							1049					4
Colorado			541	1191	456		732	840							3
Connecticut	685	346													1
Delaware	688		330												1
Illinois		1162	5776	9076	3021	2854	1357	3979	1747	6164	4370	1234	1291		42
Indiana		1135	4963	4878	4564	3663	2181	823		3104	4456	1199			31
Iowa		1595	3989	6895	8474	7798	4081	4762	919	4024	1107	2414	5083	1435	53
Kansas			1778	4936	4997	5918	3441	2418	906	1011	12153	5930	2581		46
Kentucky	300		264	381	545										1
Maine	4026	753									1084				6
Maryland	769	345													1
Massachusetts	1998	168													2
Michigan	1029	2671	3508	1992	2470	578	2107	797	896	3085	1082	2369		1361	24
Minnesota	147	2036	9839	8973	10774	7726		3209	880	4075	7762	4777	1281		61
Missouri		245	1316	1658	950	2907			878	1038	1147				10
Montana	269	463	598	772	497				850	1025				1357	6
Nebraska		1875	4708	6792	6289	5279	5509	2273		10209	4366	1171			48
New	2188	183													2
New Jersey	548	357		423											1
New Mexico	203	1076	1161	1207	2396		1418		897	1038	1128				11
New York	2756	4992	1373	1934	516		1377	825			1086				15
North Carolina	642	386		425	546										2
North Dakota		1267	4016	4035	4879	3500	2141	1570		5121	3222	2388			32
Ohio		822	2715	1540	1892	1194	4098	795		969	2212	1207			17
Oklahoma	400	1927	4179	8295	5336	4222		4016		5062	4361	1163	1291		40
Pennsylvania	5517	1176	294												7
Rhode Island	462	578													1
South Dakota	271	1847	4312	7279	6376	7708	4247	1529	1772	5047	4480	2374	1304		49
Tennessee	730	156													1
Texas			3317	3142	2874	2440	2176	789	890	2046	4413	7196	2613		32
Vermont	1537	482													2
Virginia	1340	197	561												2
West Virginia	1543	430		403											2
Wisconsin		1611	4245	1597	3940	560	1397	753		4035	1125	1230			20
Total GW	29	31	64	78	72	56	36	29	11	58	60	35	15	42	580

As shown in Table 3 approximately 8% (or 48GW) of the wind plant capability identified in this 34-state database resides in Nebraska. It also shows that the potential installations listed for Nebraska are about ten times the largest penetration scenario in this study.

Section 8.2.2 Wind Site Selection and Analysis

Section 8.2.2.1 Wind Scenario Development by Region

Wind generation siting for the Nebraska Statewide Wind Integration Study were selected from the wind resources identified in the NREL meso-scale database. The selection criteria were based upon plant capability, energy, location dispersion and ability to meet the energy criteria for each scenario.

Wind selection was made for Nebraska labeled as the Nebraska Power Association (NPA) and the rest of the Southwest Power Pool (SPP). It was determined at the study's Technical Review Committee (TRC) meeting in March that the wind siting identified in the reference case for the Eastern Wind Integration and Transmission Study (EWITS) would be used. This provides a constant reference point with this interconnection and focuses the wind penetration impact on NPA, and SPP. The Western Area Power Administration (WAPA) and the Dakotas (MAPP) are represented in the EWITS reference case and held constant. The Tennessee Valley Authority (TVA) wind sites also remain constant for each scenario.

The energy levels for wind selection were based upon the estimated system energy for each region in year 2018. NPA calculated the wind generation energy necessary to provide an estimated 1% penetration for Nebraska in year 2018. The amount, 405 GWh included consideration of both retail load and transmission and distribution losses from the generation bus to the retail meter bus. Losses of 7.4% were assumed which would make the 405 GWh generated equivalent to 375 GWh to serve retail load and with the balance of 30 GWh for losses. The energy targets for NPA were established by multiplying the 405 GWh by 10, 20 and 40 for each respective scenario Table 4, Figure 1, and Figure 2.

The energy targets for SPP were derived from publicly available data filed by the utilities with FERC and adjusted to year 2018 assuming typical growth rate. For these regions wind penetration levels of 10%, 20% and 40% of energy were calculated Table 5, Figure 1 and Figure 2. Wind sites from the meso-scale database were selected to closely achieve meeting these energy levels.

Table 4: Nebraska Selected Wind Generation Penetration Details

Nebraska	10% Pen	20% Pen	40% Pen
Target (GWH)	4,052	8,104	16,208
Selected (GWH)	4,523	8,856	16,831
% of Target	112%	109%	104%
Nameplate (MW)	1,249	2,488	4,727
Capacity Factor	0.41	0.41	0.41
Number of Sites	5	8	11
Average Site Size	250	311	430

Table 5: SPP w/o Nebraska Selected Wind Generation Penetration Details

SPP	10% Pen	20% Pen	40% Pen
Target (GWH)	22,321	44,641	89,283
Selected (GWH)	22,901	45,807	91,548
% of Target	103%	103%	103%
Nameplate (MW)	6,256	12,596	25,431
Capacity Factor	0.41	0.41	0.40
Number of Sites	7	18	33
Average Site Size (MW)	894	700	771

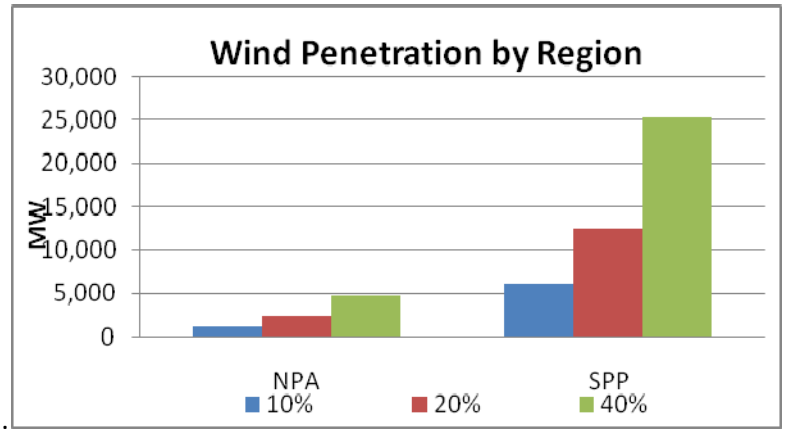

Figure 1: Scenario Nameplate Capacity summary by Region

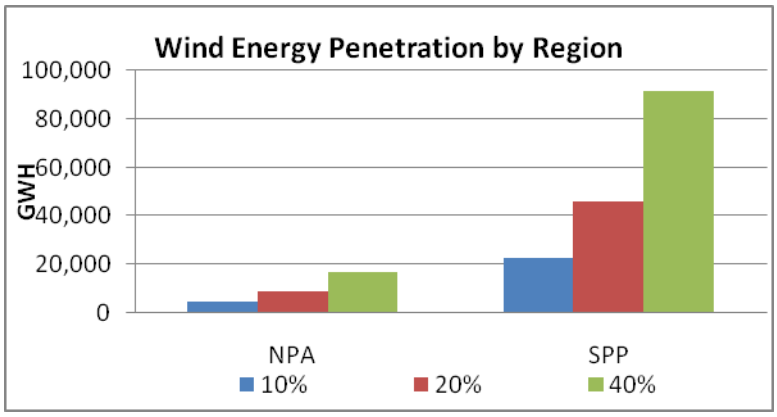

Figure 2: Average Annual Energy by Scenario by Region

Table 6: Summary of Capacity, Capacity Factor and Energy for each Scenario by Region

Region	10% Penetration			20% Penetration			40% Penetration		
	Name Plate	CF	Reference Energy	Name Plate	CF	Reference Energy	Name Plate	CF	Reference Energy
NPA	1,249	41%	4,523	2,488	41%	8,855	4,727	41%	16,831
SPP	6,256	42%	22,901	12,596	41%	45,807	25,431	41%	91,548
PJM	25,807	36%	81,460	25,807	36%	81,460	25,807	36%	81,460
MISO/MAPP	19,547	36%	61,700	19,547	36%	61,700	19,547	36%	61,700
SERC	3,615	36%	11,410	3,615	36%	11,410	3,615	36%	11,410
TVA	1,397	36%	4,410	1,397	36%	4,410	1,397	36%	4,410
Total	57,871	37%	186,405	65,450	37%	213,642	80,524	38%	267,359

The following figures provide visual locations of wind siting utilized in the study. The sitings identified for MISO include the MAPP and WAPA regions. These sitings along with the TVA sitings are constant for each scenario. Wind penetrations are varied only in the NPA and SPP areas.

The map in Figure 3 shows the Wind Siting for the EWITS Reference Case. Figure 4 is a sub set of the EWITS showing West MISO which includes MAPP and WAPA areas. TVA sitings are shown in Figure 5. Sitings for Nebraska are shown in Figure 6 - Figure 8 and details are listed in Table 7. The Reference Energy column in Table 7is the average annual energy for three years of hourly data. The SPP siting, not including Nebraska, are shown in Figure 9 - Figure 11.

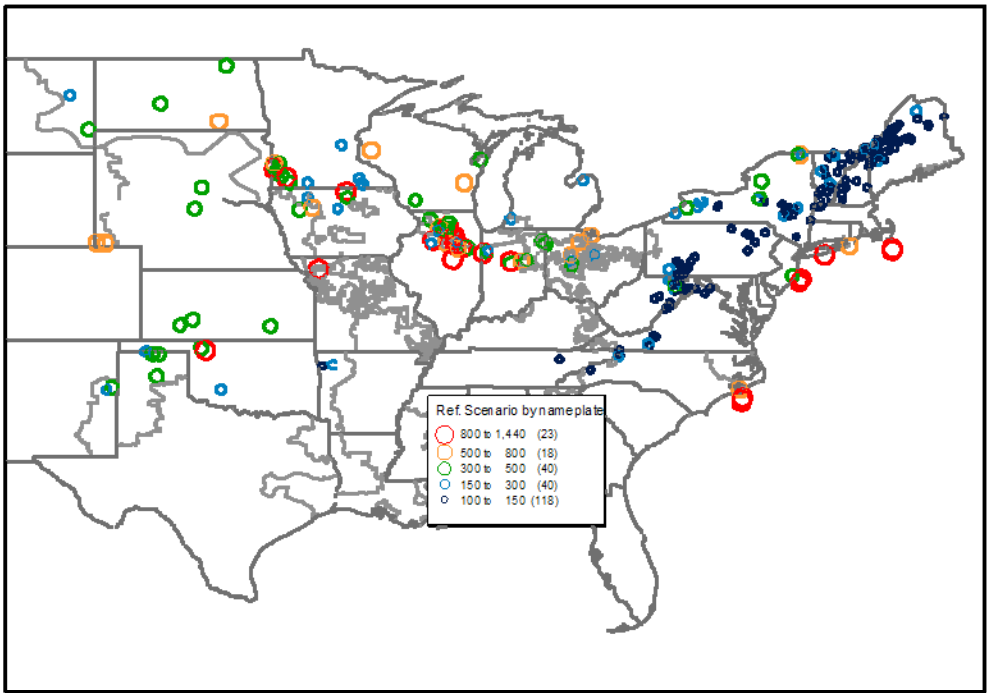

Figure 3: Wind Siting for the EWITS Reference Case – All sites

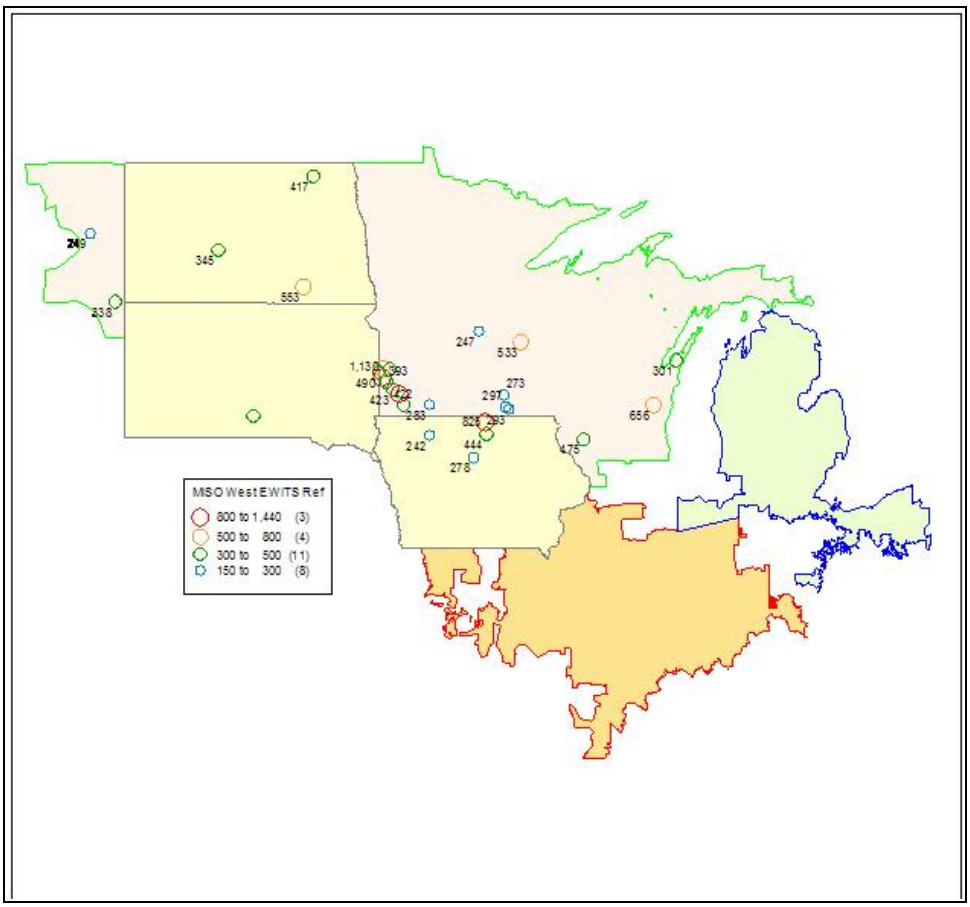

Figure 4: MISO West EWITS Reference case

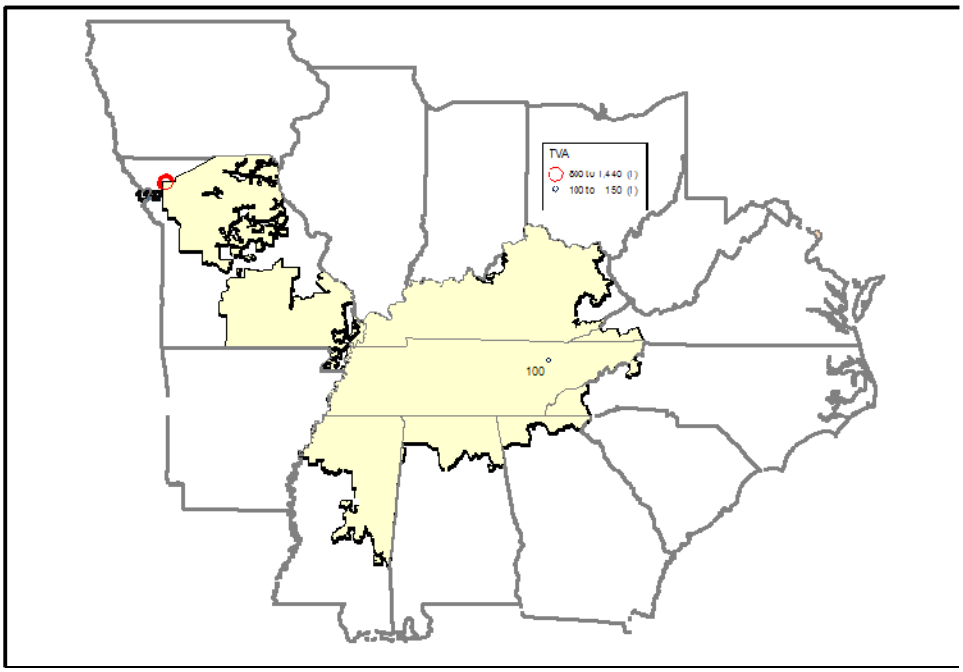

Figure 5: TVA Site ID's for all Penetrations

Table 7: Nebraska Site Details

Penetration Level	Site ID	Lat	Lon	Name plate	Capacity Factor	Reference Energy GWH	Bus ID
10%	22	41.92	-97.77	261	0.42	971	640226
10%	143	42.66	-98.66	268	0.41	966	652509
10%	208	41.05	-97.29	245	0.41	880	640271
10%	160	41.84	-101.27	240	0.41	869	659247
10%	205	42.07	-98.16	235	0.41	837	640227
20%	47	41.92	-97.68	285	0.41	1027	640226
20%	245	42.66	-100.80	453	0.41	1619	640392
20%	1149	40.66	-97.97	501	0.38	1686	640271
40%	70	42.65	-98.42	1100	0.41	3958	652509
40%	695	41.19	-103.54	660	0.39	2283	659133
40%	76	41.77	-101.11	479	0.41	1734	640183

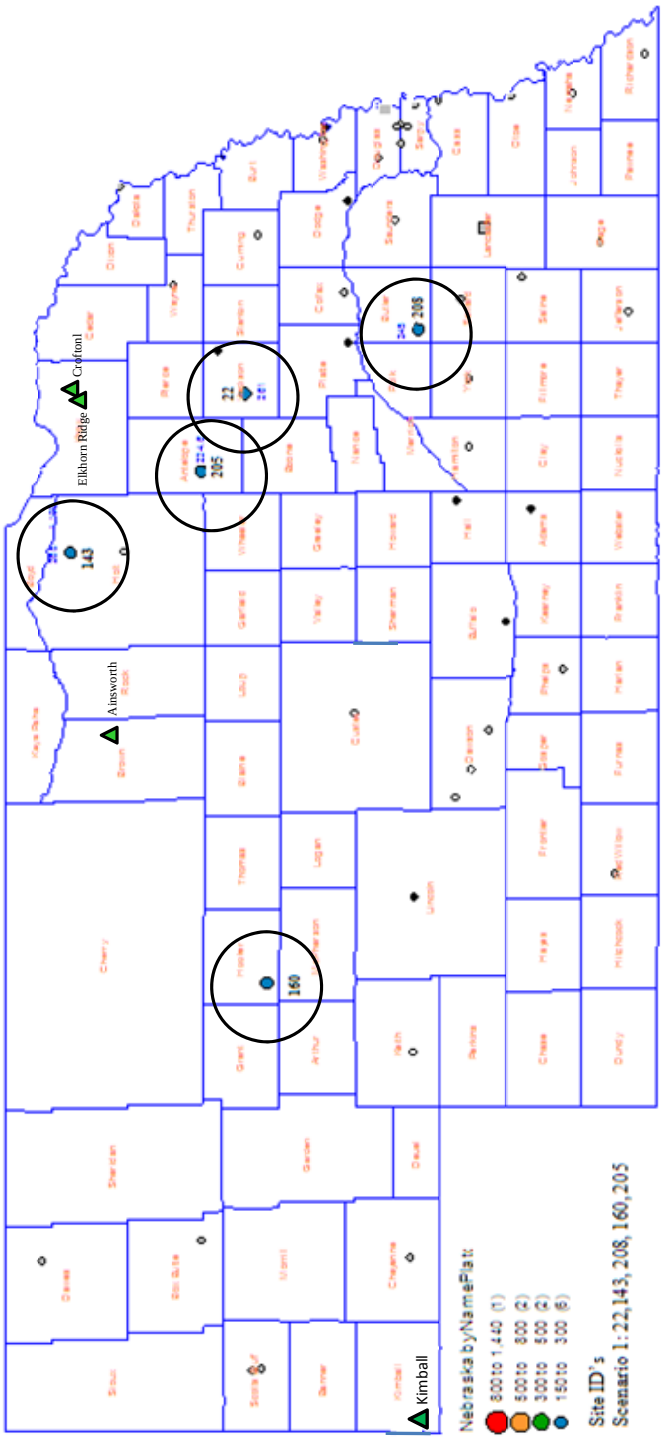

Figure 6: NPA Site ID's for 10% Penetration

Figure 7 identifies with circles the Nebraska wind sites that are added to the sites in the 10% penetration scenario make the 20% penetration scenario.

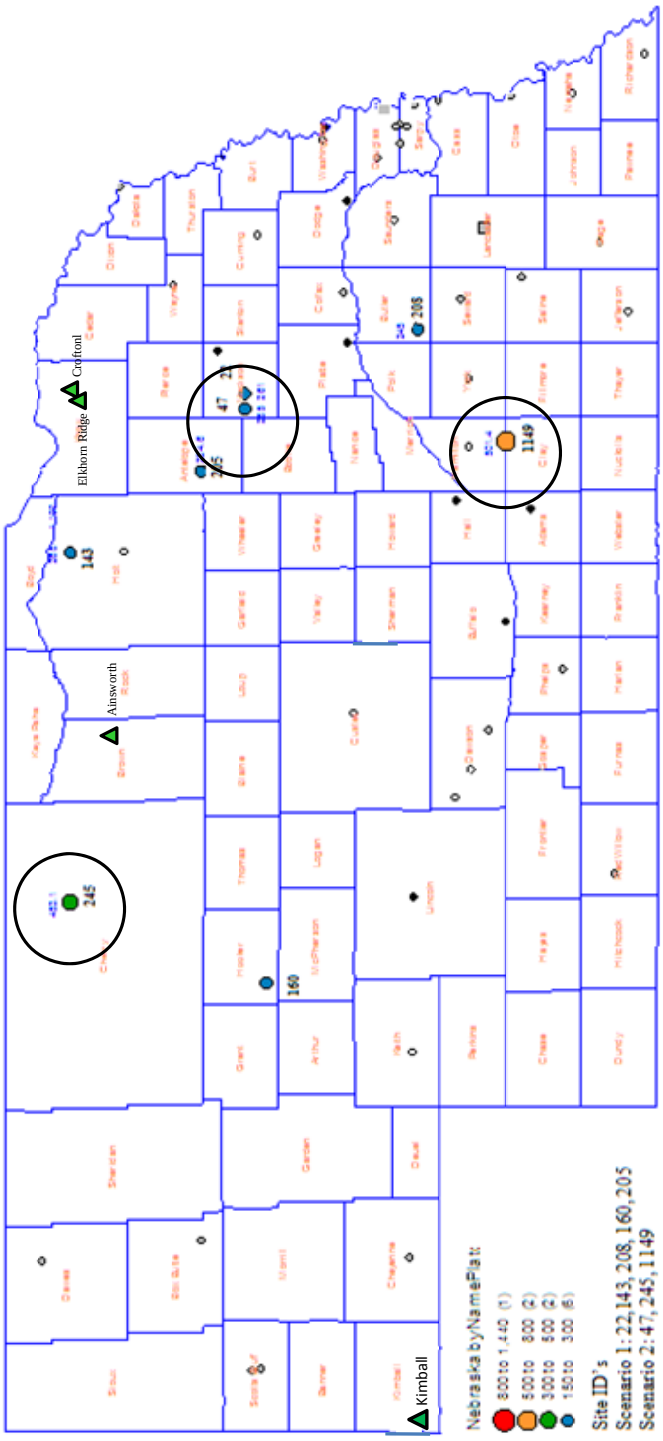

Figure 7: NPA Site ID's for 20% Penetration

Figure 8 identifies with circles the Nebraska wind sites that are added to the sites in the 20% penetration scenario to make the 40% penetration scenario.

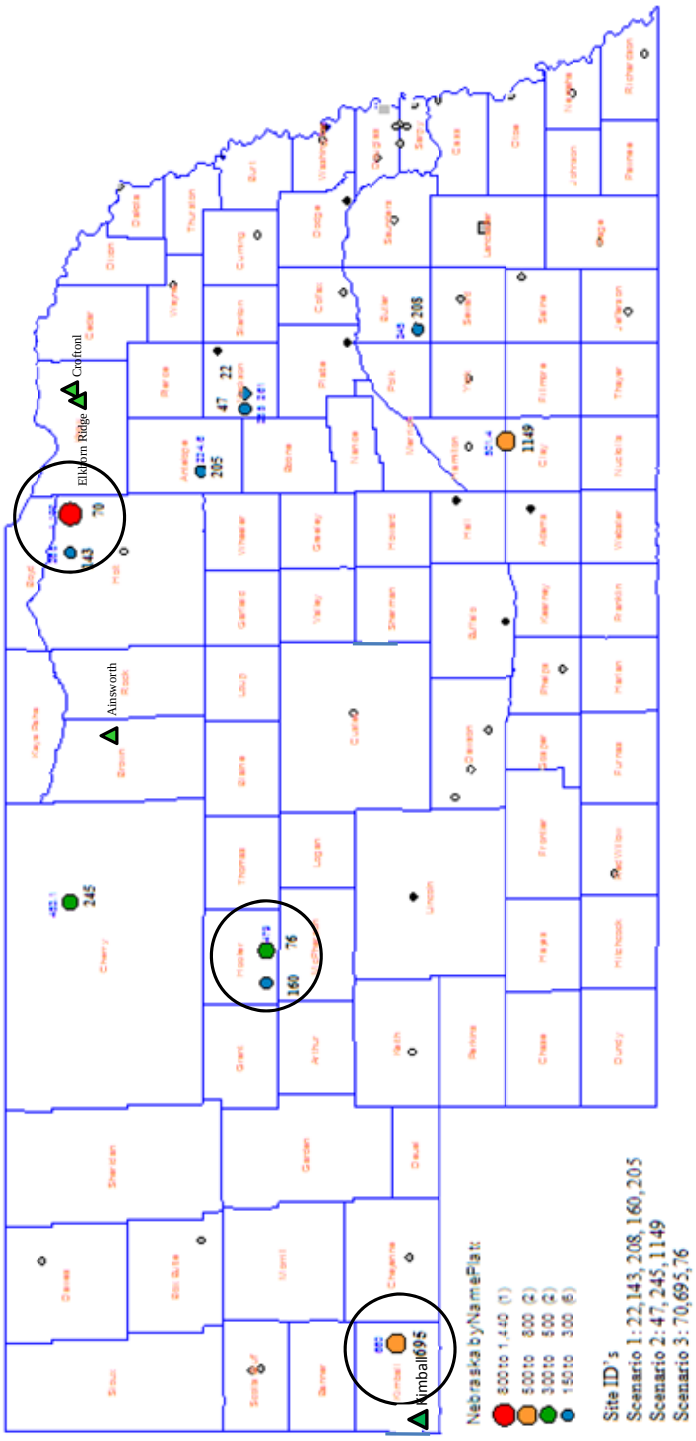

Figure 8: Nebraska Site ID's for 40% Penetration

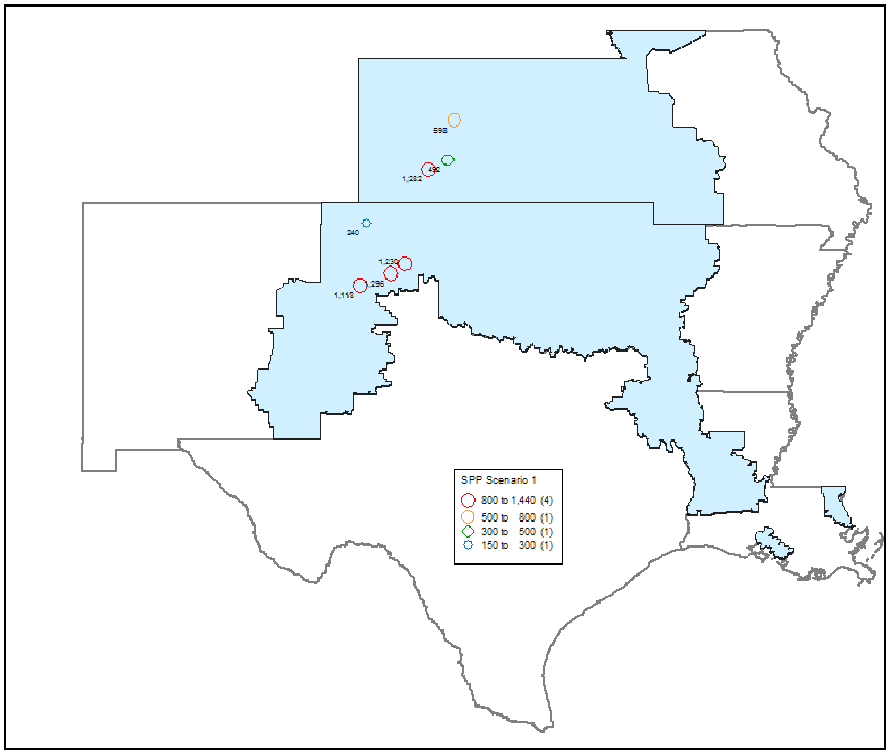

Figure 9: SPP Site ID's for 10% Penetration

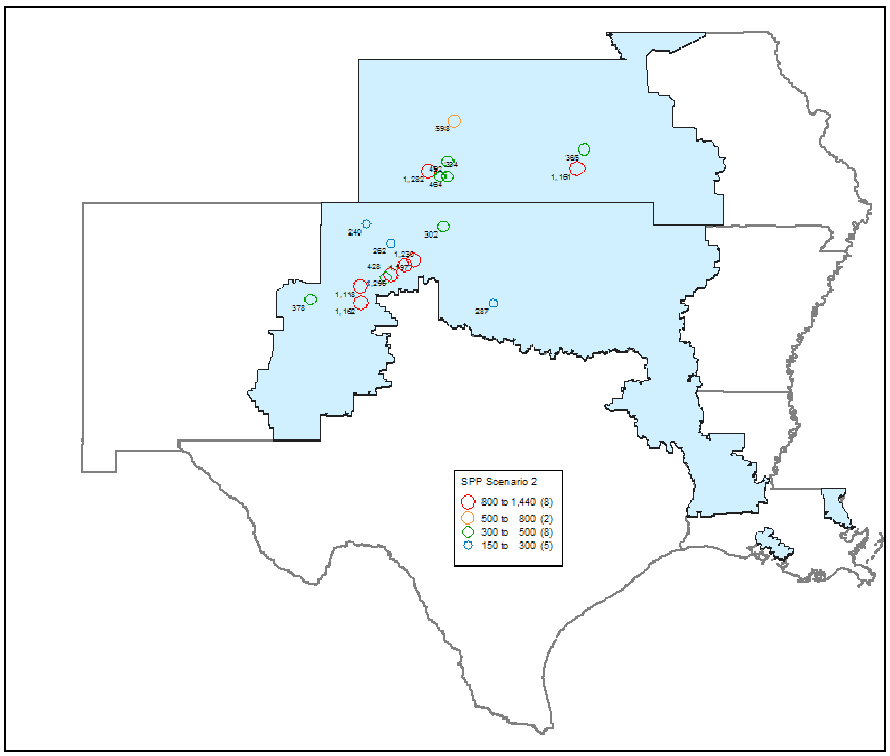

Figure 10: SPP Site ID's for 20% Penetration

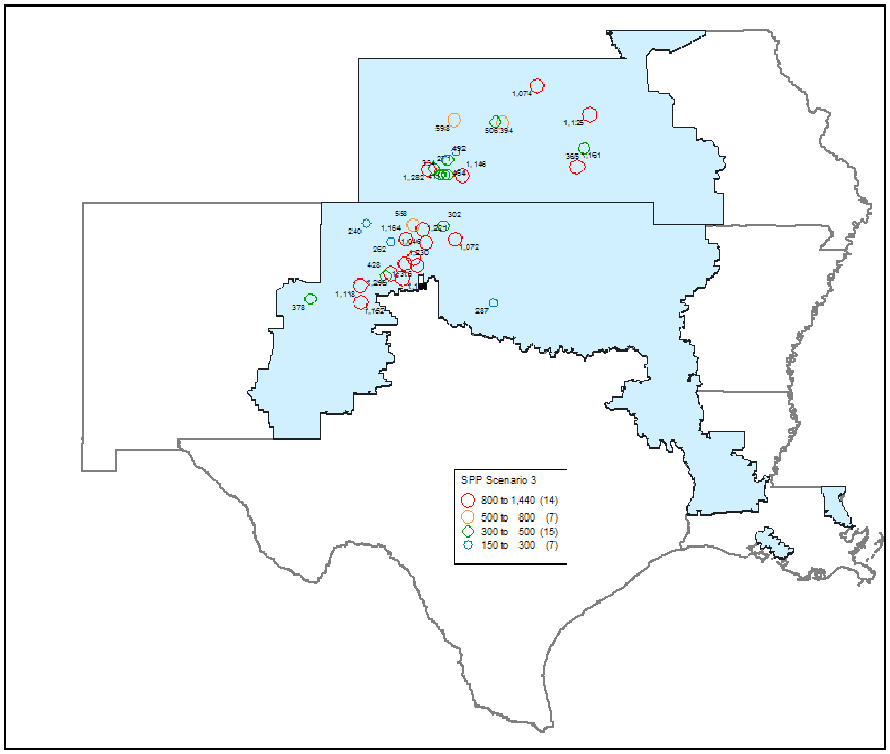

Figure 11: SPP Site ID's for 40% Penetration

Section 8.2.2.2 Installed Capacity by Scenario

Table 8 shows a summary of the nameplate values for the aggregated wind sites modeled in the study for NPA, the rest of SPP, and for the rest of the system.

Table 8: Wind Generation Capacity Assumptions by Region

Region	10% Penetration Nameplate (MW)	20% Penetration Nameplate (MW)	40% Penetration Nameplate (MW)
NPA	1,249	2,488	4,727
SPP	6,256	12,596	25,431
Rest of System	50,366	50,366	50,366
Total	57,871	65,450	80,524

Section 8.2.2.3 Annual Energy & Capacity Factors

Table 9, Table 10, and Table 11 show summaries of the aggregate wind energy from the selected sites for NPA and the rest of SPP for three historical years 2004-2006. Table 12, Table 13, and Table 14 convert the data in Table 8 - Table 11 into annual capacity factor values.

Table 9: Annual Wind Energy (GWh) by Region – 10% Penetration

Annual Energy by Region - 10%			
Region	2004	2005	2006
NPA	4,326	4,549	4,736
SPP	22,045	23,144	23,448

Table 10: Annual Wind Energy (GWh) by Region – 20% Penetration

Annual Energy by Region - 20%			
Region	2004	2005	2006
NPA	8,478	8,945	9,235
SPP	44,270	45,719	47,221

Table 11: Annual Wind Energy (GWh) by Region – 40% Penetration

Annual Energy by Region -40%			
Region	2004	2005	2006
NPA	16,317	16,992	17,696
SPP	88,704	91,583	94,470

Table 12: Aggregate Capacity Factor by Region – 10% Penetration

Aggregate Capacity Factor by Region 10%			
Region	2004	2005	2006
NPA	39.5%	41.6%	43.3%
SPP	40.2%	42.2%	42.8%

Table 13: Aggregate Capacity Factor by Region – 20% Penetration

Aggregate Capacity Factor by Region 20%			
Region	2004	2005	2006
NPA	38.9%	41.0%	42.4%
SPP	40.1%	41.4%	42.8%

Table 14: Aggregate Capacity Factor by Region – 40% Penetration

Aggregate Capacity Factor by Region 40%			
Region	2004	2005	2006
NPA	39.4%	41.0%	42.7%
SPP	39.8%	41.1%	42.4%

Section 8.2.2.4 Wind Generation Capacity Factors (monthly and accumulative)

Figure 12 shows the aggregated wind capacity factor for NPA penetrations. The generally high capacity factor can be attributed to the wind site diversity. Observe not only the monthly variations but also from year to year (2006 is the highest overall).

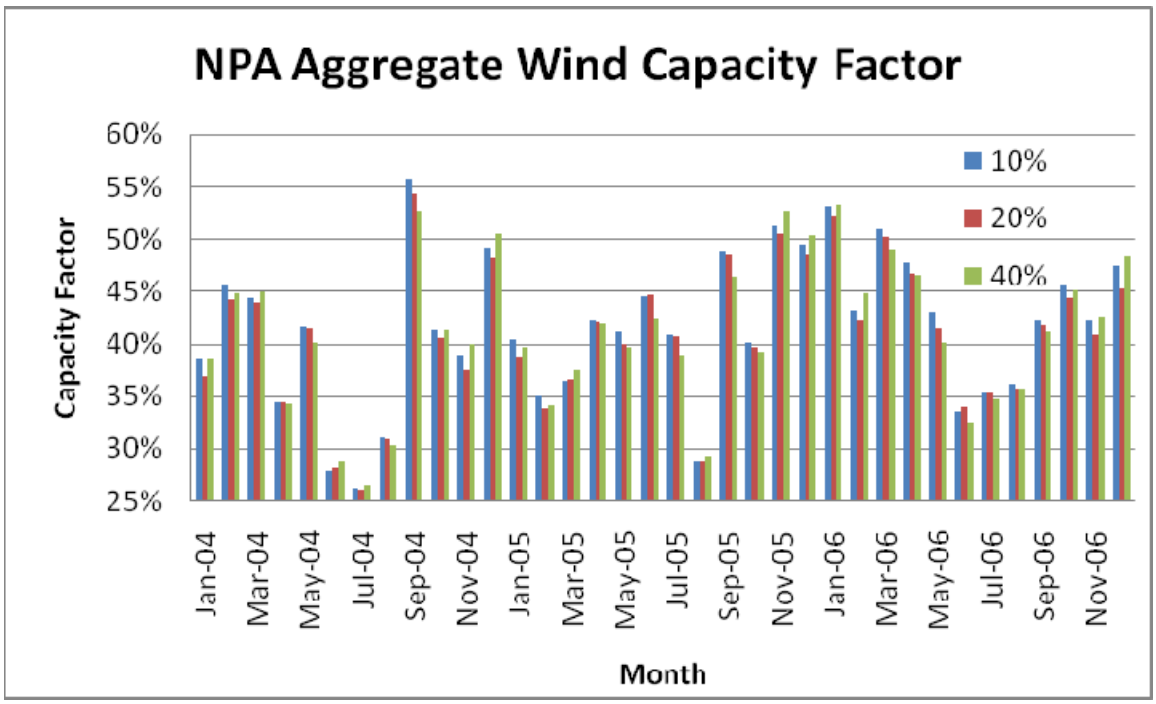

Figure 12: NPA Aggregated Capacity Factor for Wind Generation

Table 15: Monthly Capacity Factors for NPA wind

NPA Aggregate Wind	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10% CF 2004	39%	46%	44%	34%	42%	28%	26%	31%	56%	41%	39%	49%
10% CF 2005	40%	35%	36%	42%	41%	45%	41%	29%	49%	40%	51%	49%
10% CF 2006	53%	43%	51%	48%	43%	34%	35%	36%	42%	46%	42%	47%
20% CF 2004	37%	44%	44%	34%	42%	28%	26%	31%	54%	41%	38%	48%
20% CF 2005	39%	34%	37%	42%	40%	45%	41%	29%	48%	40%	51%	49%
20% CF 2006	52%	42%	50%	47%	42%	34%	35%	36%	42%	44%	41%	45%
40% CF 2004	39%	45%	45%	34%	40%	29%	27%	30%	53%	41%	40%	51%
40% CF 2005	40%	34%	38%	42%	40%	42%	39%	29%	46%	39%	53%	50%
40% CF 2006	53%	45%	49%	47%	40%	33%	35%	36%	41%	45%	43%	48%

Figure 13, Figure 14, and Figure 15 examine, in an accumulative fashion, the capacity factors for the 1,000 highest load hours for each of the historical years and each of the three penetrations. That is, the first data point at the left side is the aggregated capacity factor of the highest load hour (the July peak hour). Then the next data point is the average of the aggregated capacity factors for the two hours with the highest loads for the year, and so on. Note that the aggregated averages after 1,000 hours center around 30% capacity factor thereby indicating that the wind is reduced during the higher load hours, as the capacity factors over all hours is approximately 40%, or more.

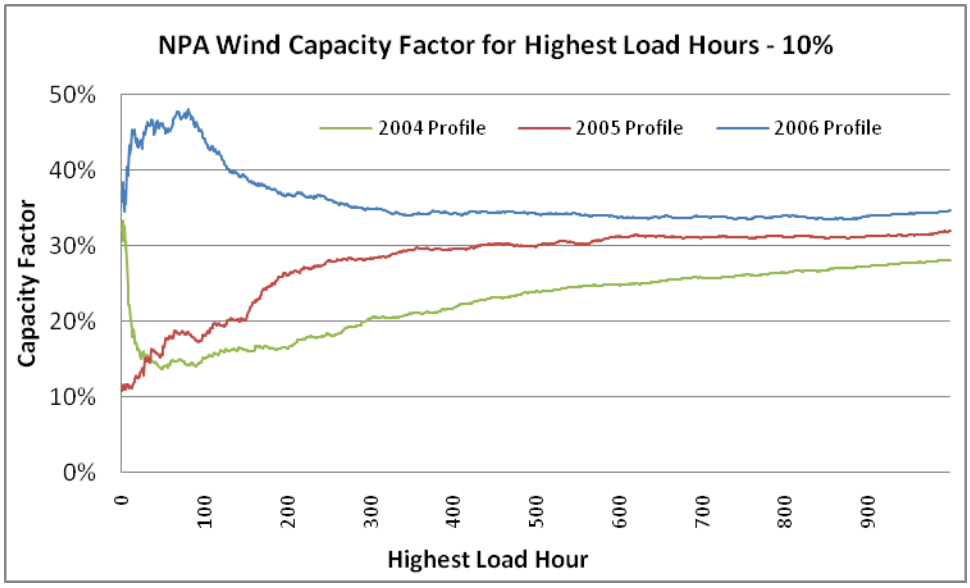

Figure 13: NPA 10% Penetration Wind Capacity Factors during Highest Load Hours

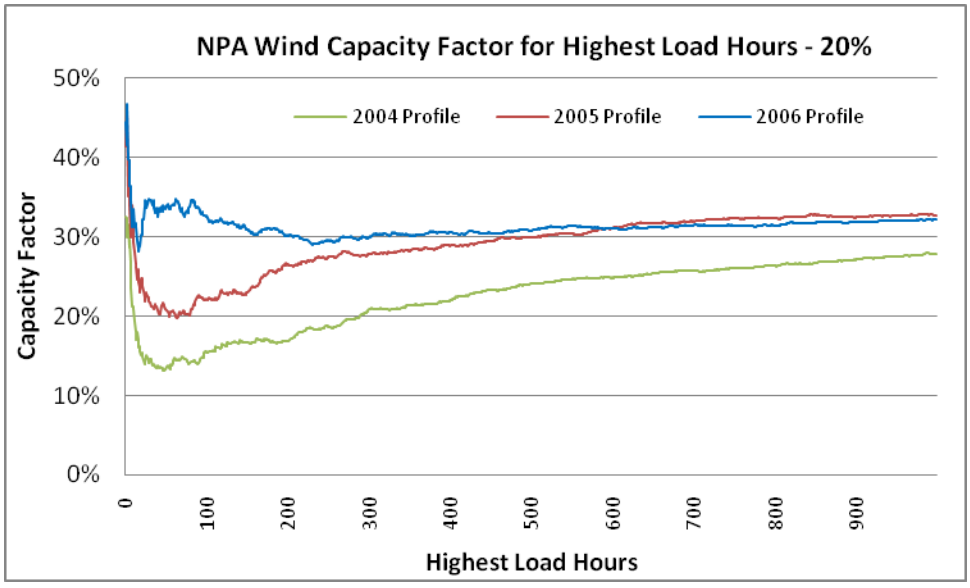

Figure 14: NPA 20% Penetration Wind Capacity Factors during Highest Load Hours

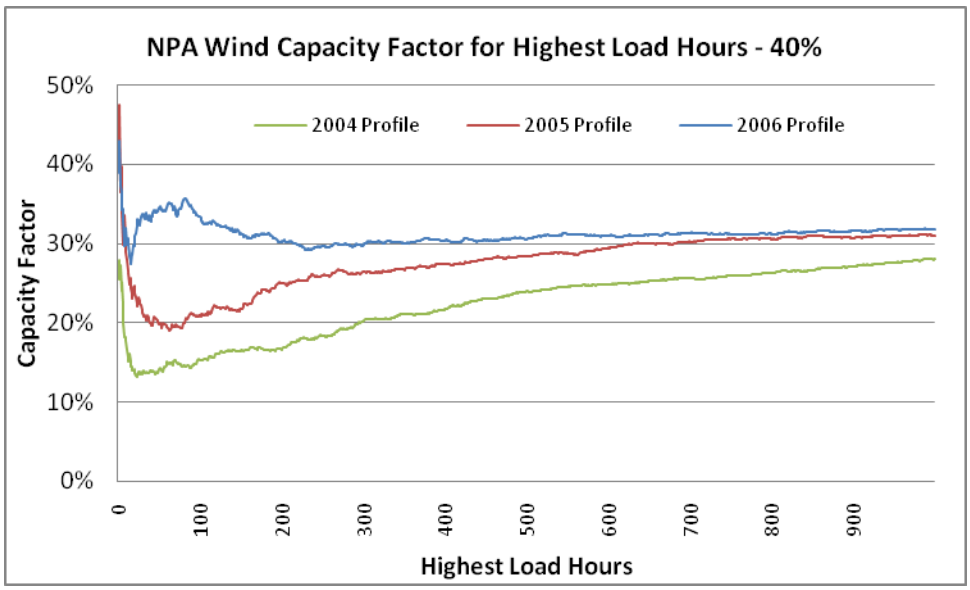

Figure 15: NPA 40% Penetration Wind Capacity Factors during Highest Load Hours

Section 8.2.2.5 Nebraska Wind Diversity

Wind diversity for sites selected could be quantified by calculating the correlation between the hourly wind generation of each plant in the scenarios. A correlation value of 1 is a perfect correlation between sites meaning as one site increases so does the other. A correlation of 0 indicates no correlation. A correlation of -1 indicates a negative correlation meaning as one site increases in generation the other site decreases by the same amount. Values in between these limits shows where the data correlates to these limits.

Table 16 presents a matrix of correlations between wind sites. The correlation values for the 55 pairings of the eleven Nebraska wind sites might be quantified in the following way:

- Zero to .20 negligible correlation or high wind diversity (zero pairs)
- .20 to .40 low degree of correlation or marked degree of wind diversity (12 pairs)
- .40 to .60 moderate degree of correlation or moderate degree of wind diversity (15 pairs)
- .60 to .80 marked degree of correlation or low degree of wind diversity (14 pairs)
- .80 to 1.00 high correlation or low degree of wind diversity (14 pairs)

Table 16: Correlation between NPA wind sites

Correlation of hourly wind data between wind sites for actual wind data in years 2004 to 2006											
	10% sites					20% sites			40% sites		
Site ID	22	143	160	205	208	47	245	1149	70	76	695
22	1	0.77	0.47	0.93	0.81	0.99	0.49	0.78	0.82	0.49	0.24
143	0.77	1	0.61	0.83	0.58	0.75	0.69	0.58	0.97	0.64	0.32
160	0.47	0.61	1	0.55	0.35	0.46	0.83	0.39	0.60	0.98	0.57
205	0.93	0.83	0.55	1	0.74	0.92	0.57	0.73	0.88	0.57	0.28
208	0.81	0.58	0.35	0.74	1	0.82	0.34	0.90	0.63	0.36	0.21
47	0.99	0.75	0.46	0.92	0.82	1	0.48	0.79	0.81	0.48	0.23
245	0.49	0.69	0.83	0.57	0.34	0.48	1	0.37	0.67	0.83	0.51
1149	0.78	0.58	0.39	0.73	0.90	0.79	0.37	1	0.62	0.41	0.22
70	0.82	0.97	0.60	0.88	0.63	0.81	0.67	0.62	1	0.62	0.30
76	0.49	0.64	0.98	0.57	0.36	0.48	0.83	0.41	0.62	1	0.54
695	0.24	0.32	0.57	0.28	0.21	0.23	0.51	0.22	0.30	0.54	1

Figure 16 shows graphically the correlations in Table 16. From this chart SiteID 695 shows a marked degree of wind diversity (low correlation) when compared to wind sites 22, 143, 205, 208, 47, 1149 and 70.

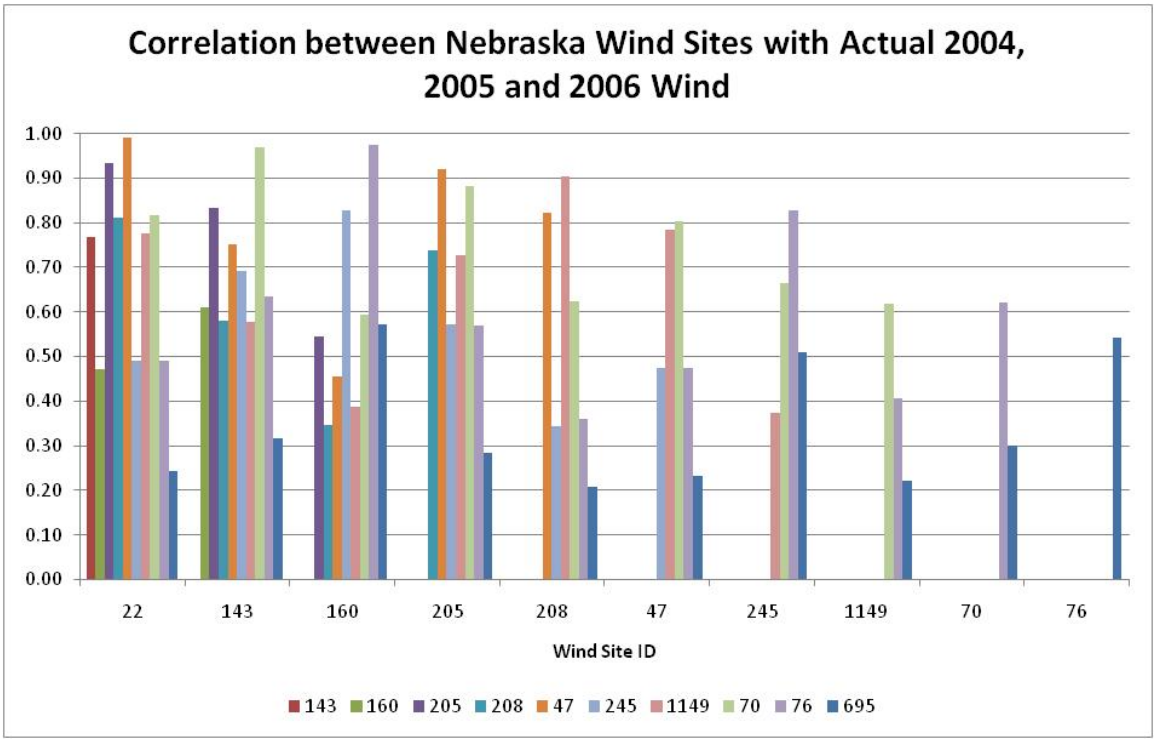

Figure 16: Nebraska wind site wind correlation

Section 8.2.2.6 Wind Variability Histograms

The following twelve histograms Figure 17 - Figure 28 depict the change in wind variability from one hour to the next. For the 3 years of hourly wind data (26,280 data points) the maximum and minimum changes were identified. The range of change was divided into deciles. The histograms show the count when the MW changes by the decile amount. For example in Figure

17 there are about 4,000 hours when there is a downward change in MW between -144MW and -58MW whereas there are over 10,000 hours when the change between hour is between -58 MW and 28 MW. For this example the minimums change (i.e., largest negative) is -402MW, and the maximum is 458MW, yielding deciles that each span 86 MW. A corresponding histogram shows the change as a % of nameplate capacity.

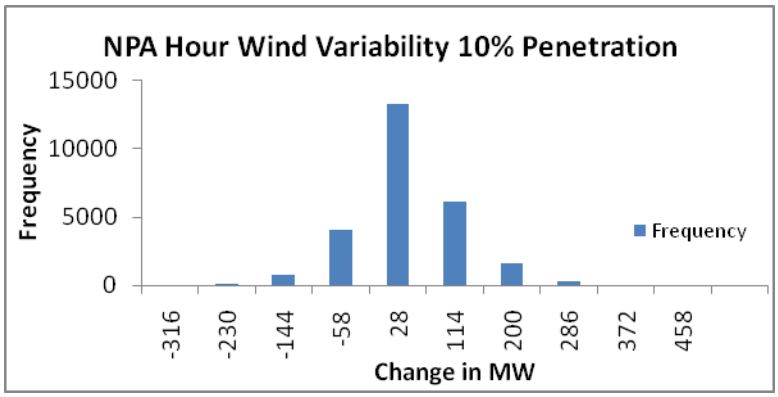

Figure 17: Histogram of NPA Hourly Wind Variability – 10% Penetration

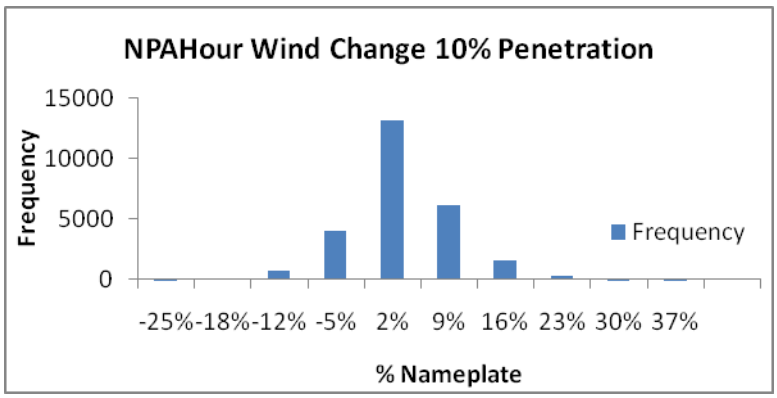

Figure 18: Histogram of NPA Hourly Wind Variability as Percent of Nameplate – 10% Penetration

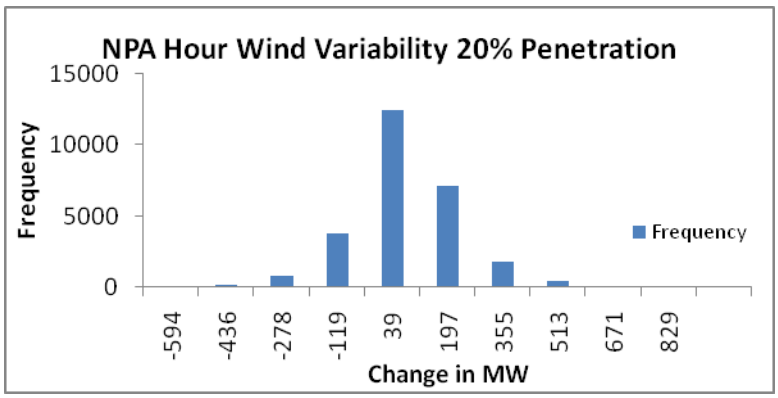

Figure 19: Histogram of NPA Hourly Wind Variability – 20% Penetration

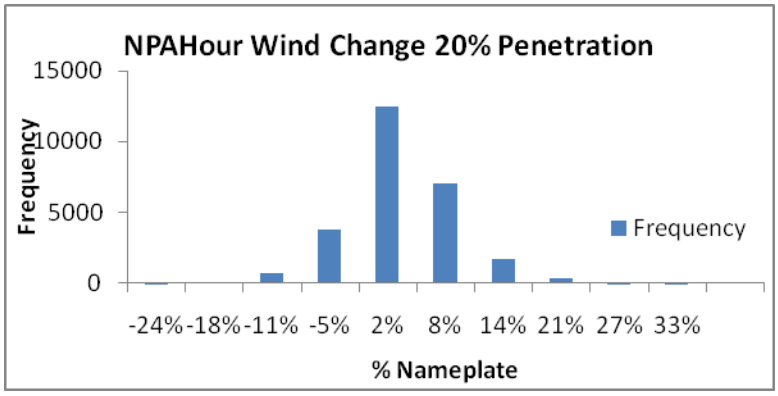

Figure 20: Histogram of NPA Hourly Wind Variability as Percent of Nameplate – 20% Penetration

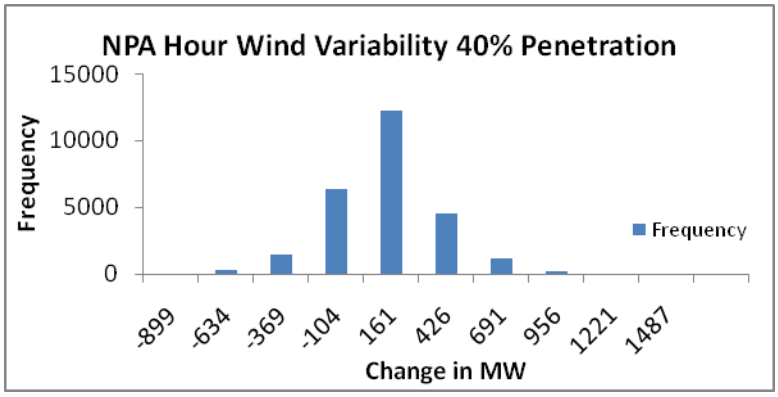

Figure 21: Histogram of NPA Hourly Wind Variability – 40% Penetration

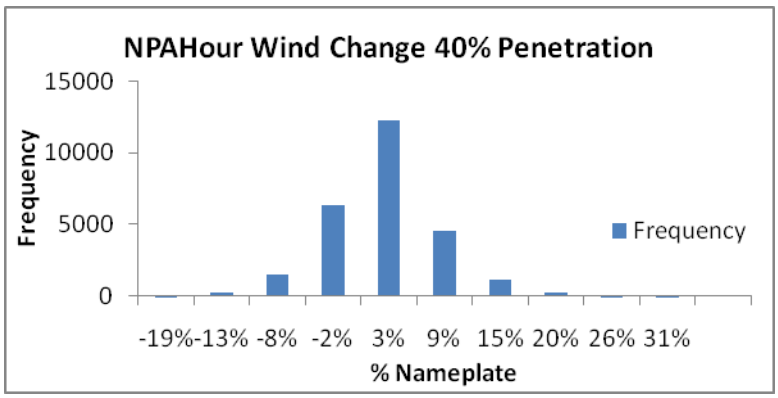

Figure 22: Histogram of NPA Hourly Wind Variability as Percent of Nameplate – 40% Penetration

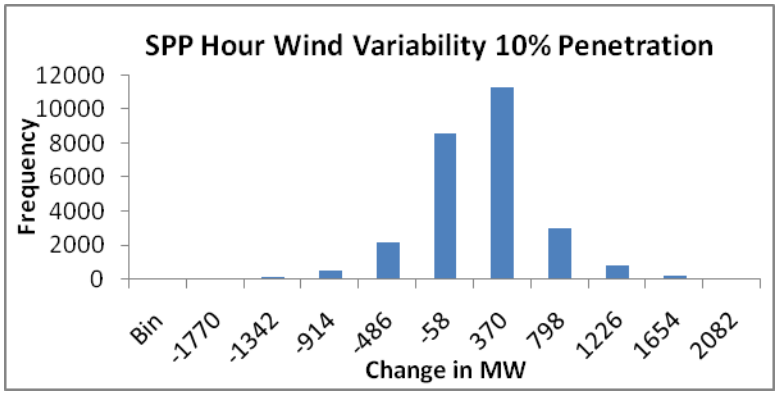

Figure 23: Histogram of SPP Hourly Wind Variability – 10% Penetration

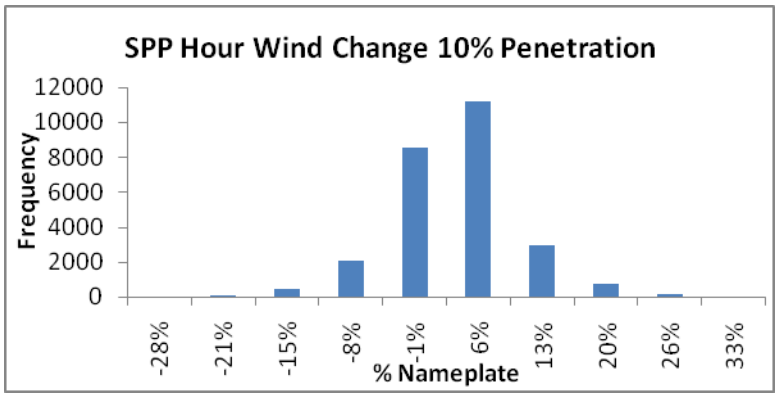

Figure 24: Histogram of SPP Hourly Wind Variability as Percent of Nameplate – 10% Penetration

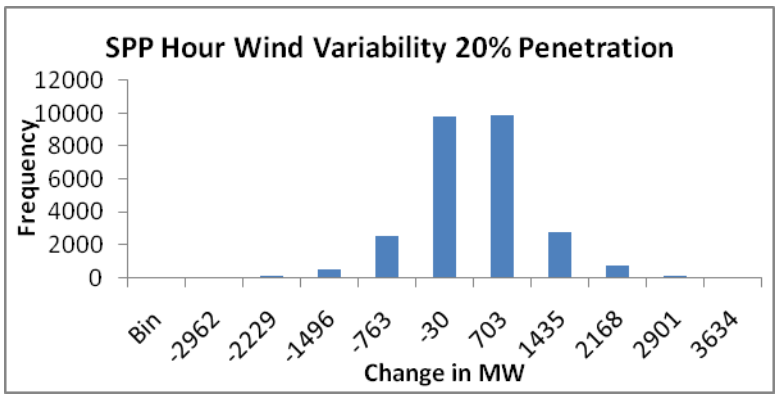

Figure 25: Histogram of SPP Hourly Wind Variability – 20% Penetration

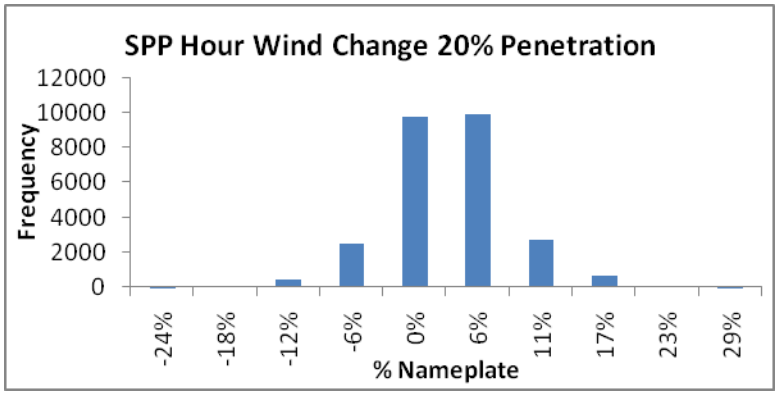

Figure 26: Histogram of SPP Hourly Wind Variability as Percent of Nameplate – 20% Penetration

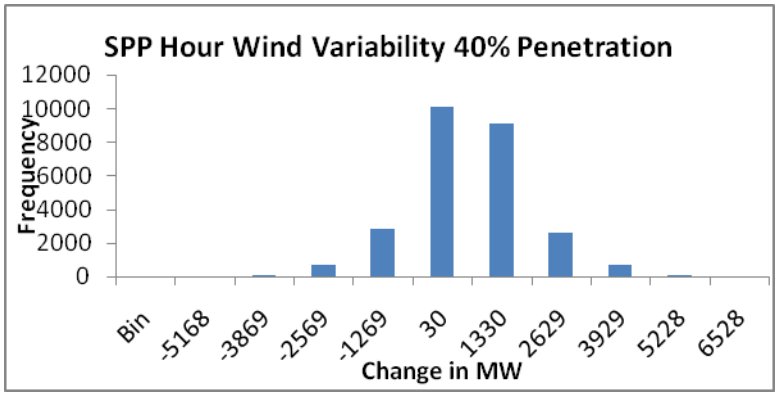

Figure 27: Histogram of SPP Hourly Wind Variability – 40% Penetration

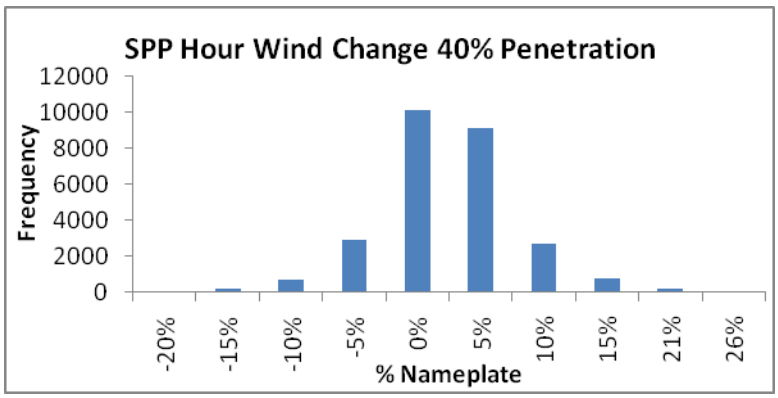

Figure 28: Histogram of SPP Hourly Wind Variability as Percent of Nameplate – 40% Penetration

Section 8.2.2.7 Variability and Uncertainty – Wind

Figure 29, Figure 30, and Figure 31 show plots of an analysis of short term forecast errors. Figure 29 uses a one hour persistence forecast of actual wind generation for the aggregated wind in the 40% penetration case. The expected next-hour forecast errors are calculated along with sigma. The generation is sorted low to high with respective forecast error. The sigma of each deciles forecast error are plotted on these charts. Figure 30 uses sub hourly (10 minute) generation data. Note the reduction in sigma from greater than 100 in the 1 hour persistence forecast for low and high range wind generation to less than 100 in the sub-hourly persistence forecast. The mid range operation of wind generation has similar reduction from greater than 300 to less than 250.

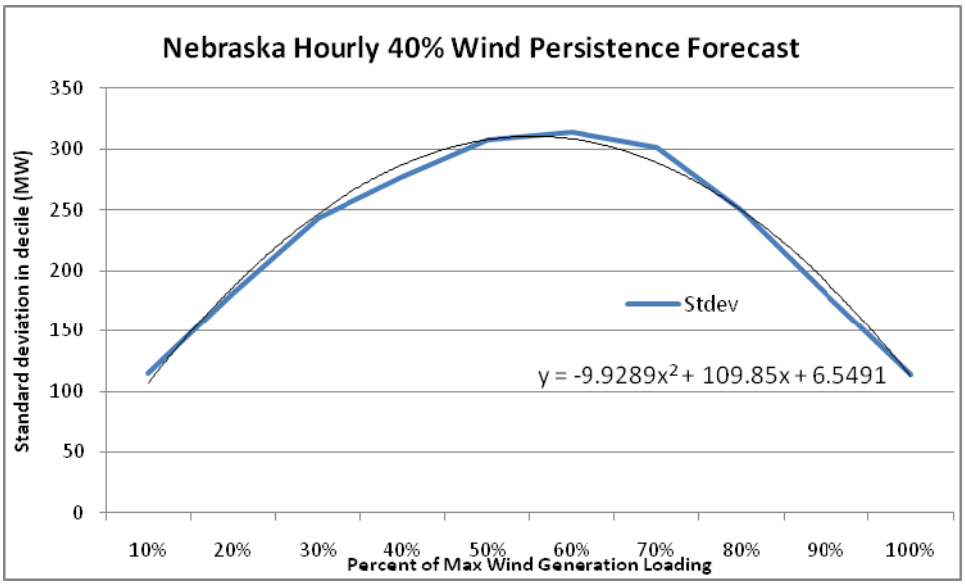

Figure 29: Nebraska Persistence Hourly Wind Forecast Error 40% Penetration

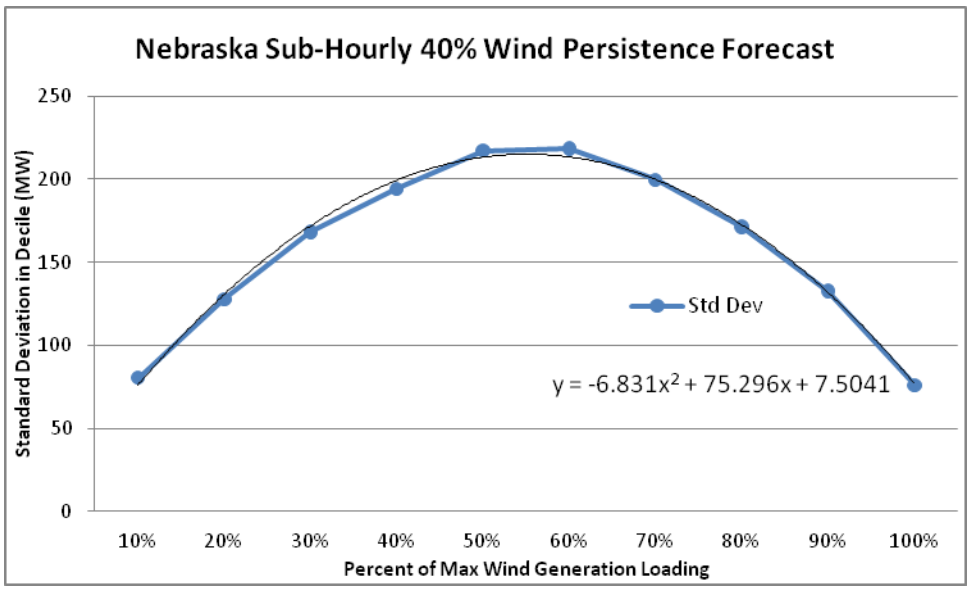

Figure 30: Nebraska Persistence Sub Hourly Wind Forecast Error 40% Penetration

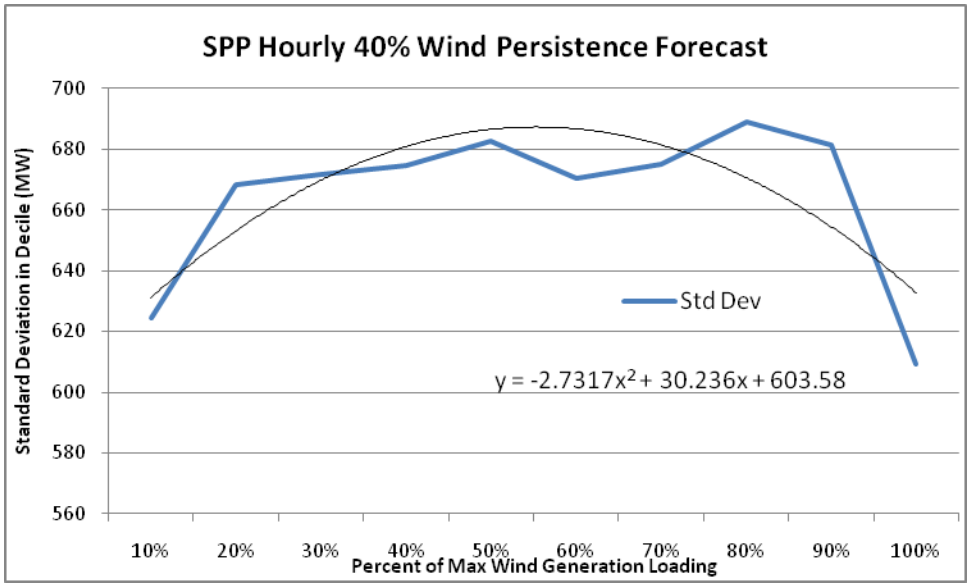

Figure 31: Forecast error SPP 40% Penetration

Section 8.2.2.8 Wind Capacity Value Estimates

The following Capacity Value estimates are calculated using rules outlined in the SPP Wind Accreditation Criteria that can be found on pages 12-6 and 12-7 of their document. SPP Criteria with Appendices can be accessed at: http://www.spp.org/section.asp?group=215&pageID=27 (currently dated 2009/07/28).

These criteria can be summarized as follows:

- Calculations result in twelve unique monthly values.
- Normally 10 years of data is used – here data is only available for the years 2004-2006.
- Select the hourly wind generation values during the top 10% of load hours for each month of each of the three years (e.g., 72 hours from June 2004, 72 hours from June 2005, and 72 hours from June 2006).
- Select the hourly wind generation value that can be expected from the plant 85% of the time or greater (e.g., the 184th value from the 216 values for June ranked highest to lowest).
- A seasonal or annual net capability may be determined by selecting the appropriate monthly MW values corresponding to the Load Serving Member's peak load month of the season of interest.

For the calculation of seasonal or annual net capability NPA's peak load month is July for each reference year in the study, see Table 17.

Table 17: NPA Peak Load

NPA Load		
Ref. Year	Peak MW	Date
2004	7553	7/17/18 15:00
2005	7461	7/20/18 15:00
2006	7489	7/18/18 15:00

Table 18: SPP Peak Load

SPP w/o NPA		
Ref Year	Peak MW	Date
2004	46403	8/23/18 15:00
2005	46023	8/1/18 15:00
2006	46005	8/8/18 15:00

Table 19: SPP + NPA Peak Load

SPP with NPA		
Ref Year	Peak MW	Date
2004	53607	8/23/18 15:00
2005	53352	8/1/18 15:00
2006	53387	7/18/18 15:00

Capacity Value estimates were calculated for each SiteID identified in each scenario for NPA and SPP, see Figure 32 - Figure 45 and Table 20 - Table 23. The Capacity Value was also calculated for each scenario after aggregating the sites. Capacity Values were calculated separately by scenario for NPA and SPP. A separate Capacity Value for SPP + NPA is also provided. The load profiles used for identifying the top 10% load hours were the aggregate NPA and SPP profiles, as appropriate.

The charts shown in Figure 32 through Figure 34 display the capacity value for NPA sites as a percentage of each sites nameplate capacity. Figure 35 shows the NPA aggregate capacity value of all wind by scenario, although capacity value by aggregation is not a part of the SPP criteria – this exercise is for information purposes only.

Key observations noted using the SPP criteria are:

- Very low summer values that trend with the generally negative correlation between wind and load, see Figure 90. The peak hours over the year tend to be in the summer months of July and August at which time wind is low.

The effects of wind diversity can be seen with the wide variety in capacity values such as:

- In the 10% scenario for November, the capacity values for NPA are relatively low (typically less than 5% whereas the values for SPP are typically greater than 10%), Table 20 - Table 22 and Figure 36 - Figure 44.
- The site-specific charts (Figure 32- Figure 34 and Table 20 - Table 22) show considerable variation in capacity value from site to site. For example in the 40% scenario for May, the capacity value varies from 4% for site 76 to 12% for site 70 while the reverse relationship appears in several other months.
- However, Figure 35 for NPA shows the diversity benefit in capacity value terms that as more wind generation is added (moving from 10% to 40% penetration), there is nearly always more capacity value in normalized percentage terms.
- Wind site diversity contributes to the wide variety of capacity values for different sites, e.g., site 208 for NPA has values less than 5% in many months but some of the highest values, greater than 10% in February, May and September when compared to other sites in this scenario.

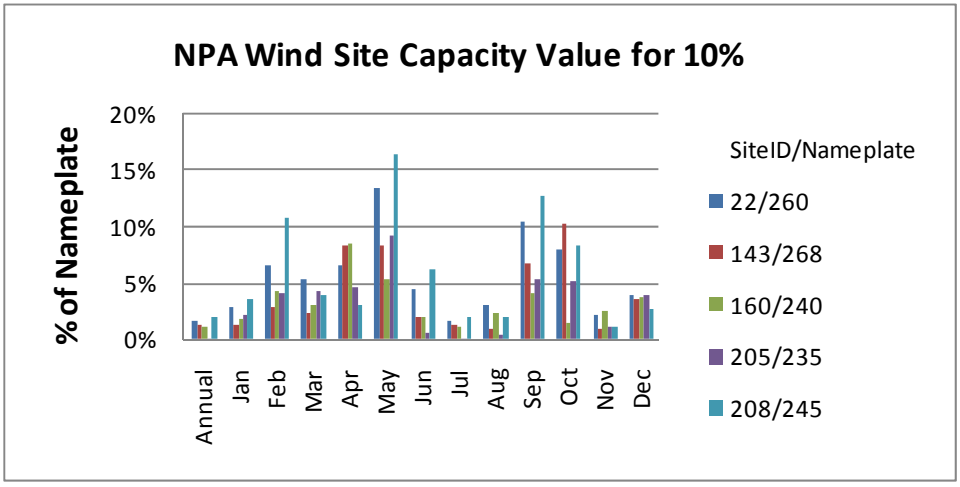

Figure 32: NPA Wind Site Capacity Values – 10% Penetration

Table 20: NPA Wind Site Capacity Values – 10% Penetration

SiteID/ Nameplate	NPA - 10% Penetration				
	22/260	143/268	160/240	205/235	208/245
Annual	1.54%	1.17%	1.08%	0.06%	1.96%
Jan	2.79%	1.19%	1.82%	2.24%	3.59%
Feb	6.60%	2.79%	4.23%	4.06%	10.85%
Mar	5.27%	2.22%	2.98%	4.24%	3.90%
Apr	6.46%	8.25%	8.42%	4.69%	3.04%
May	13.52%	8.35%	5.35%	9.26%	16.53%
Jun	4.45%	1.86%	1.98%	0.63%	6.22%
Jul	1.54%	1.17%	1.08%	0.06%	1.96%
Aug	3.07%	0.81%	2.22%	0.34%	1.94%
Sep	10.40%	6.79%	4.05%	5.35%	12.66%
Oct	7.92%	10.23%	1.47%	5.21%	8.36%
Nov	2.10%	0.86%	2.43%	1.20%	0.98%
Dec	3.94%	3.59%	3.76%	3.87%	2.73%

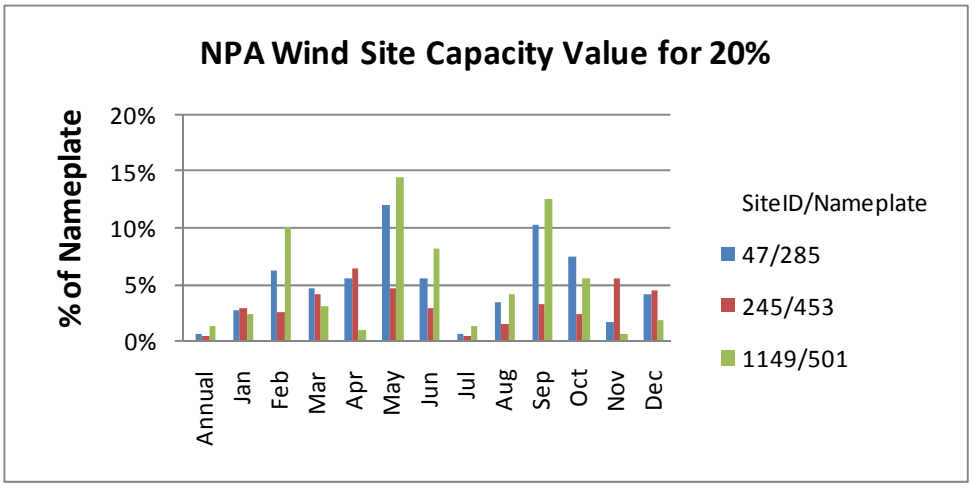

Figure 33: NPA Wind Site Capacity Values – 20% Penetration

Table 21: NPA Wind Site Capacity Values – 20% Penetration

SiteID/ Nameplate	NPA 20% Penetration		
	47/285	245/453	1149/501
Annual	0.54%	0.39%	1.26%
Jan	2.66%	2.81%	2.25%
Feb	6.26%	2.52%	10.16%
Mar	4.64%	4.01%	2.95%
Apr	5.46%	6.38%	0.86%
May	12.09%	4.55%	14.57%
Jun	5.41%	2.80%	8.19%
Jul	0.54%	0.39%	1.26%
Aug	3.29%	1.39%	4.11%
Sep	10.19%	3.14%	12.53%
Oct	7.35%	2.32%	5.47%
Nov	1.64%	5.57%	0.53%
Dec	4.07%	4.34%	1.74%

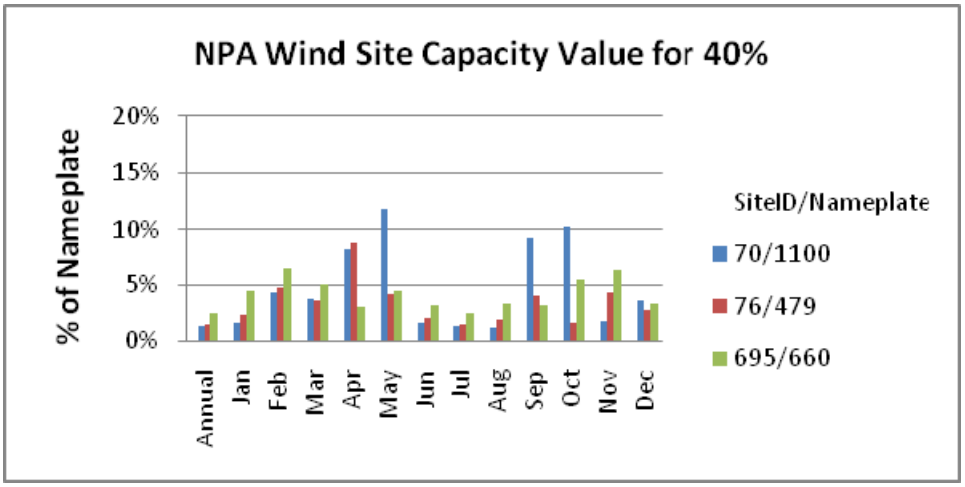

Figure 34: NPA Wind Site Capacity Values – 40% Penetration

Table 22: NPA Wind site Capacity Values – 40% Penetration

SiteID/ Nameplate	NPA 40% Penetration		
	70/1100	76/479	695/660
Annual	1.37%	1.51%	2.41%
Jan	1.63%	2.30%	4.49%
Feb	4.36%	4.77%	6.45%
Mar	3.79%	3.57%	4.95%
Apr	8.12%	8.73%	3.08%
May	11.77%	4.11%	4.39%
Jun	1.58%	2.11%	3.22%
Jul	1.37%	1.51%	2.41%
Aug	1.19%	1.86%	3.35%
Sep	9.25%	4.02%	3.13%
Oct	10.23%	1.63%	5.37%
Nov	1.77%	4.33%	6.23%
Dec	3.55%	2.80%	3.31%

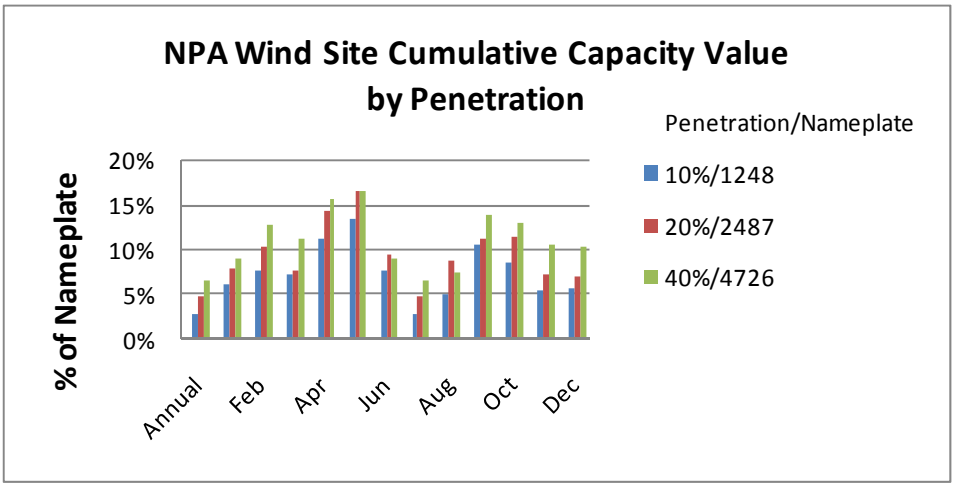

Figure 35: NPA Aggregated Wind Site Capacity Values by Penetration

Table 23: NPA Aggregated Wind Site Capacity Values by Penetration

	10%	20%	40%
Nameplate	1249	2488	4727
Annual	2.94%	4.75%	6.55%
Jan	6.18%	7.96%	9.02%
Feb	7.73%	10.30%	12.74%
Mar	7.29%	7.71%	11.18%
Apr	11.19%	14.29%	15.65%
May	13.41%	16.39%	16.56%
Jun	7.75%	9.34%	8.91%
Jul	2.94%	4.75%	6.55%
Aug	4.98%	8.83%	7.56%
Sep	10.61%	11.20%	13.78%
Oct	8.60%	11.34%	13.05%
Nov	5.52%	7.19%	10.50%
Dec	5.80%	7.05%	10.23%

Charts in Figure 36 through Figure 44 show capacity value for each site ID in the SPP scenarios. Figure 45 shows the SPP aggregated capacity value for each scenario.

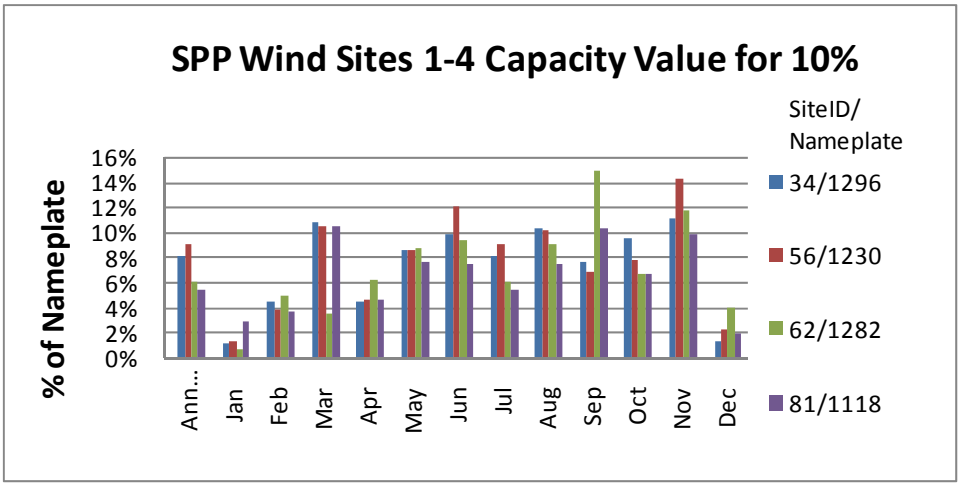

Figure 36: SPP Wind Sites 1-4 Capacity Values - 10% Penetration

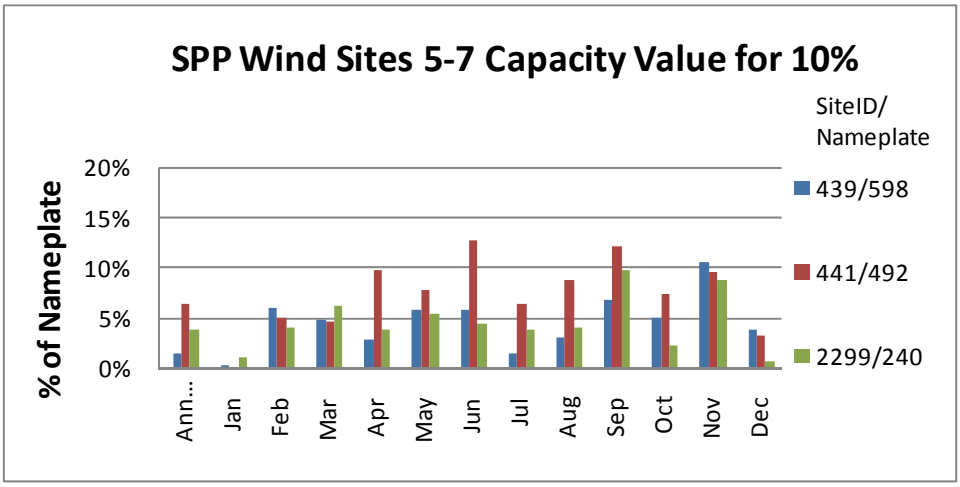

Figure 37: SPP Wind Sites 5-7 Capacity Values - 10% Penetration

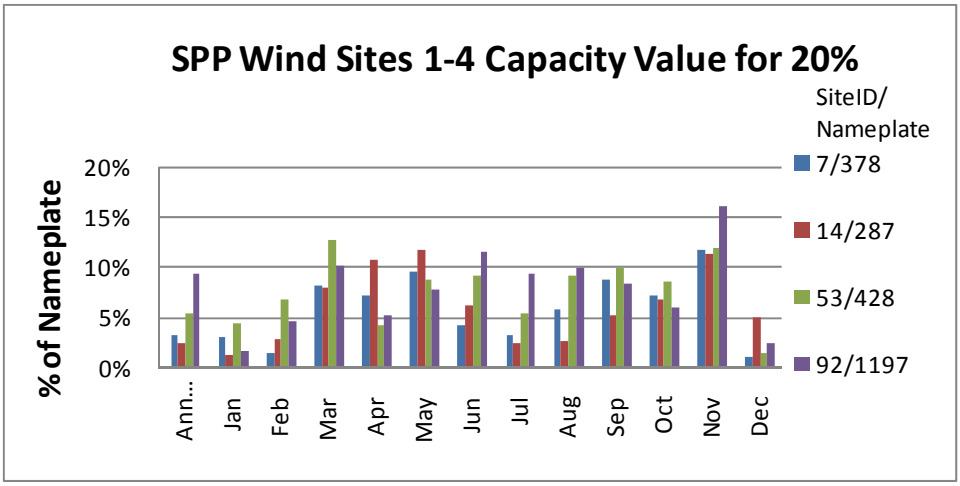

Figure 38: SPP Wind Sites 1-4 Capacity Values - 20% Penetration

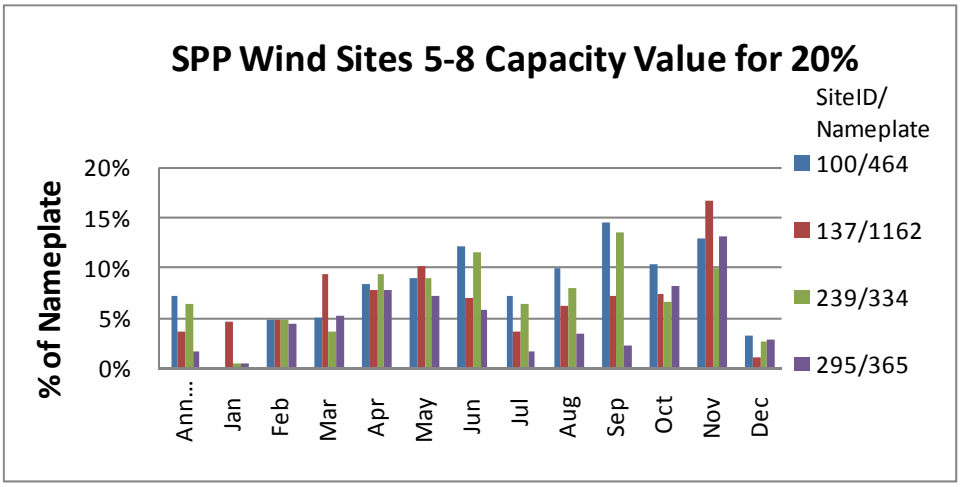

Figure 39: SPP Wind Sites 5-8 Capacity Values - 20% Penetration

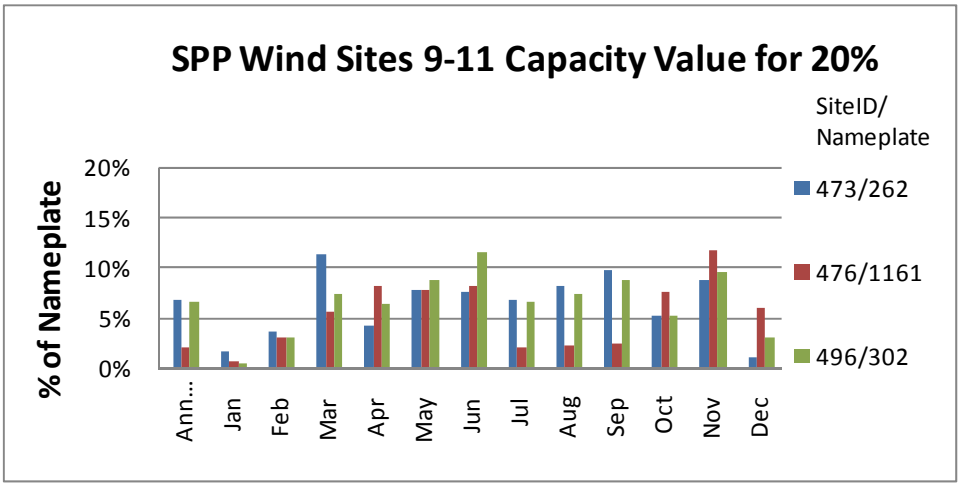

Figure 40: SPP Wind Sites 9-11 Capacity Values - 20% Penetration

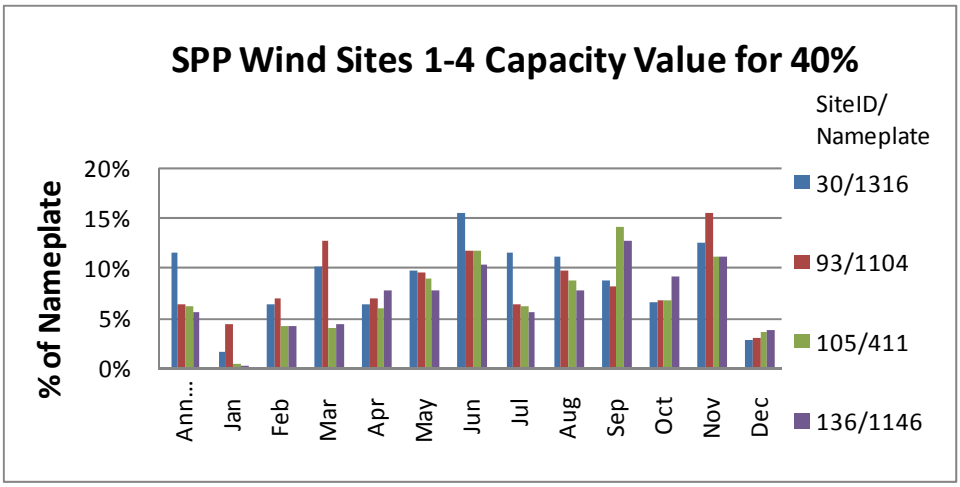

Figure 41: SPP Wind Sites 1-4 Capacity Values - 40% Penetration

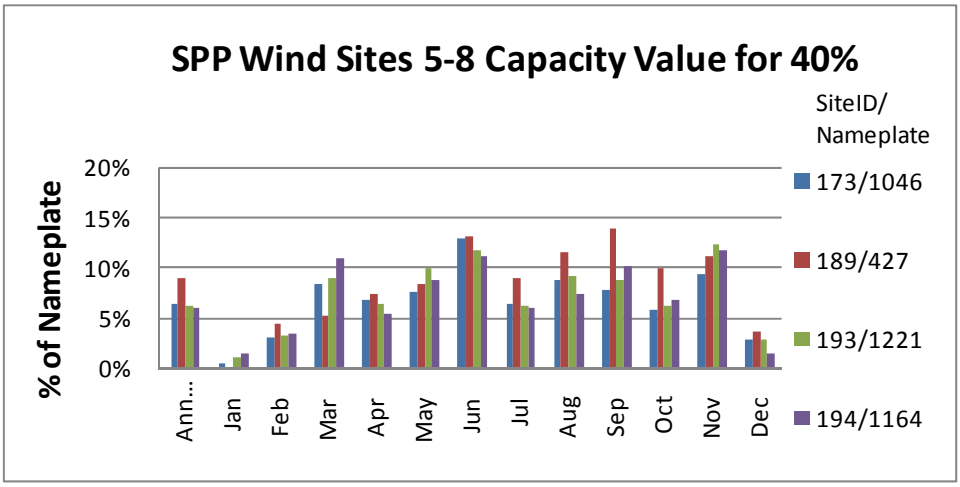

Figure 42: SPP Wind Sites 5-8 Capacity Values - 40% Penetration

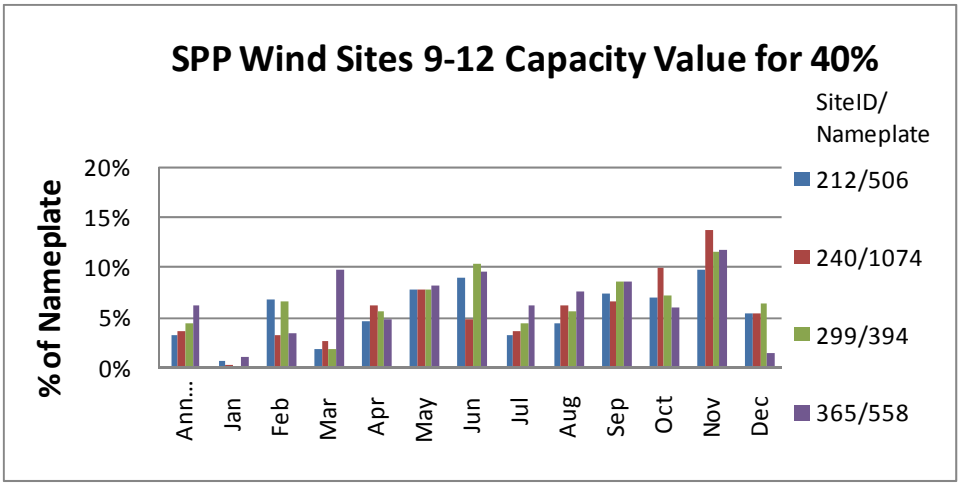

Figure 43: SPP Wind Sites 9-12 Capacity Values - 40% Penetration

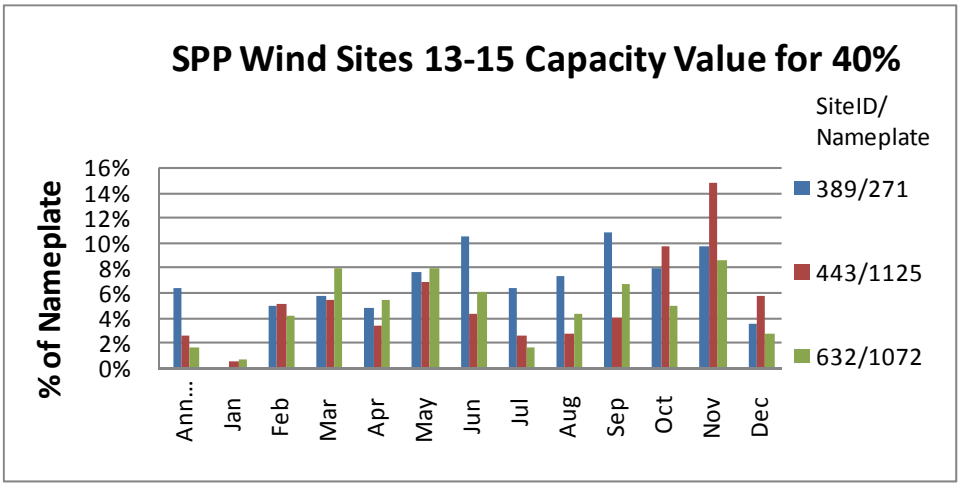

Figure 44: SPP Wind Sites 13-15 Capacity Values - 40% Penetration

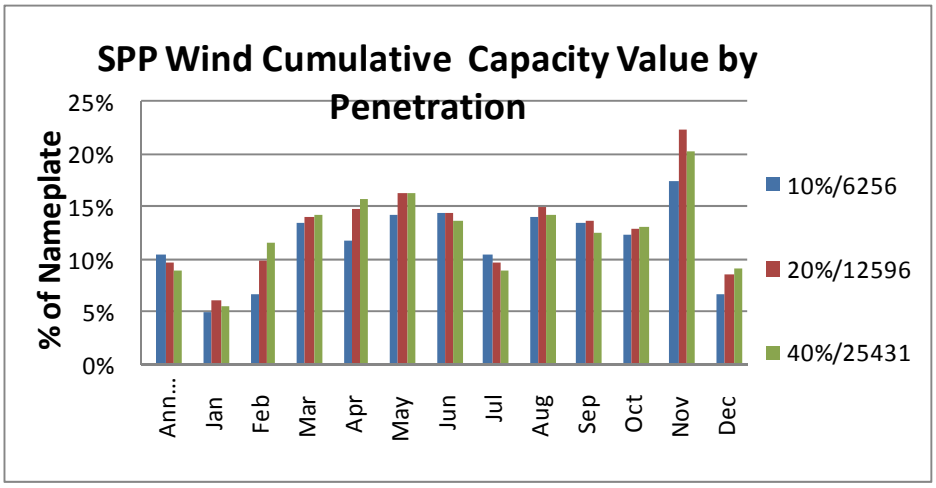

Figure 45: NPA + SPP Wind Site Capacity Value by Penetration

Section 8.2.3 Wind and Load Characteristics

NPA provided hourly load data for 2004, 2005 and 2006. For each year's data loads were escalated to 2018. Load data for the remaining regions were taken from the EWITS study and escalated to 2018. As stated previously, the wind data came from the NREL database for the Eastern Interconnection.

Section 8.2.3.1 Hourly Characteristics by Year / Scenario / Region

The next several pages show charts that display wind and load for different regions. Figure 46 through Figure 54 show the relationship of each year of NPA load with corresponding year of wind data. Figure 55 to Figure 63 shows SPP load with SPP wind.

All SPP Load and Wind data shown in the charts do not include Nebraska unless specifically noted.

At 40% penetrations there are hours when wind generation exceeds system load.

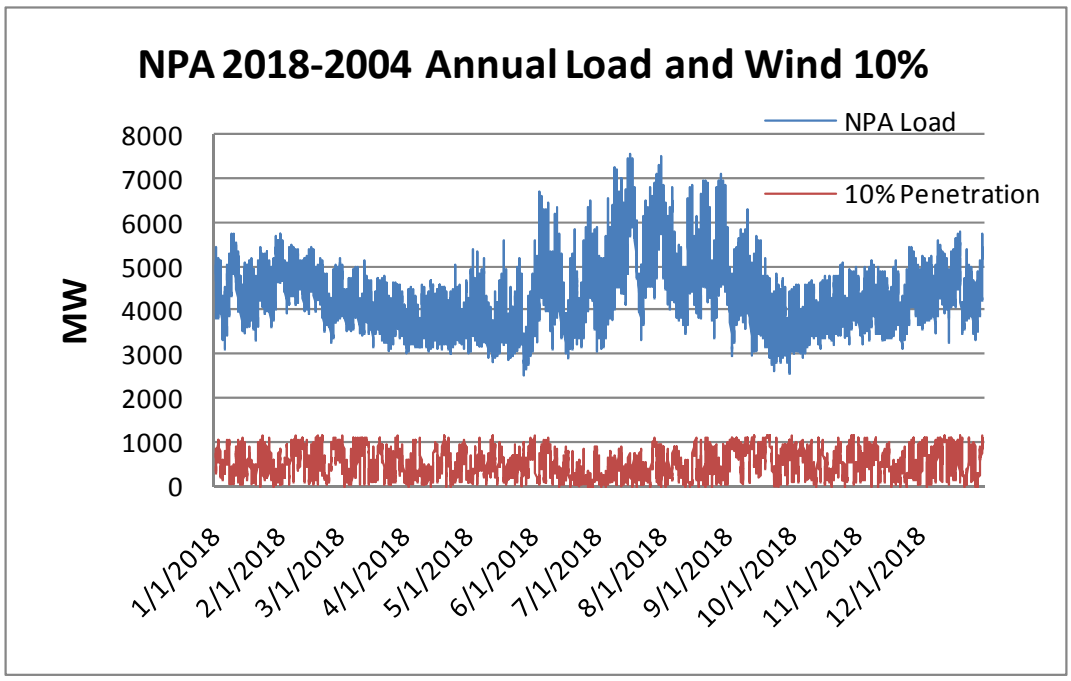

Figure 46: NPA 2004 Load and Wind Analysis – 10% Penetration

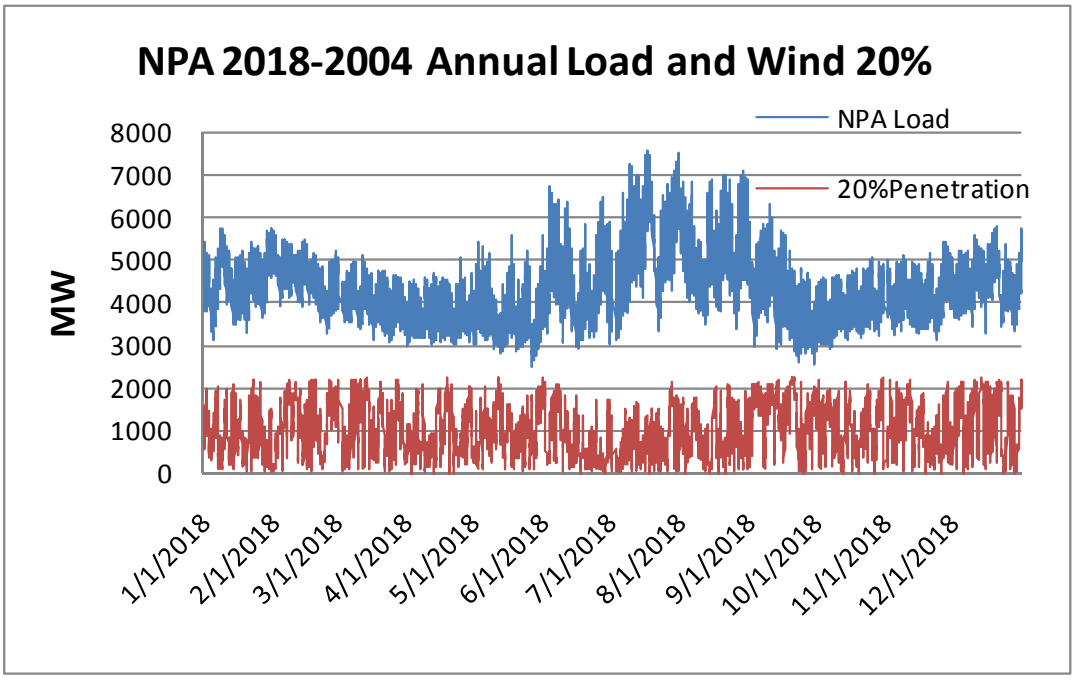

Figure 47: NPA 2004 Load and Wind Analysis – 20% Penetration

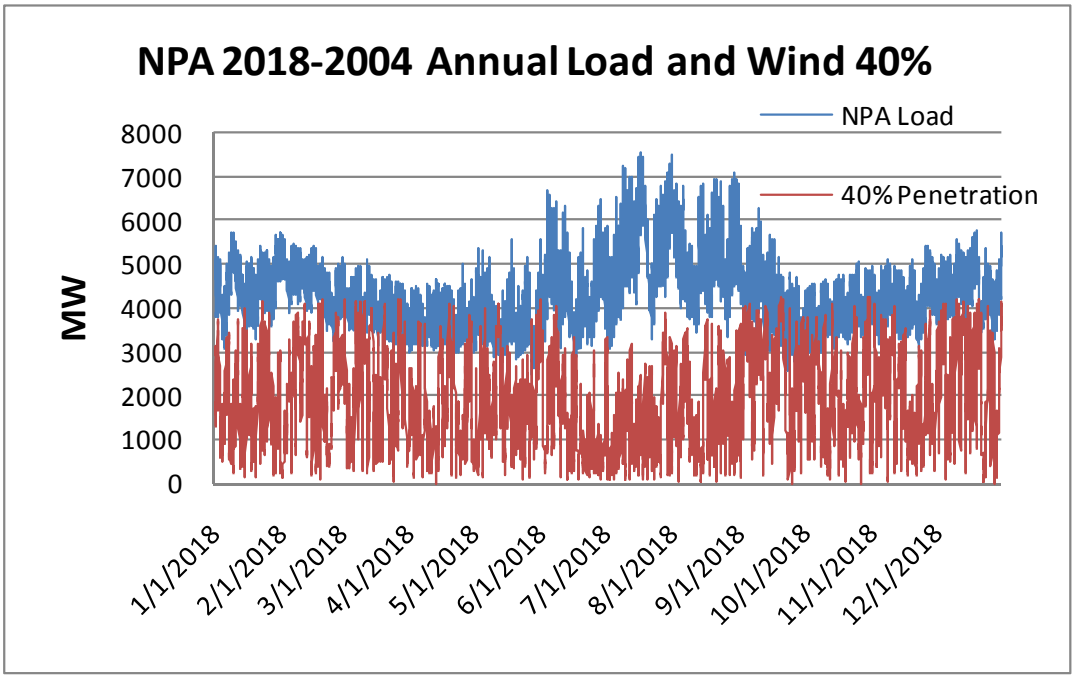

Figure 48: NPA 2004 Load and Wind Analysis – 40% Penetration

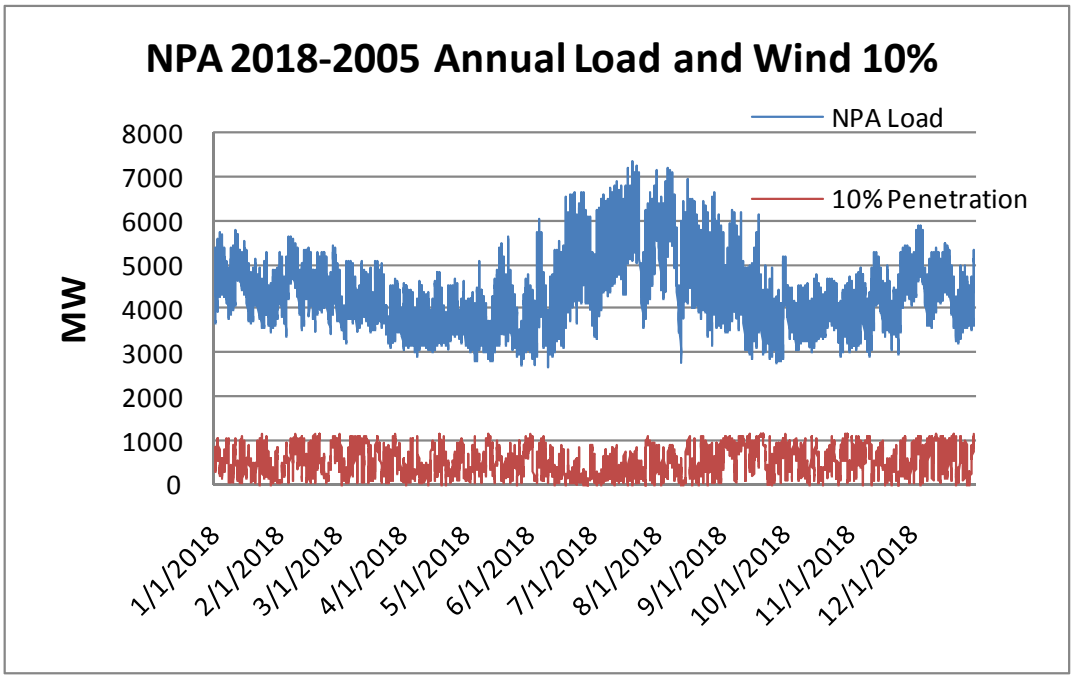

Figure 49: NPA 2005 Load and Wind Analysis – 10% Penetration

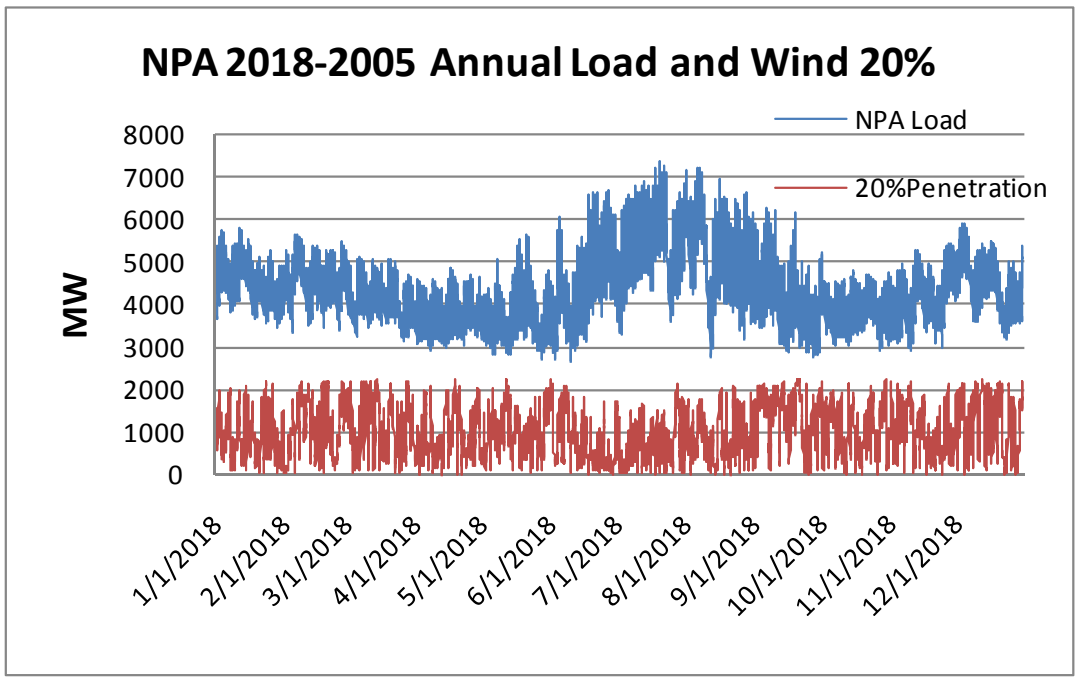

Figure 50: NPA 2005 Load and Wind Analysis – 20% Penetration

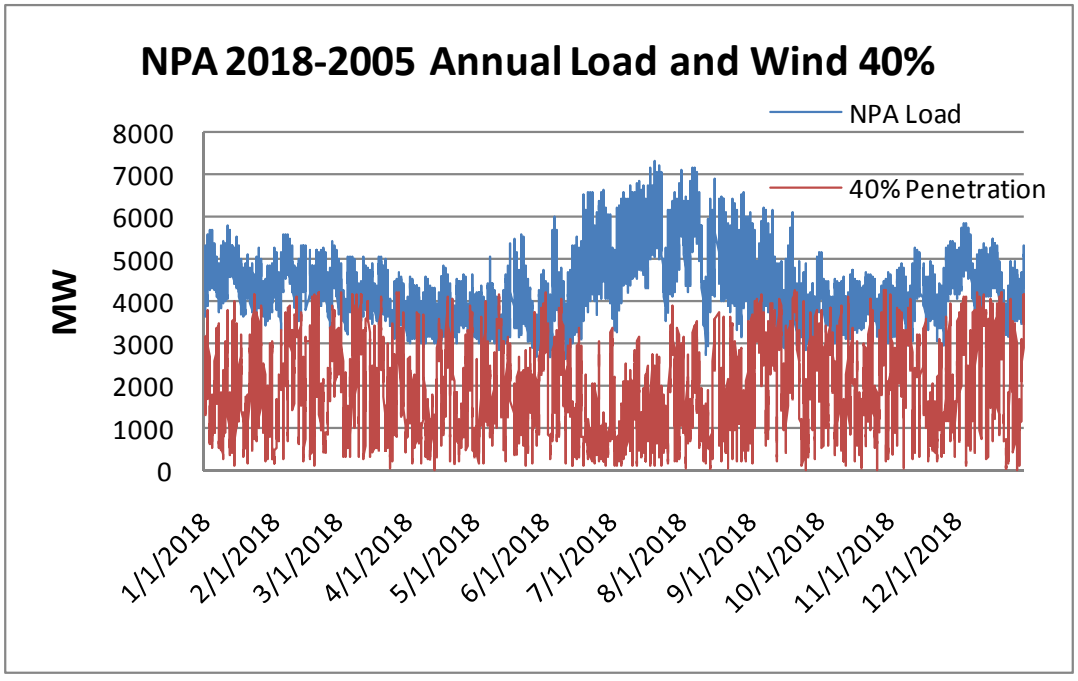

Figure 51: NPA 2005 Load and Wind Analysis – 40% Penetration

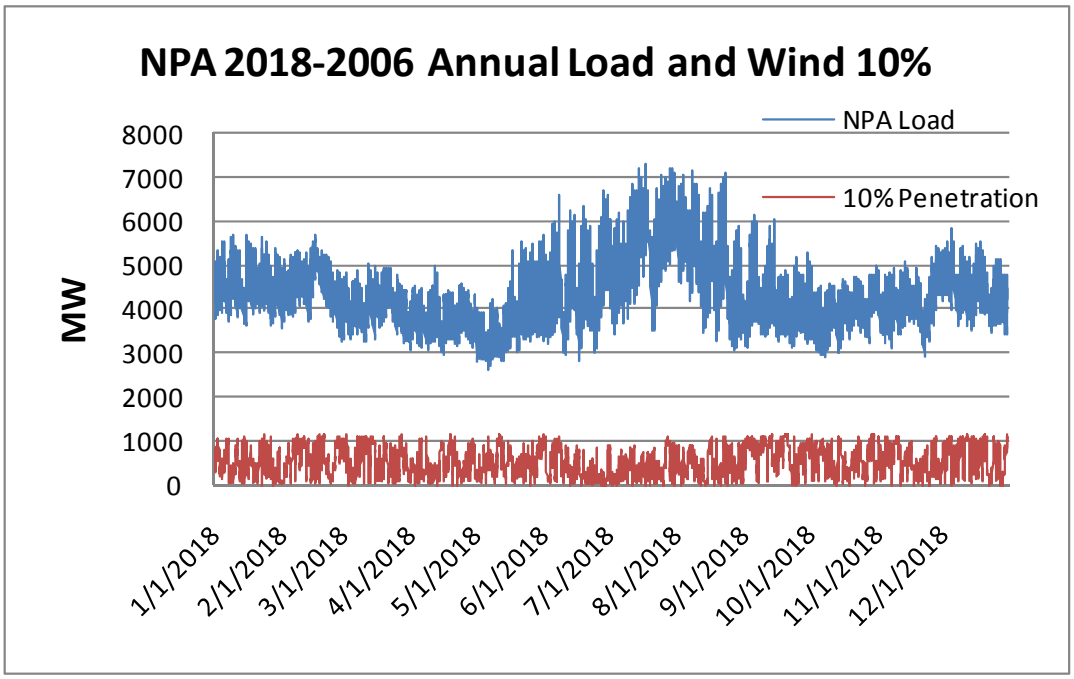

Figure 52: NPA 2006 Load and Wind Analysis – 10% Penetration

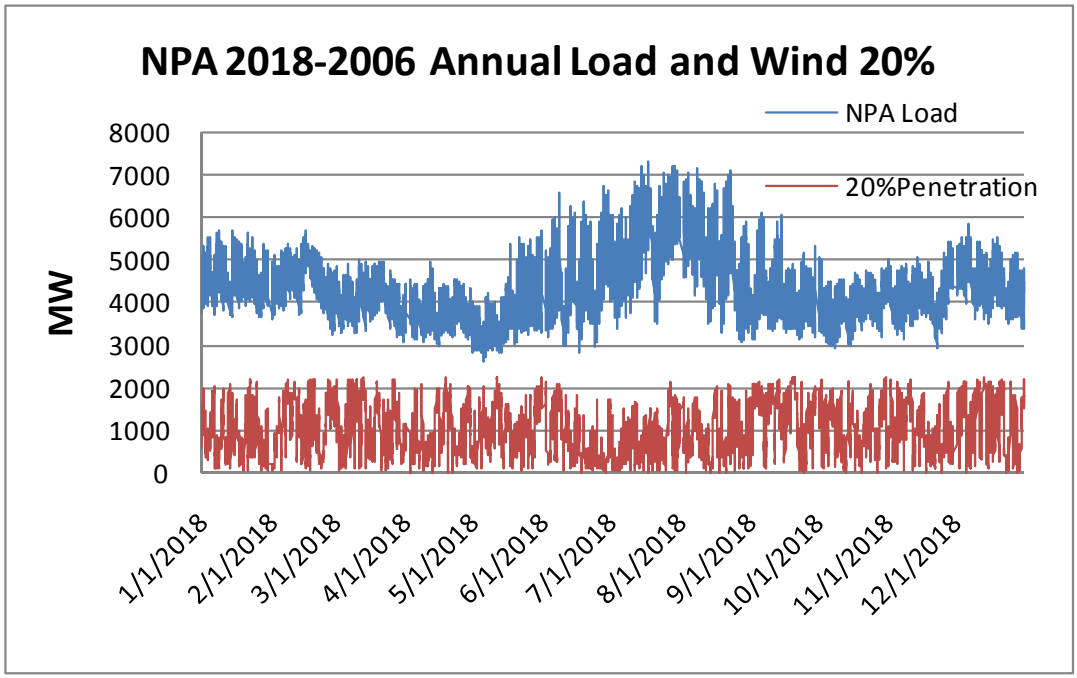

Figure 53: NPA 2006 Load and Wind Analysis – 20% Penetration

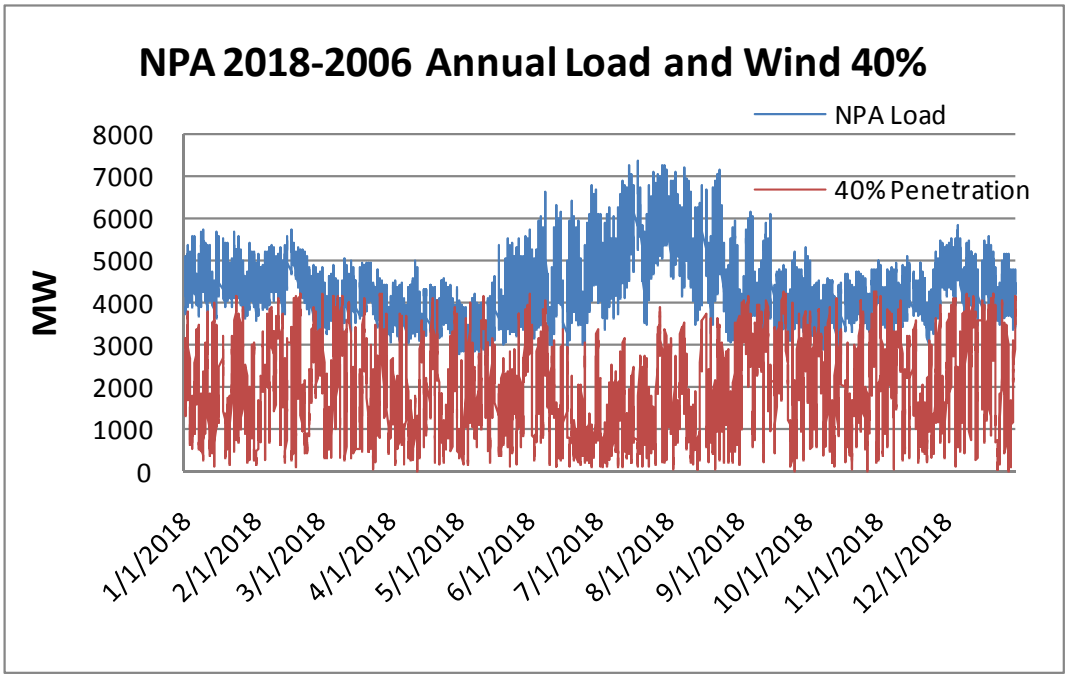

Figure 54: NPA 2006 Load and Wind Analysis – 40% Penetration

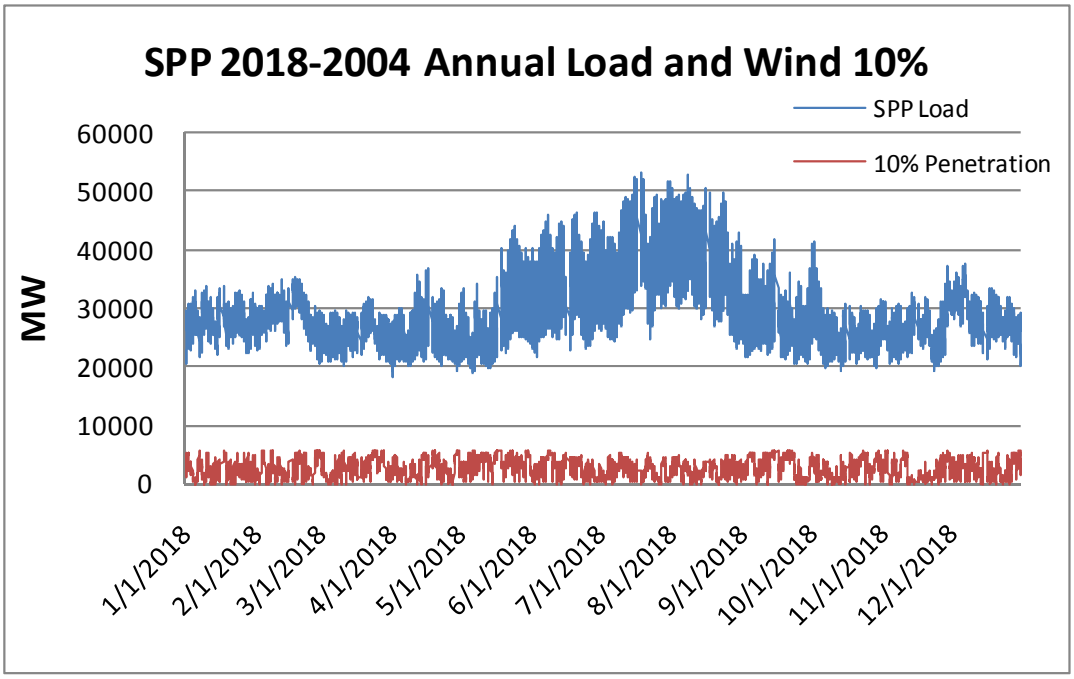

Figure 55: SPP 2004 Load and Wind Analysis – 10% Penetration

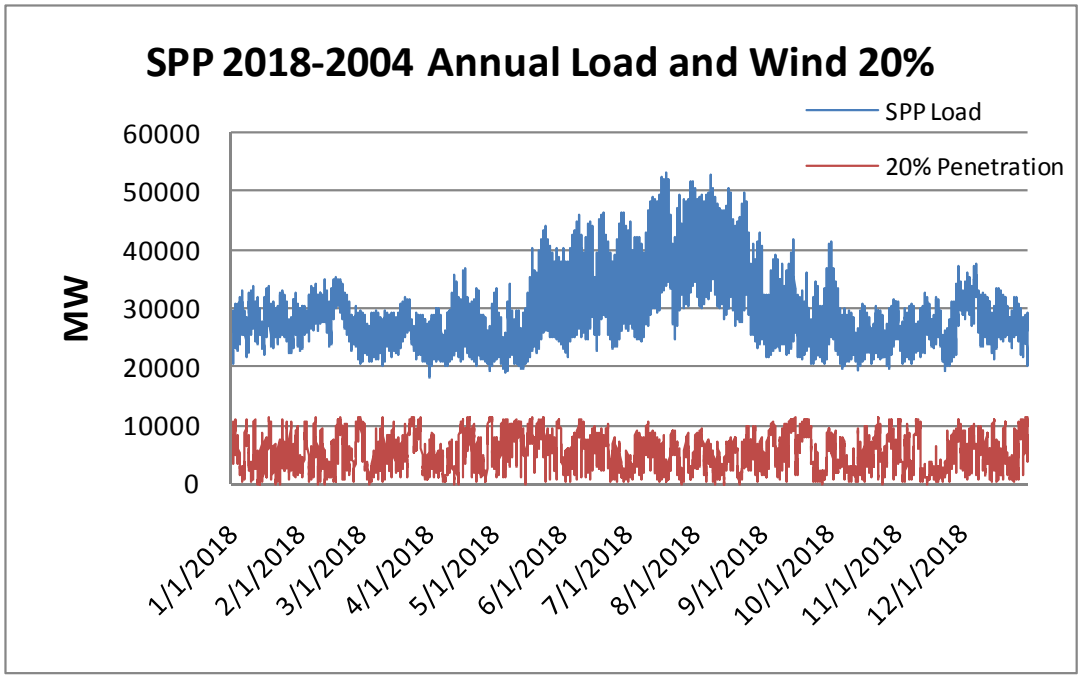

Figure 56: SPP 2004 Load and Wind Analysis – 20% Penetration

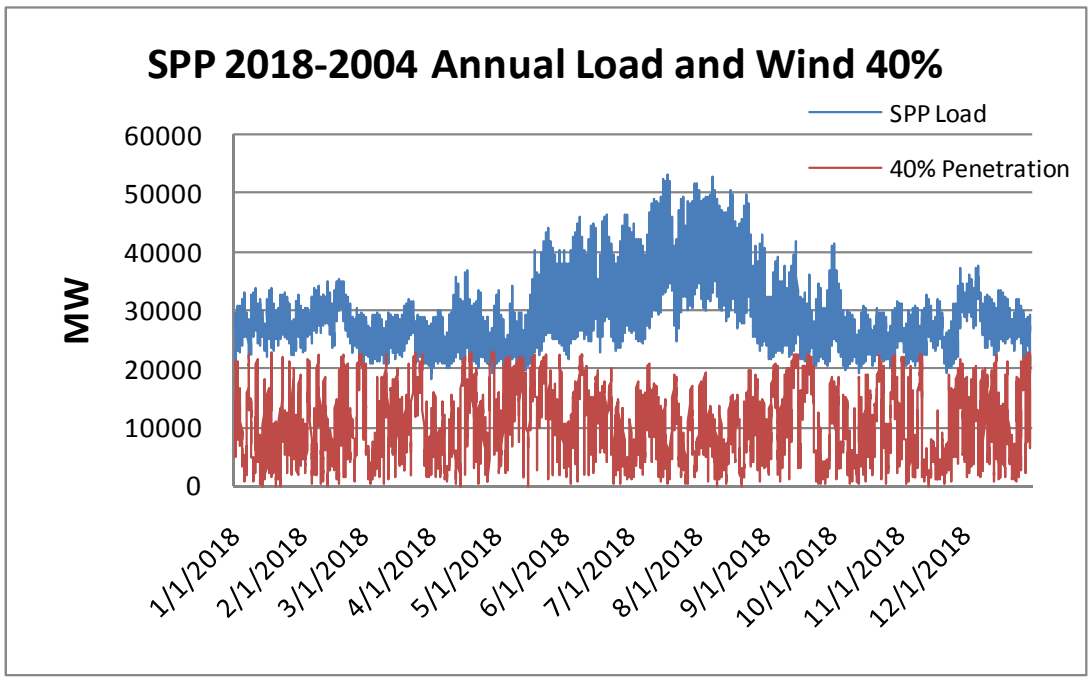

Figure 57: SPP 2004 Load and Wind Analysis – 40% Penetration

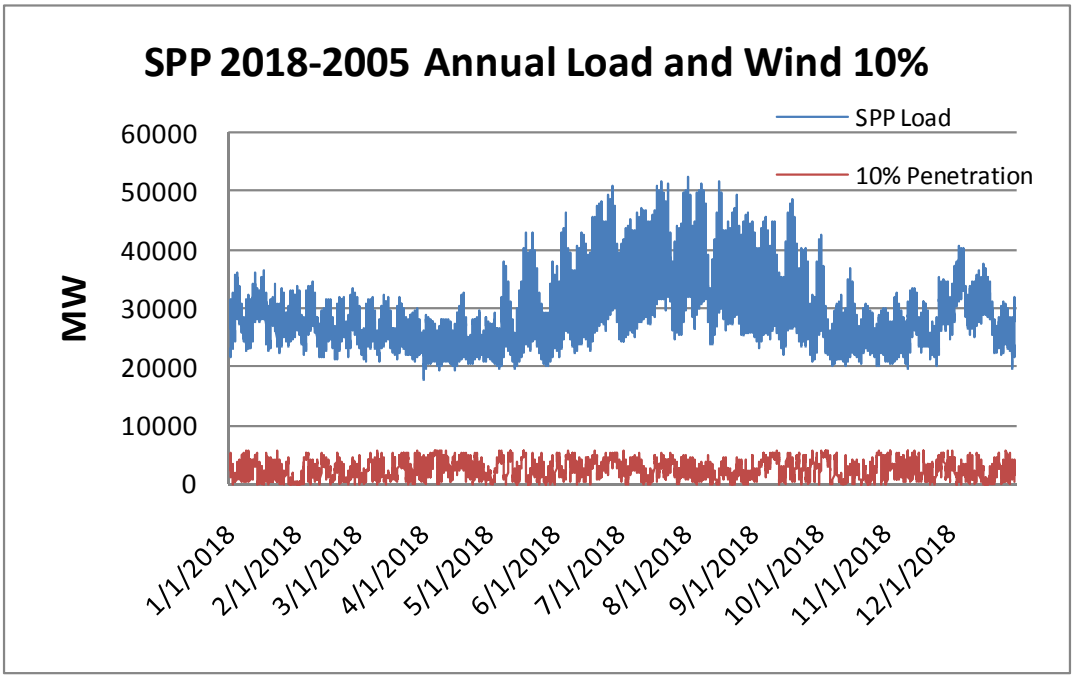

Figure 58: SPP 2005 Load and Wind Analysis – 10% Penetration

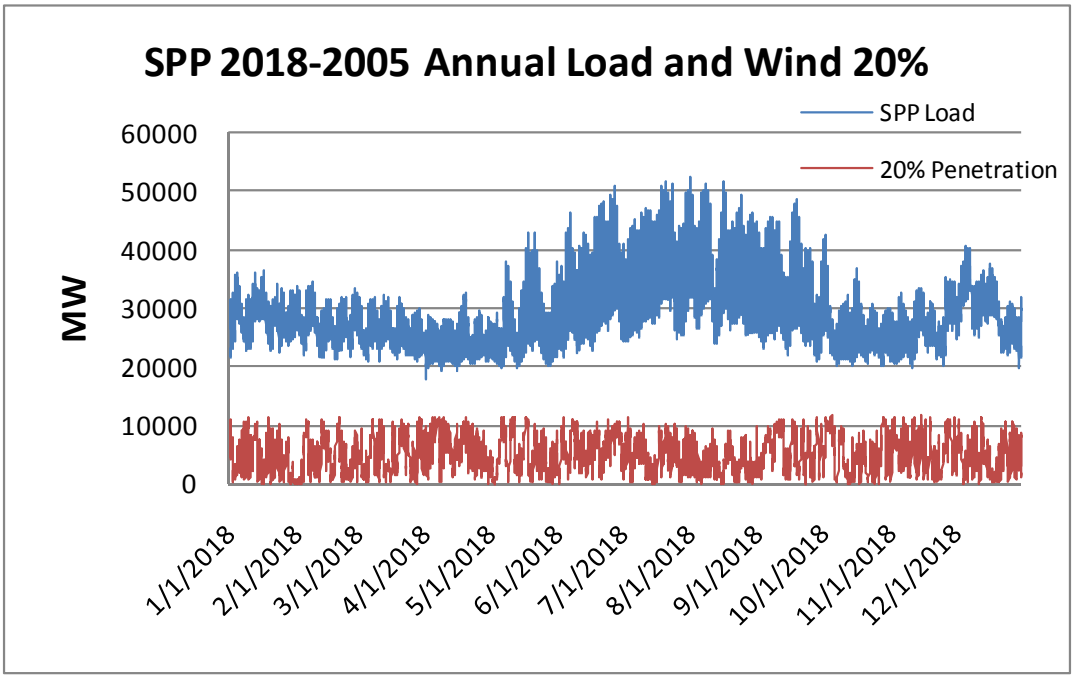

Figure 59: SPP 2005 Load and Wind Analysis – 20% Penetration

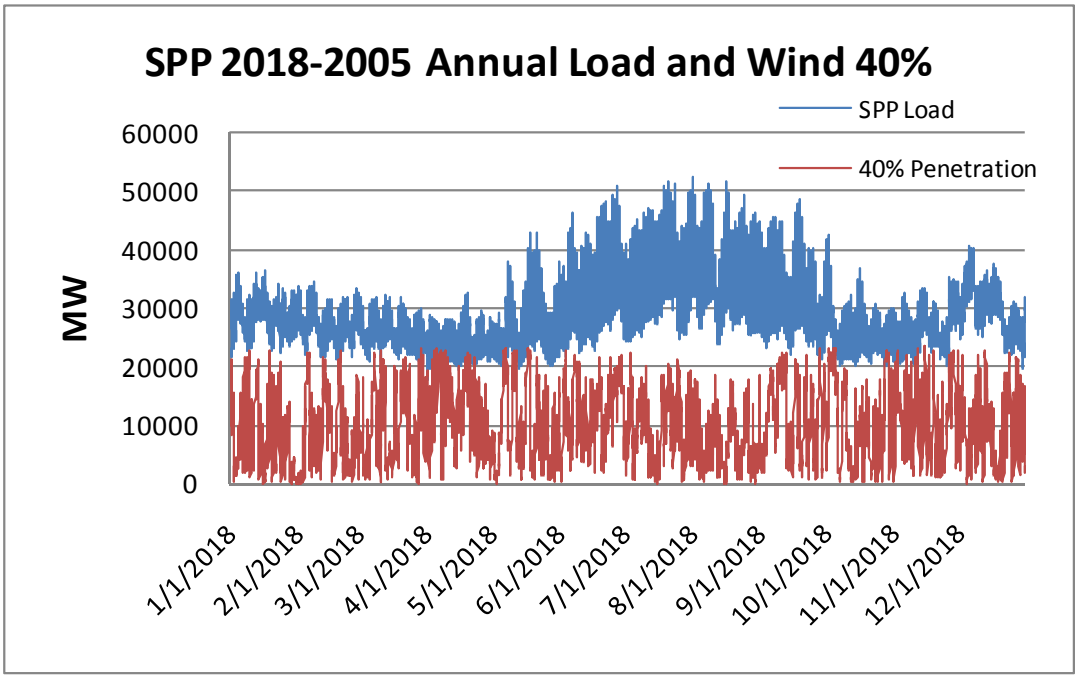

Figure 60: SPP 2005 Load and Wind Analysis – 40% Penetration

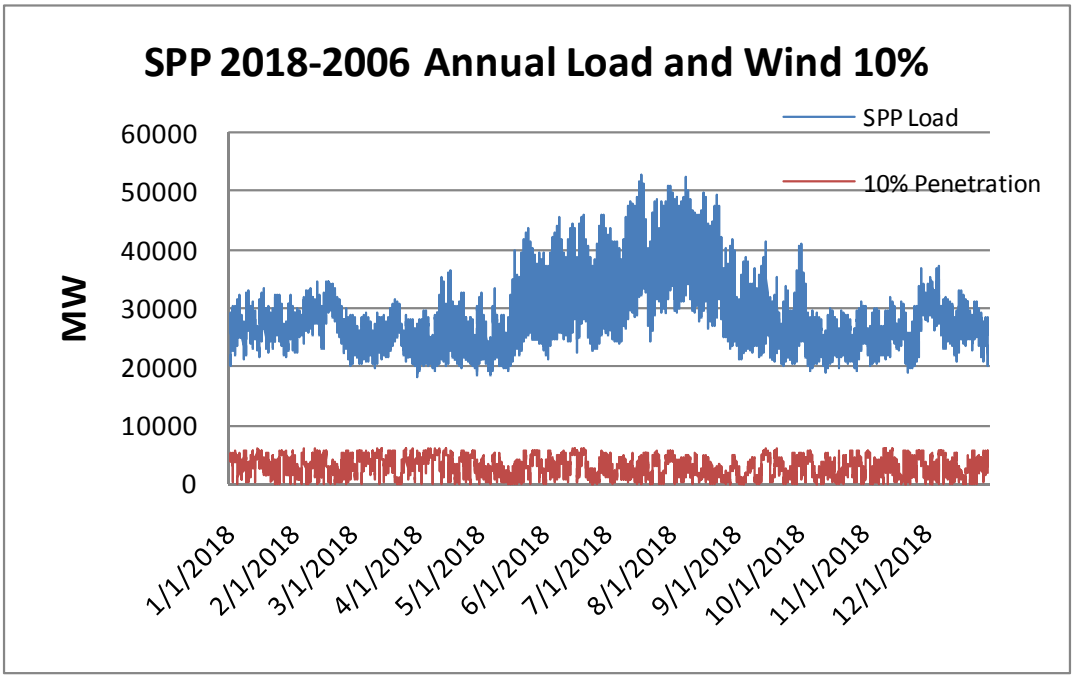

Figure 61: SPP 2006 Load and Wind Analysis – 10% Penetration

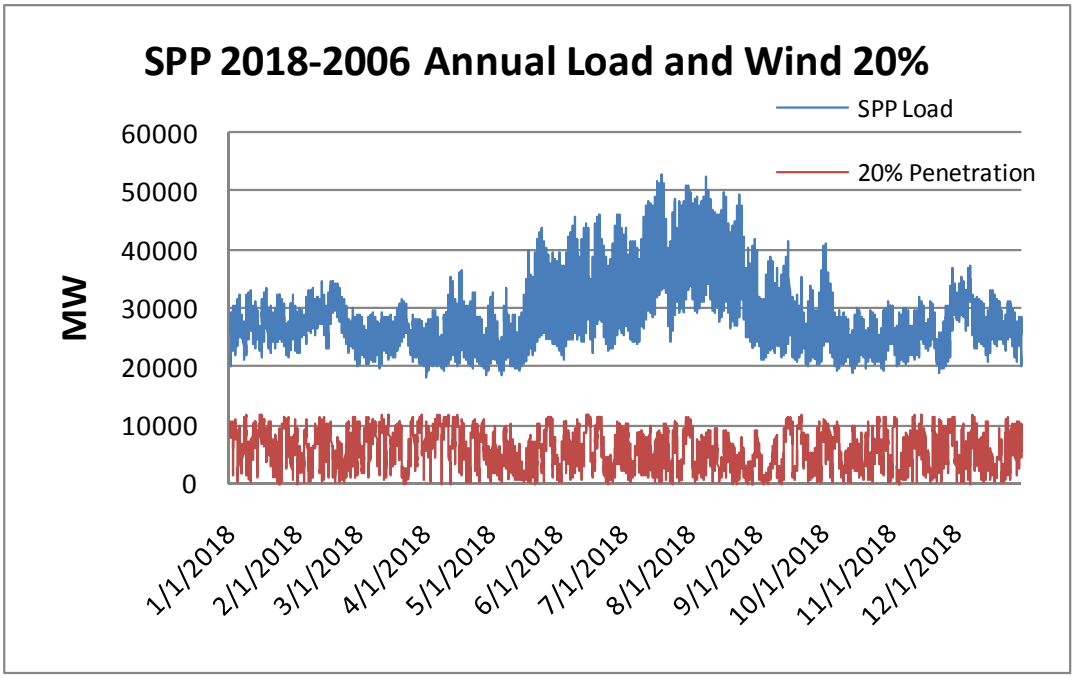

Figure 62: SPP 2006 Load and Wind Analysis – 20% Penetration

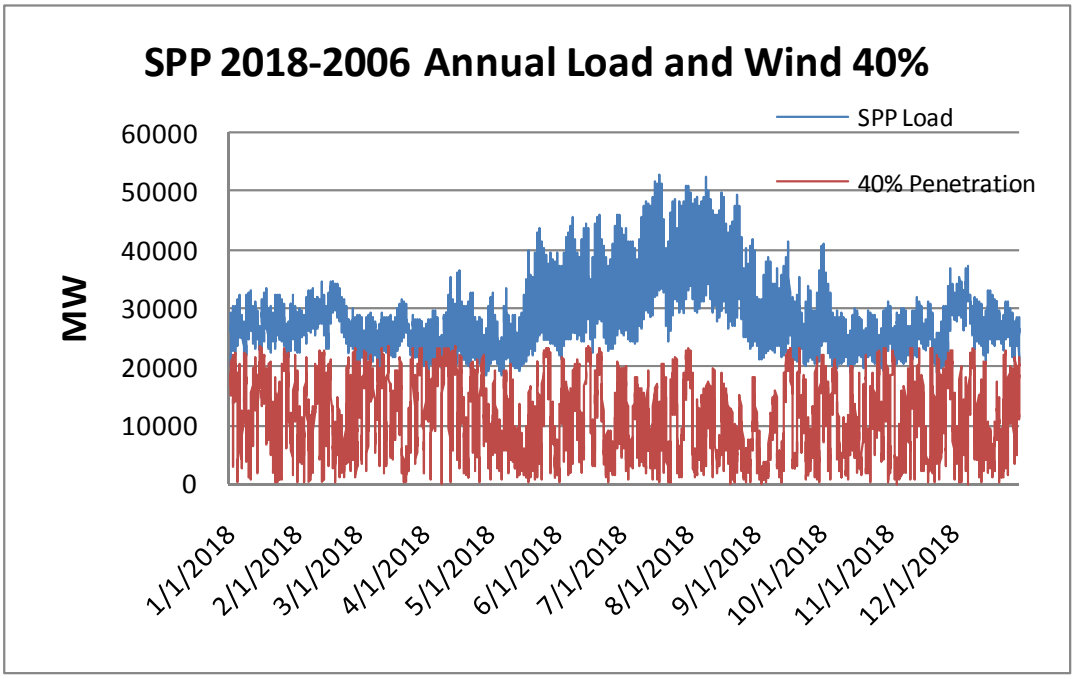

Figure 63: SPP 2006 Load and Wind Analysis – 40% Penetration

Section 8.2.3.2 Histogram Charts for Hourly Loads

Three histograms, Figure 64 - Figure 66, show the distribution of average hourly loads for NPA, SPP including NPA, and SPP excluding NPA. "Average" is used here to mean the average of an hour's three values taken from 2004-2006 load data.

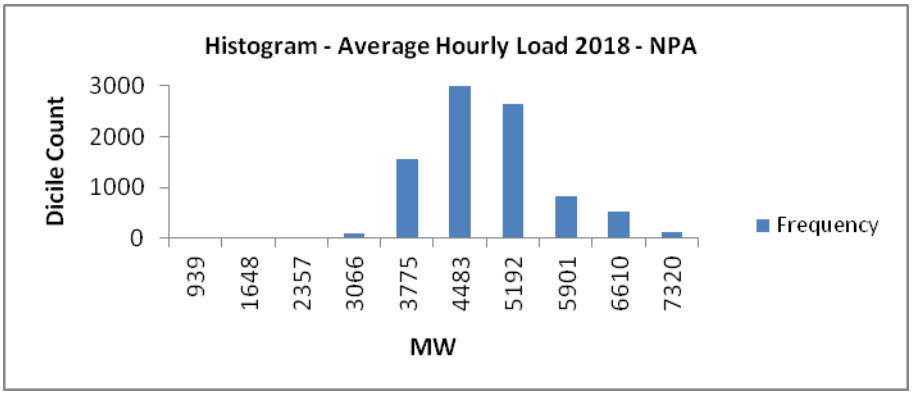

Figure 64: Histogram of Average NPA 2018 Load

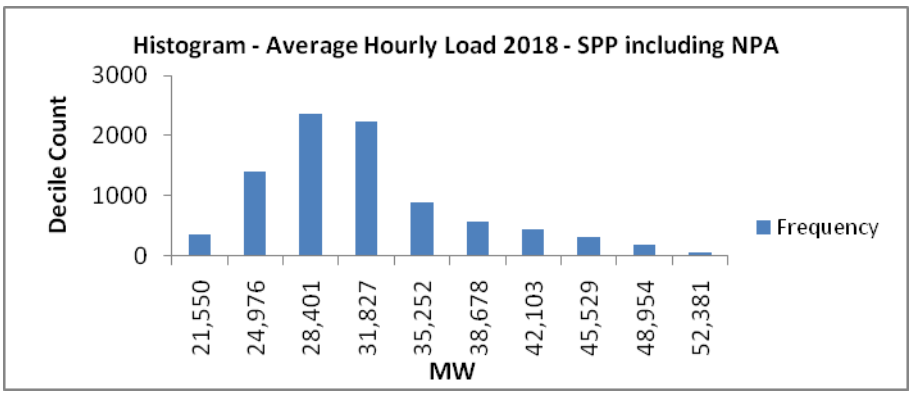

Figure 65: Histogram of Average SPP 2018 Load Including NPA

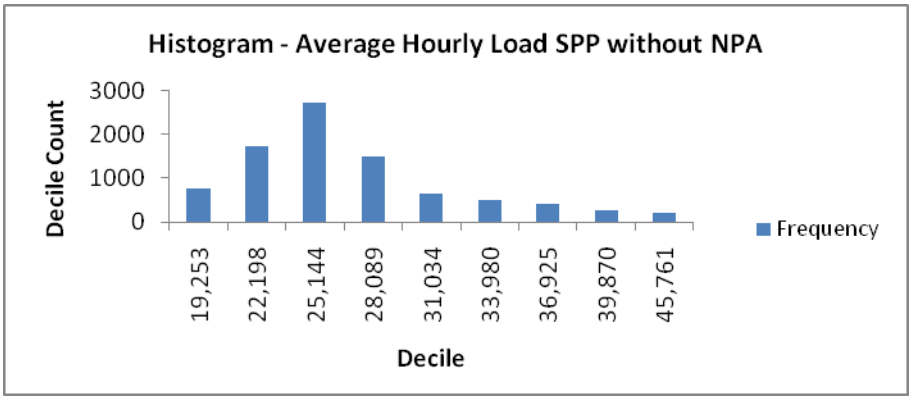

Figure 66: Histogram of Average SPP - NPA 2018 Load Excluding NPA

Section 8.2.3.3 Average Seasonal Load and Wind Production

The charts below in Figure 67 through Figure 81 show 24 hour day shapes for each region. The seasons are defined as winter: December – February; spring: March – May; summer: June – August; fall: September – November. Day shapes are created by averaging each respective hour of the day for the period of interest. The relative relationship between wind and load for the 10%, 20% and 40% penetration scenarios can be seen as well as separate charts with wind only to enhance display of wind differences.

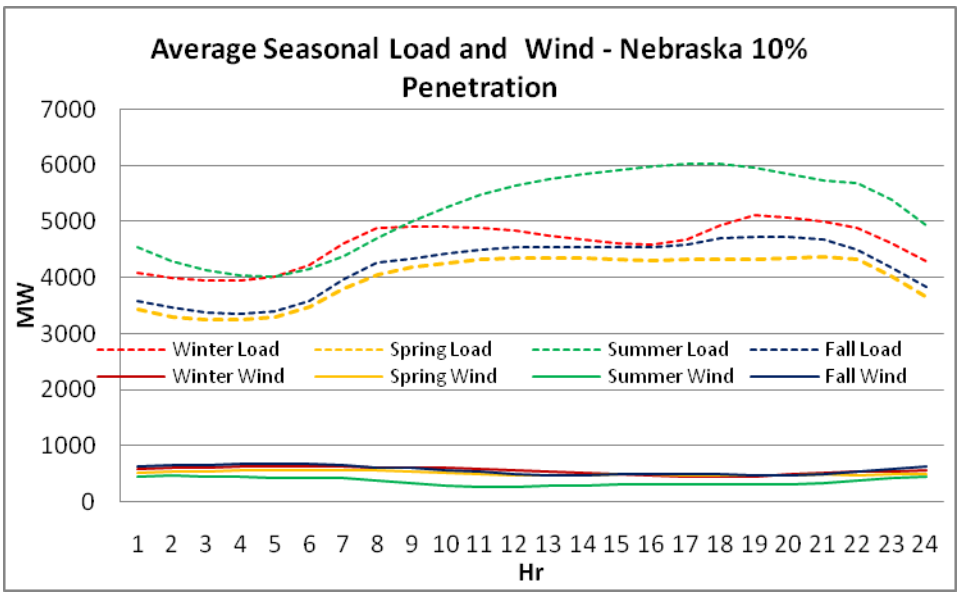

Figure 67: NPA - 24-Hour Average Seasonal Load and Wind 10% Penetration

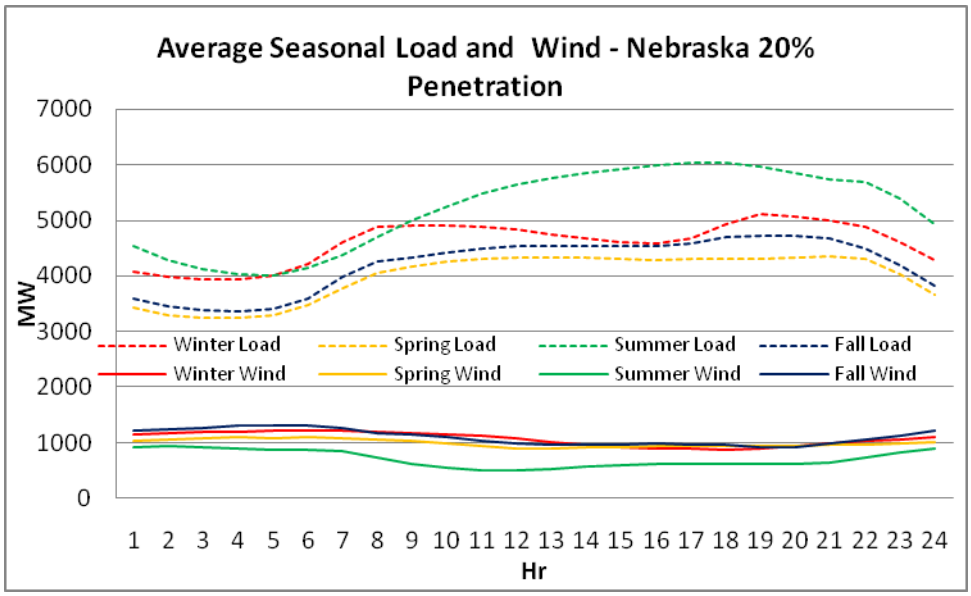

Figure 68: NPA - 24-Hour Average Seasonal Load and Wind 20% Penetration

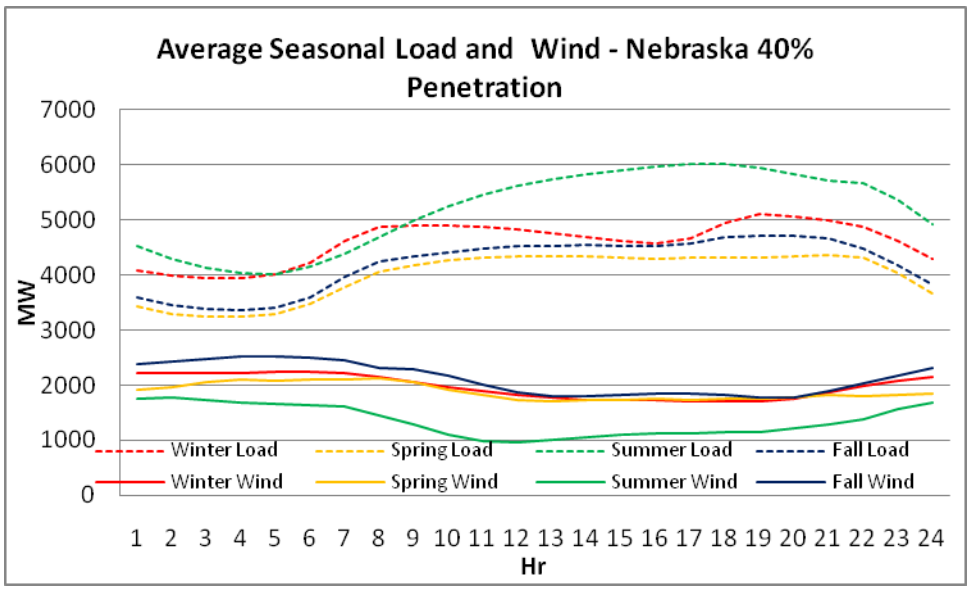

Figure 69: NPA - 24-Hour Average Seasonal Load and Wind 40% Penetration

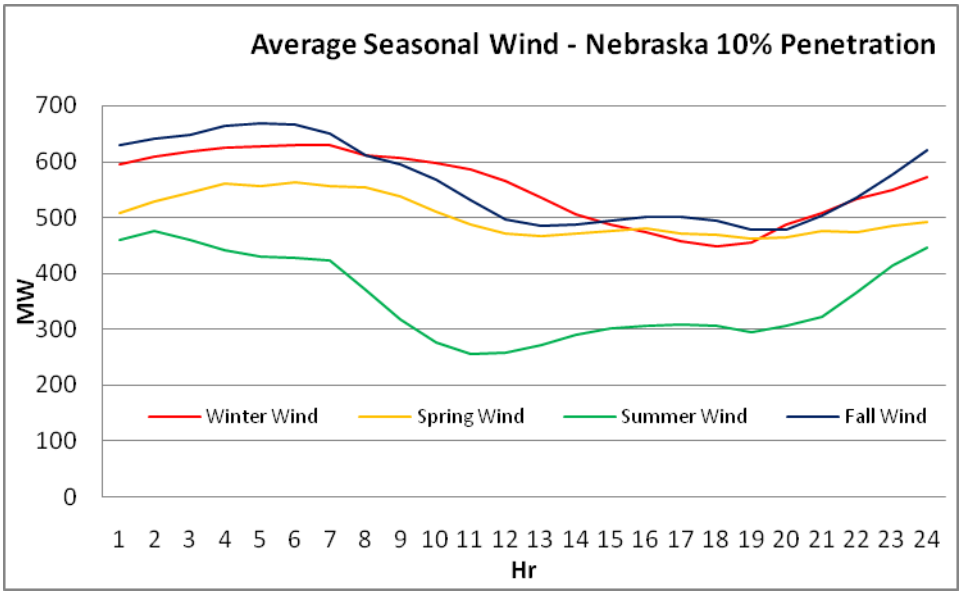

Figure 70: NPA – 24 Hour Average Seasonal Wind 10% Penetration

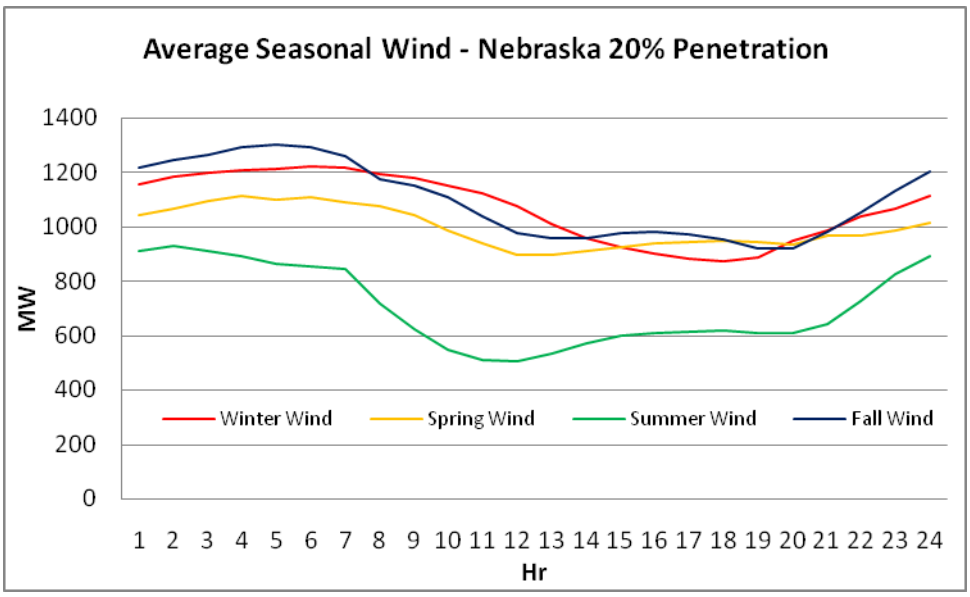

Figure 71: NPA – 24 Hour Average Seasonal Wind 20% Penetration

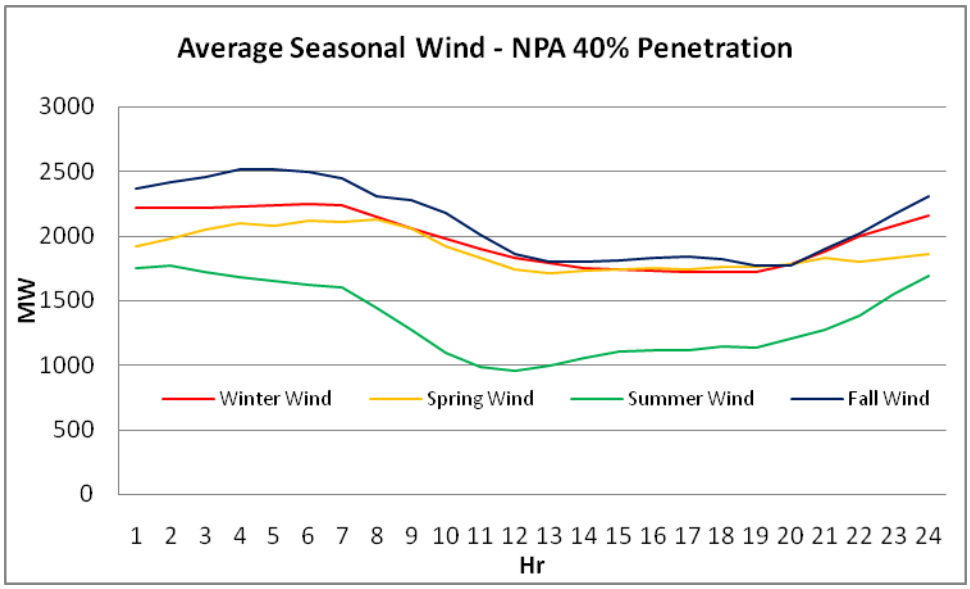

Figure 72: NPA – 24 Hour Average Seasonal Wind 40% Penetration

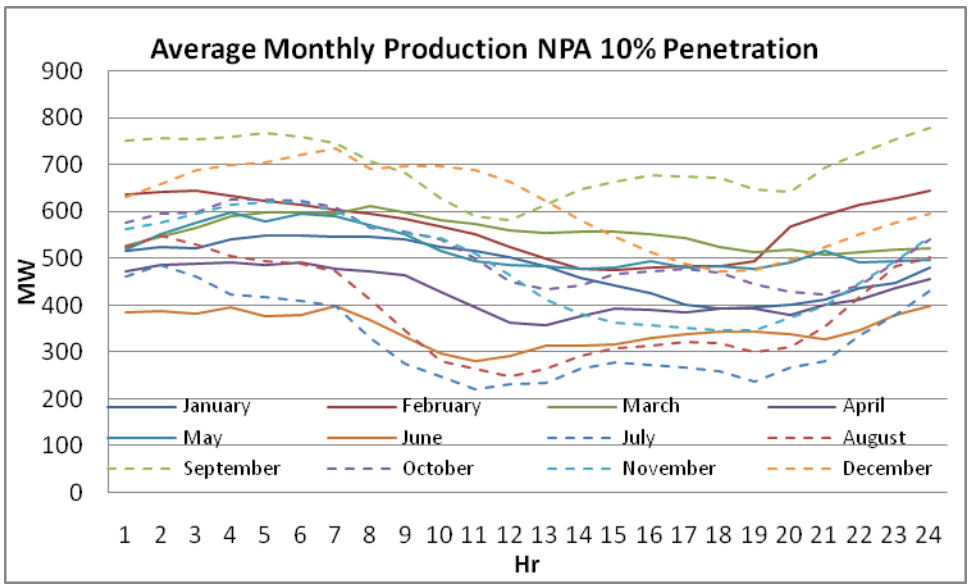

Figure 73: NPA – 24 Hour Average Monthly Wind 10% Penetration

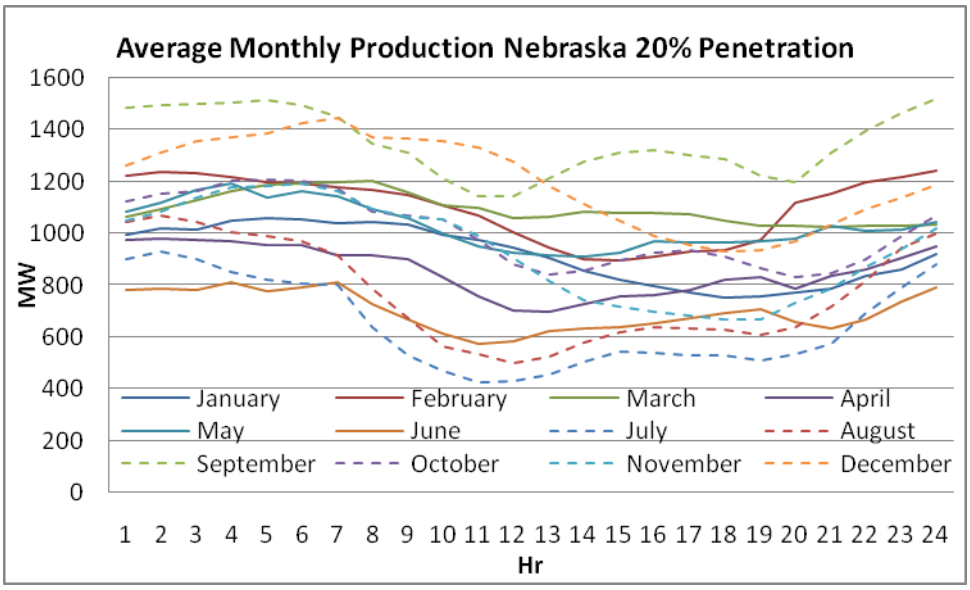

Figure 74: NPA – 24 Hour Average Monthly Wind 20% Penetration

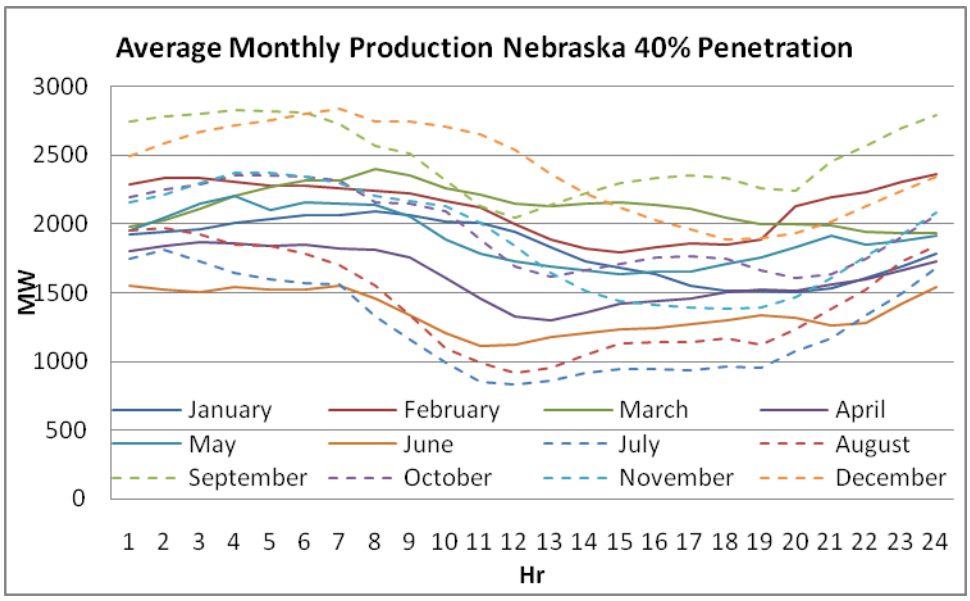

Figure 75: NPA – 24 Hour Average Monthly Wind 40% Penetration

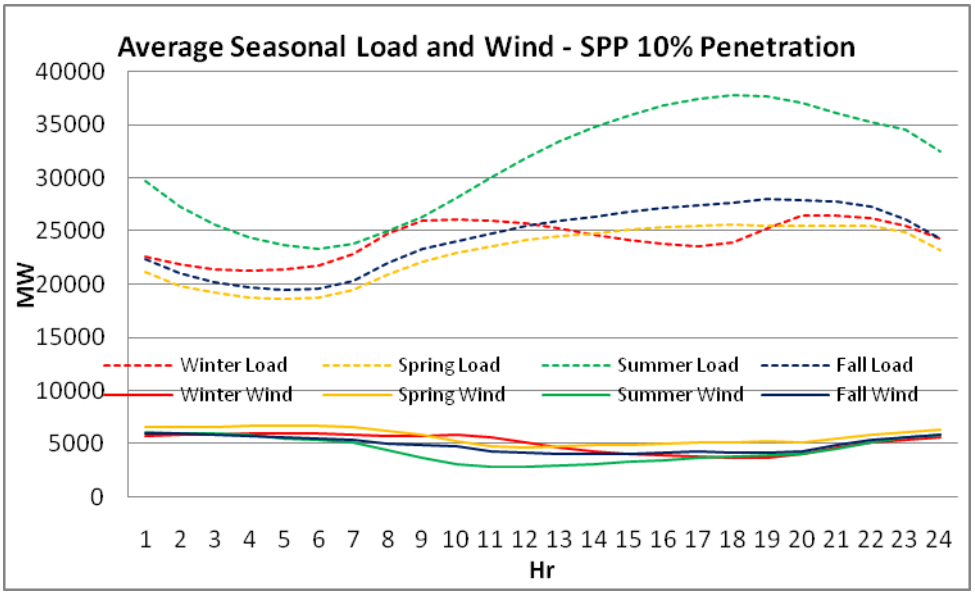

Figure 76: SPP – 24 Hour Average Seasonal Load and Wind 10% Penetration

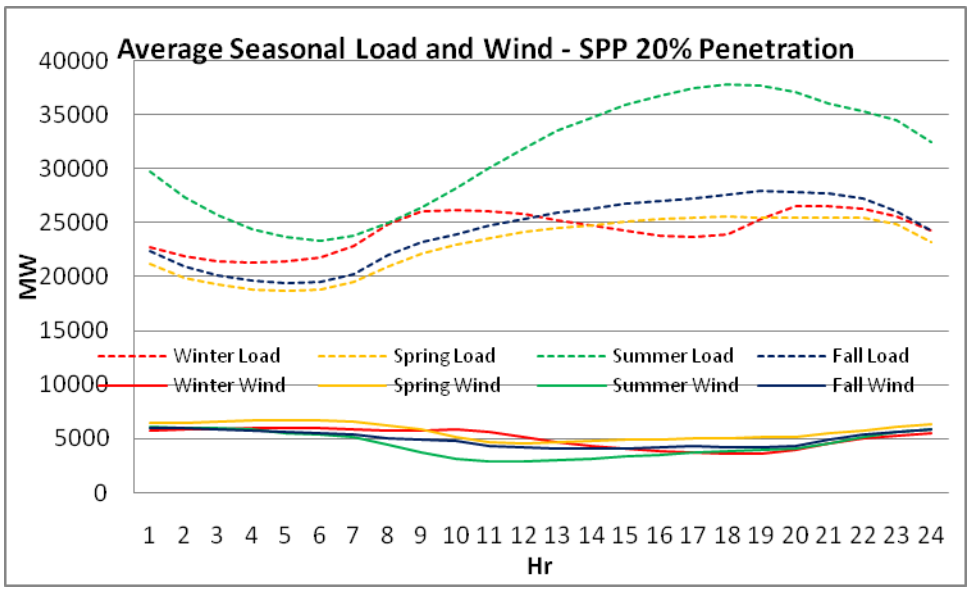

Figure 77: SPP – 24 Hour Average Seasonal Load and Wind 20% Penetration

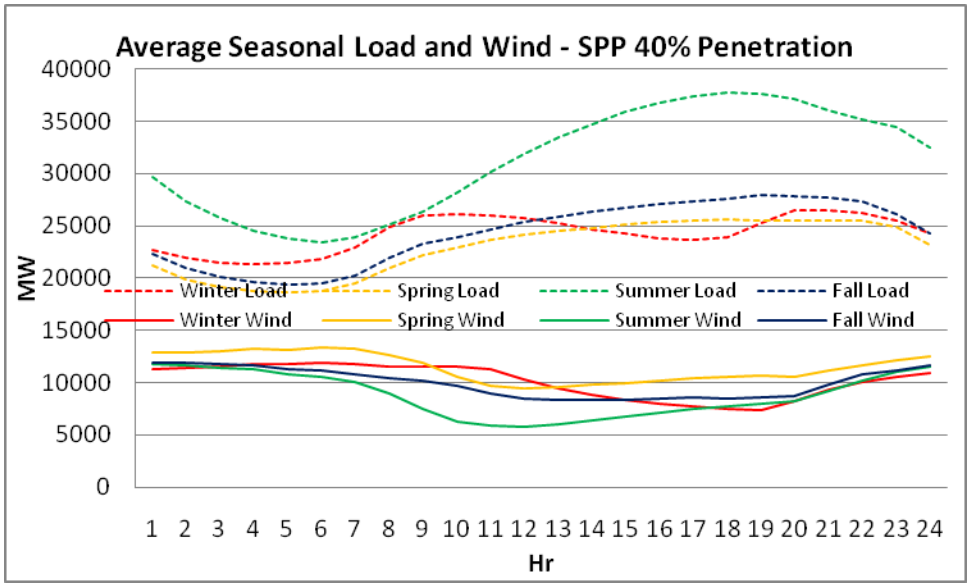

Figure 78: SPP – 24 Hour Average Seasonal Load and Wind 40% Penetration

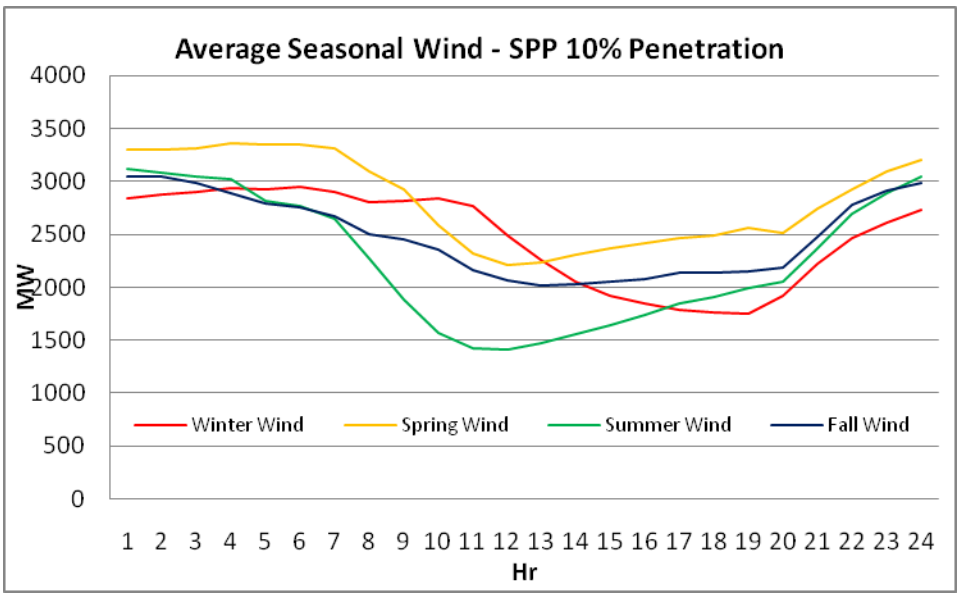

Figure 79: SPP – 24 Hour Average Seasonal Wind 10% Penetration

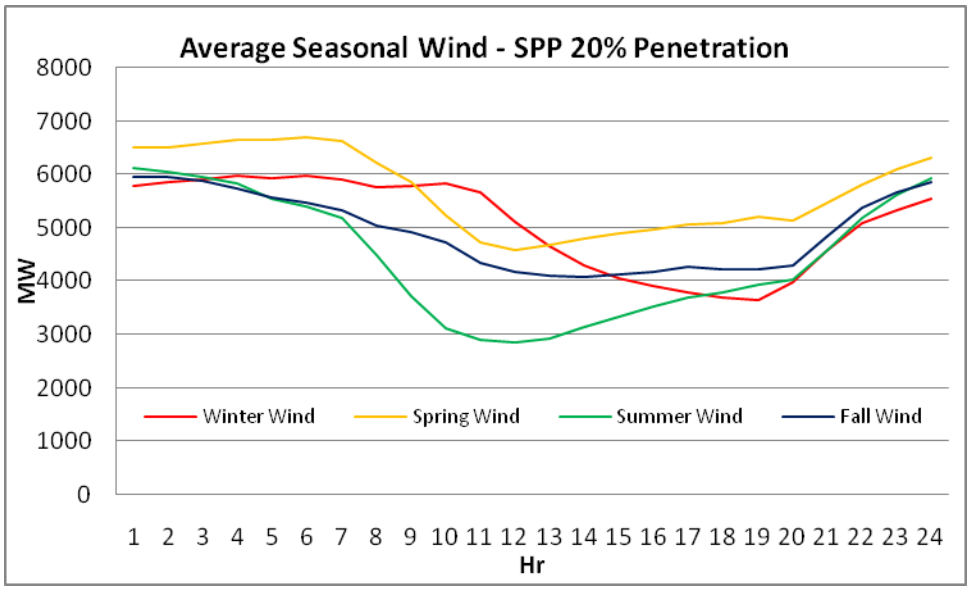

Figure 80: SPP – 24 Hour Average Seasonal Wind 20% Penetration

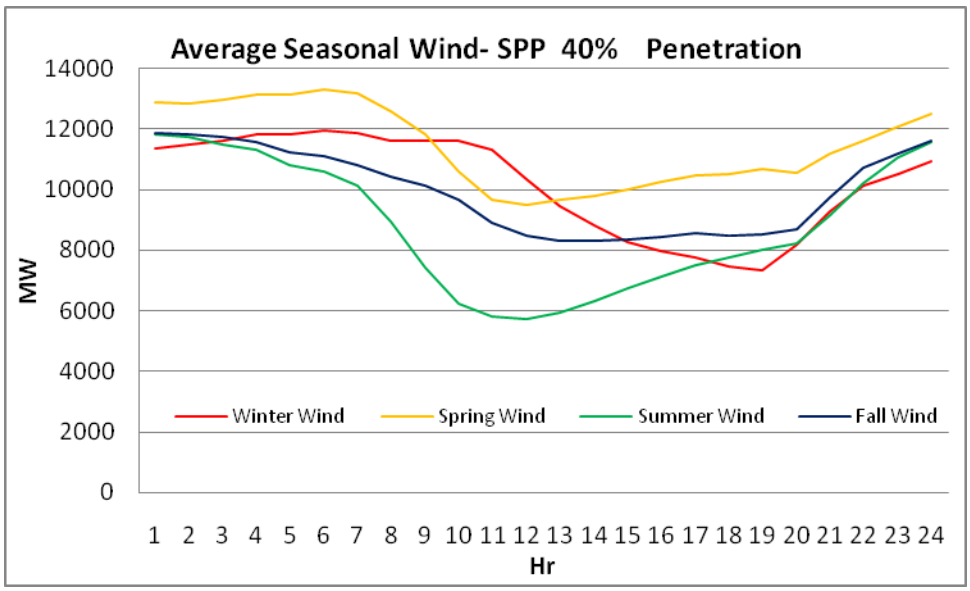

Figure 81: SPP – 24 Hour Average Seasonal Wind 40% Penetration

Section 8.2.3.4 Load, Wind and Load net Wind

Figure 82 and Figure 84 show time series plots for Nebraska data during a day with variable wind generation from 20% wind penetration together with low loads and then the overall week in April 2018. These figures show how the ramping requirement is increased due to the variable wind (i.e., ramping for load net wind exceeds that for the load alone).

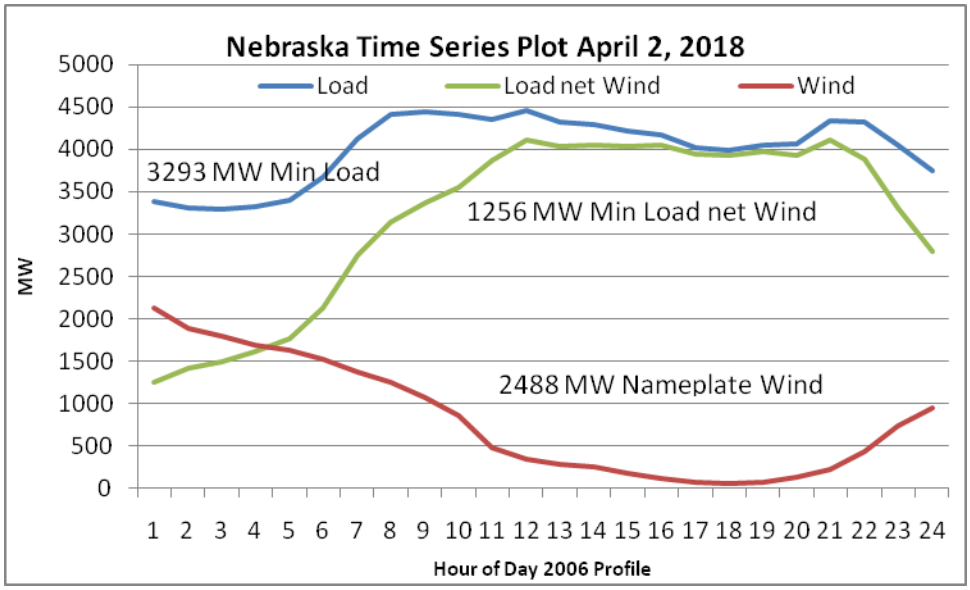

Figure 82: Time Series Plot for April Day of Load, Wind, and Load net Wind

Table 24 shows hourly data for April 2, 2018 using the 2006 profile. This data is used as an example of the effects of wind variability on ramping conditions. Note: The rule used to dispatch generation in this example is to ramp according to the ratio of the dispatch range that

must run generation can cover (1700MW), to the min to max load net wind ramping requirement (4115MW – 1256MW).

It is important to examine Nebraska ramping capability for a springtime day when large wind generation fluctuations may occur combined with low loads (e.g., the April 2, 2018 day being displayed). At that time, the operating range of must run generation from minimum to maximum would be approximately 1,700 MW, or from 2,500 MW to 4,210 MW. These values are applied in Table 24. This assumes some spring outages in that all coal and nuclear units are running except for four coal units. Also Nebraska hydro is running at half capacity and the WAPA purchases are scheduled at their minimum levels. Nuclear units are assumed to run flat out and contributing no range of operation. For this assumption the modeled maximum hourly ramping rates are 629MW-up per hour up and 739 MW-down per hour.

Table 24: Sample Day of Hourly Data (April 2, 2018) for Nebraska Load and Wind with 2006 profile

20% Wind Penetration 2006, 4/2/2018						Ramping in MW/Hour		
Load	Wind Gen	Hour	Load Net Wind (MW)	Must Run Gen (MW)	Export (MW)	Req'd by Load Net Wind	Provided by Must Run	Provided by EXPORT
3,387	2,131	1	1,256	2,500	1,244	-	-	-
3,311	1,890	2	1,421	2,598	1,177	165	98	67
3,293	1,791	3	1,502	2,646	1,145	81	48	33
3,318	1,699	4	1,619	2,716	1,097	117	70	47
3,401	1,637	5	1,764	2,803	1,039	145	86	58
3,665	1,529	6	2,136	3,025	889	373	222	150
4,119	1,375	7	2,744	3,387	643	608	362	245
4,408	1,260	8	3,148	3,629	480	405	241	163
4,438	1,073	9	3,365	3,758	393	217	129	87
4,409	854	10	3,555	3,871	316	190	113	77
4,354	487	11	3,867	4,057	190	312	186	126
4,450	341	12	4,109	4,201	93	242	144	98
4,323	294	13	4,029	4,154	125	-80	-48	-32
4,294	252	14	4,042	4,162	120	13	8	5
4,215	179	15	4,036	4,158	122	-6	-4	-3
4,165	118	16	4,047	4,164	118	11	7	4
4,016	76	17	3,940	4,101	161	-107	-64	-43
3,990	61	18	3,929	4,094	165	-11	-7	-4
4,042	75	19	3,967	4,117	150	38	23	15
4,067	132	20	3,935	4,098	163	-32	-19	-13
4,340	225	21	4,115	4,205	90	181	108	73
4,314	432	22	3,882	4,066	184	-233	-139	-94
4,056	742	23	3,314	3,727	413	-568	-339	-229
3,744	951	24	2,793	3,416	624	-521	-311	-210

Figure 83 provides a chart that shows how the must run generation ranges from min to max over the day (and with exports ramping oppositely) by plotting those data from Table 24. Also shown are the hourly ramping that will need to come from the must run units and the hourly changes to the export level by plotting that data from Table 24.

Figure 84 shows the variations for wind generation, load, and load net wind for the full week that includes April 2, which shows similar repeated patterns throughout the week.

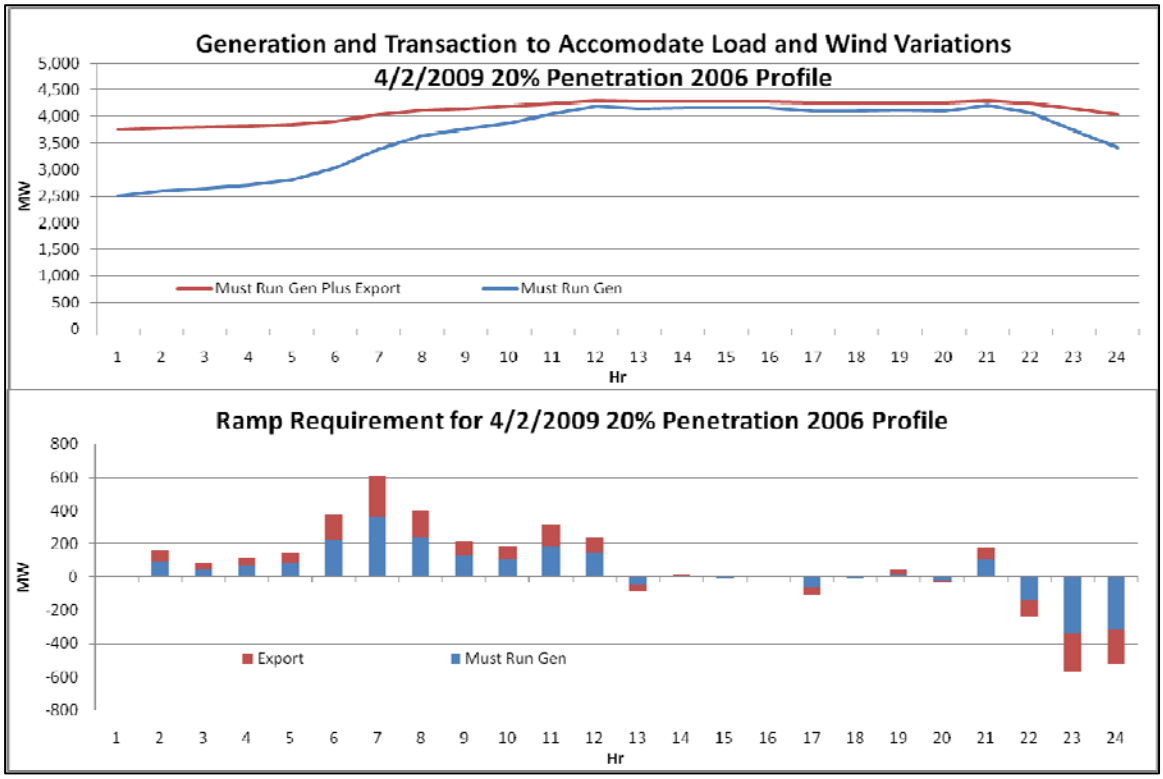

Figure 83: Generation and Transaction to accommodate load and wind variations and Ramp Requirements for April 2, 2018 for 2006 profile

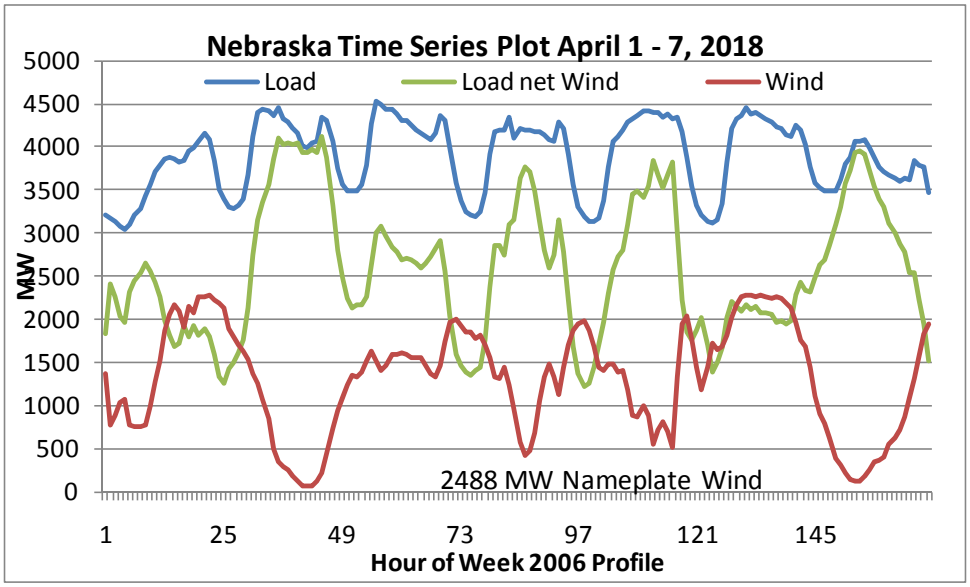

Figure 84: Time Series Plot for April Week of Load, Wind, and Load net Wind

Figure 85 provides a load duration curve of NPA 2018 load and the load net wind for 10%, 20% and 40% wind penetration for the 2006 wind/load pattern. This figure shows the impact of increased wind penetration on low load periods in that at 10% penetration wind generation in Nebraska exceeds the annual minimum load level only about 5% of the time but at 40% penetration the wind generation exceeds annual minimum load nearly 50% of the time. As clarification this does not mean that 40% wind penetration exceeds load 50% of the time because only the minimum load point is being referenced here. However, wind generation for 40% penetration exceeds Nebraska load approximately 600 hours of the year, or 7% of the time (time below the zero line in Figure 85).

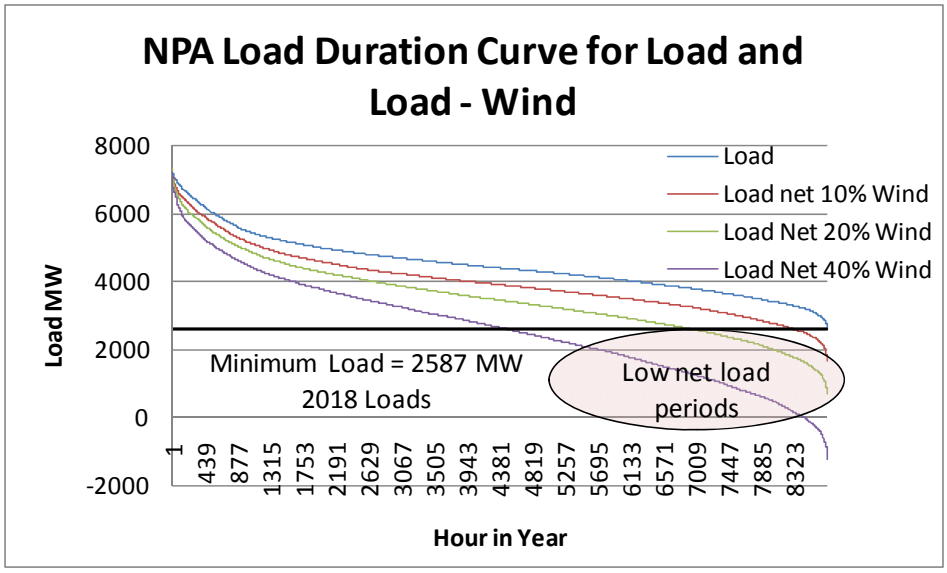

Figure 85: Load Duration for NPA load and Load net Wind

Section 8.2.3.5 Nebraska Load / Wind Hourly Correlation

A correlation analysis was performed on NPA load and wind annually and monthly from multiple years, then on the rest of SPP, then on SPP including NPA, Figure 86 - Figure 89. A zero correlation means that on average wind generation and load change independently of one another. Positive correlation means that on average as load increases wind generation tends to increase more often than decrease and vice-versa. Negative correlation means that on average as load increases wind generation tends to decrease more often than increase and vice-versa. A perfect correlation would be 100% while a perfect inverse correlation would be -100%. Loads and wind generation are generally negatively correlated.

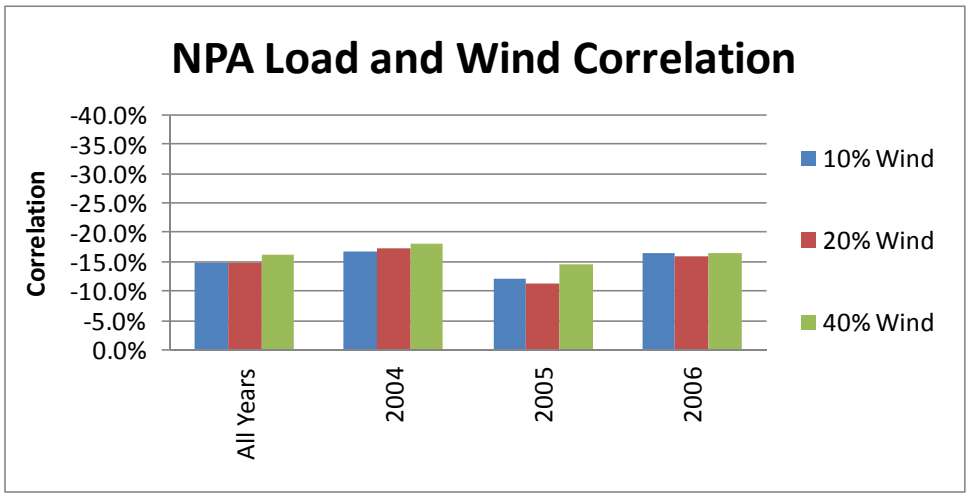

Figure 86: NPA-Annual Summary Correlation of Load and Wind

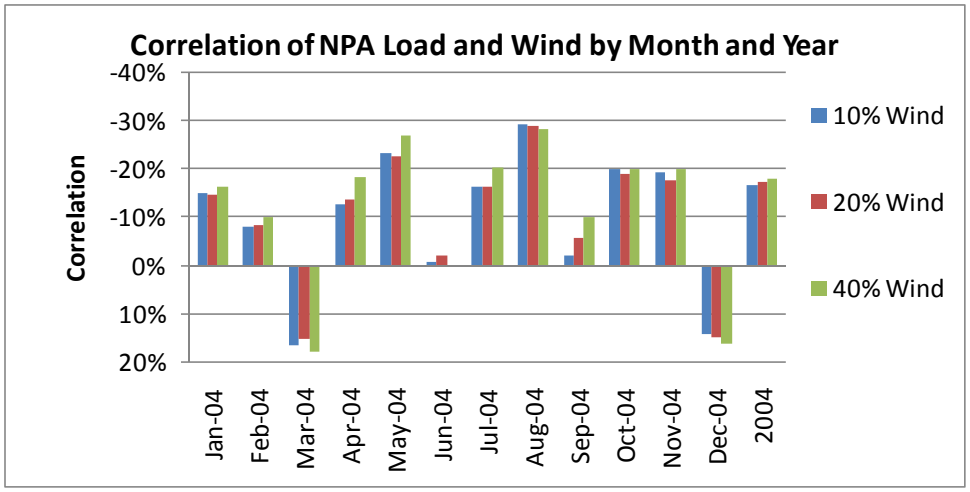

Figure 87: NPA 2004 Load and Wind Correlation by Month

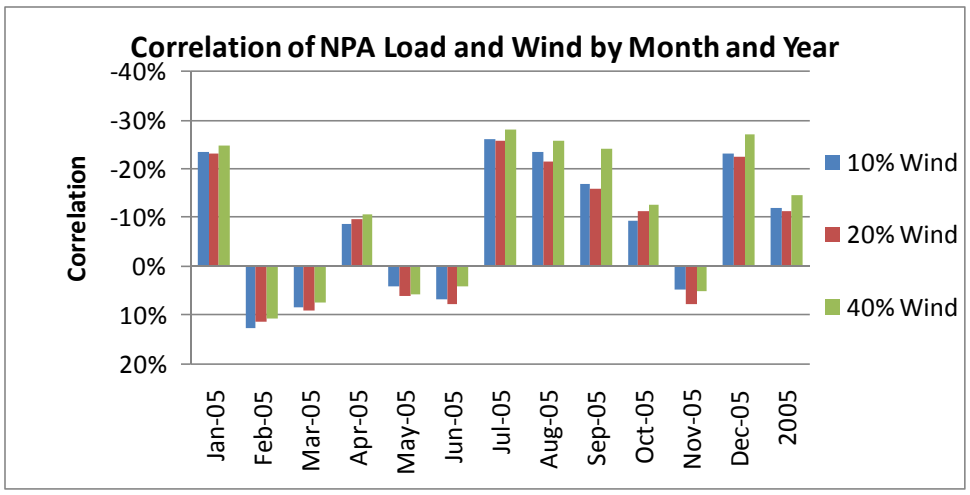

Figure 88: NPA 2005 Load and Wind Correlation by Monty

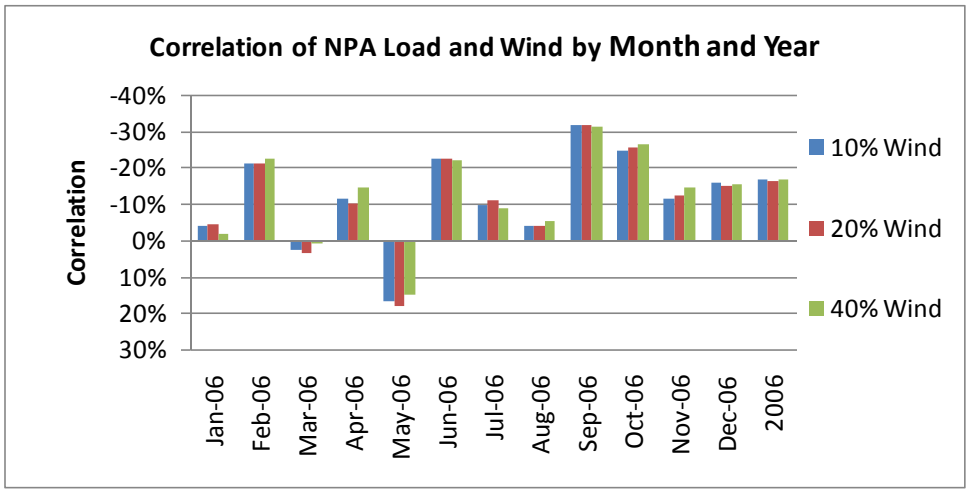

Figure 89: NPA 2006 Load and Wind Correlation by Month

Comparing correlation results between SPP and NPA:

- Overall, the rest of SPP has about 3-4% more negative correlation than NPA, as determined by comparing Figure 86 and Figure 90.
- In the rest of SPP July is the most negatively correlated month, whereas in NPA July is down the list at 5th most negatively correlated. In SPP the next most negatively correlated months are December, January, and April, all these monthly comparisons using 40% penetration results.
- The most positively correlated month in SPP is May, the same as in NPA.

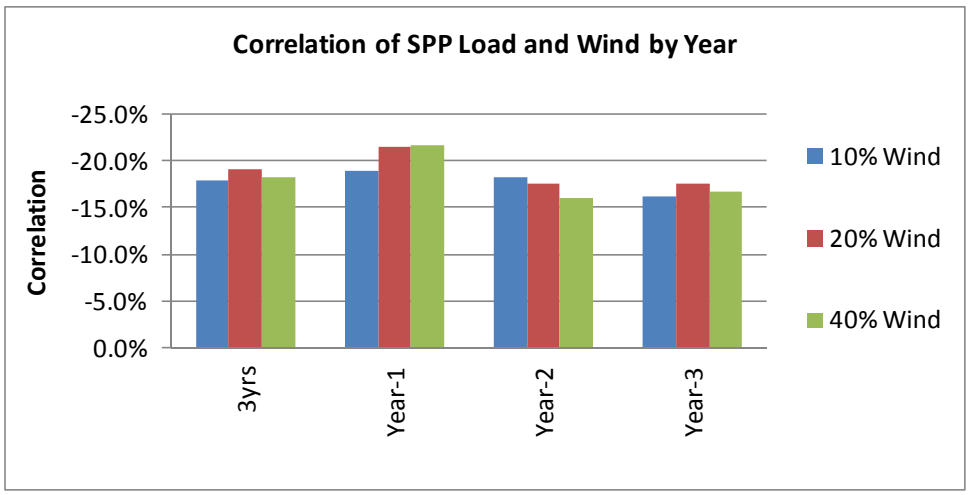

Figure 90: SPP Load and Wind Correlation by Year

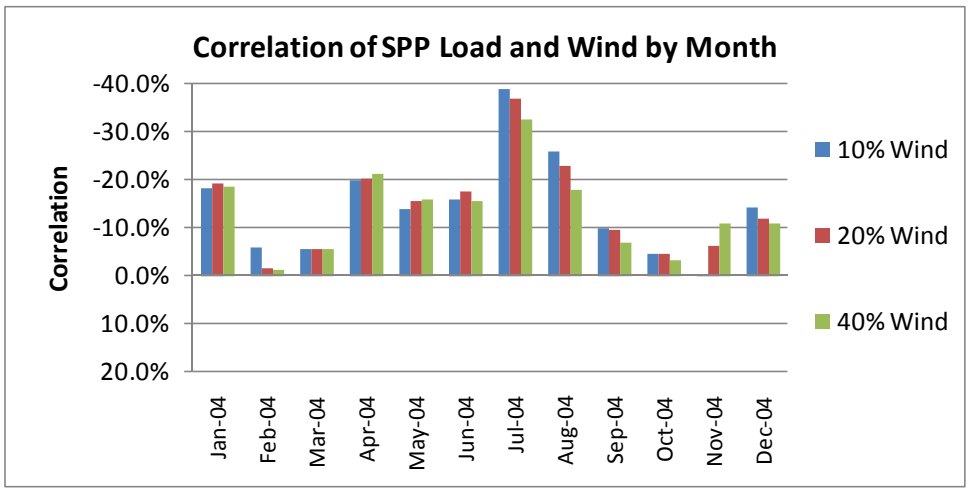

Figure 91: SPP 2004 Load and Wind Correlation by Month

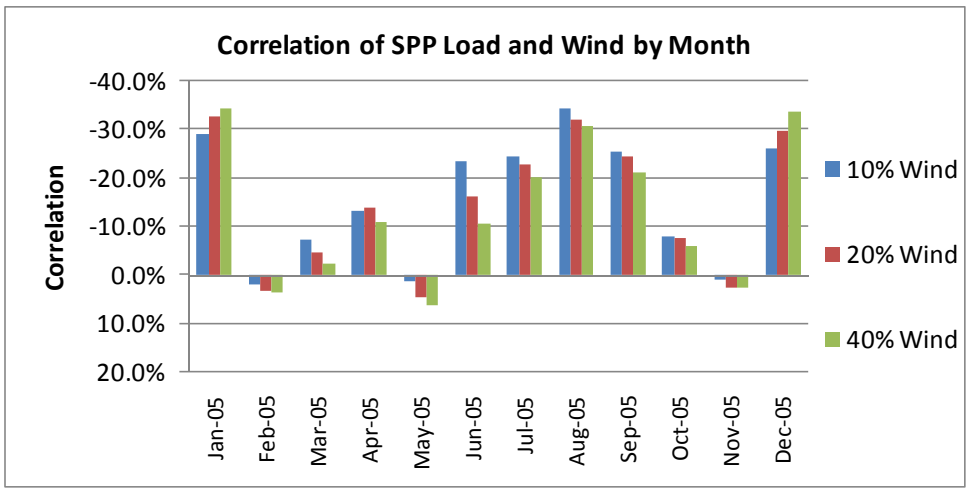

Figure 92: SPP 2005 Load and Wind Correlation by Month

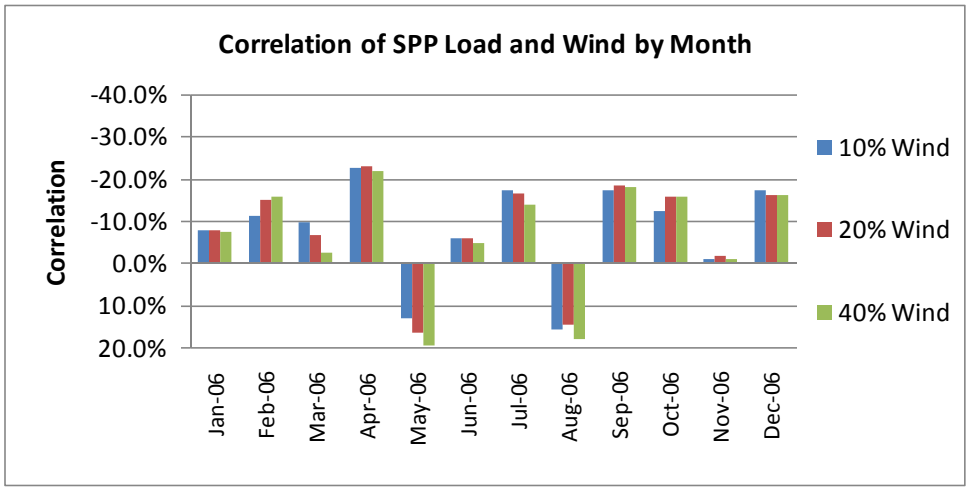

Figure 93: SPP 2006 Load and Wind Correlation by Month

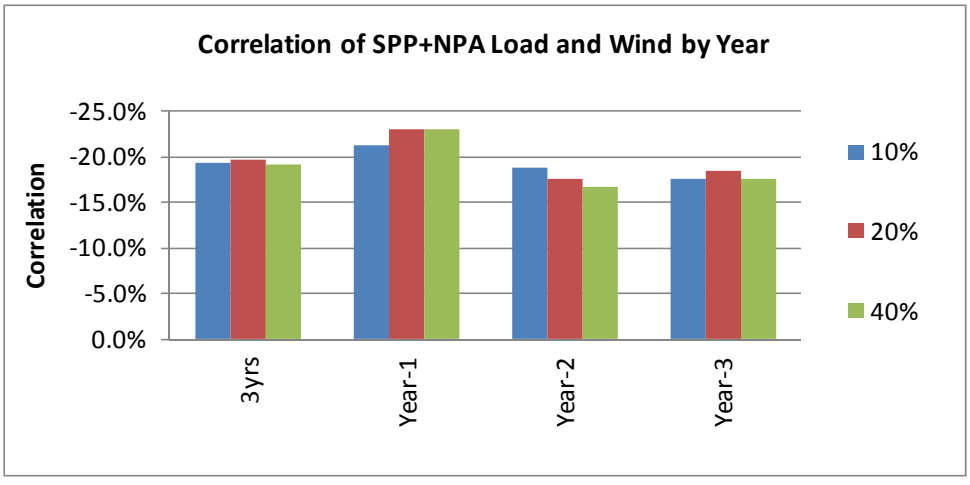

Figure 94: SPP with NPA Load and Wind Correlation by Year

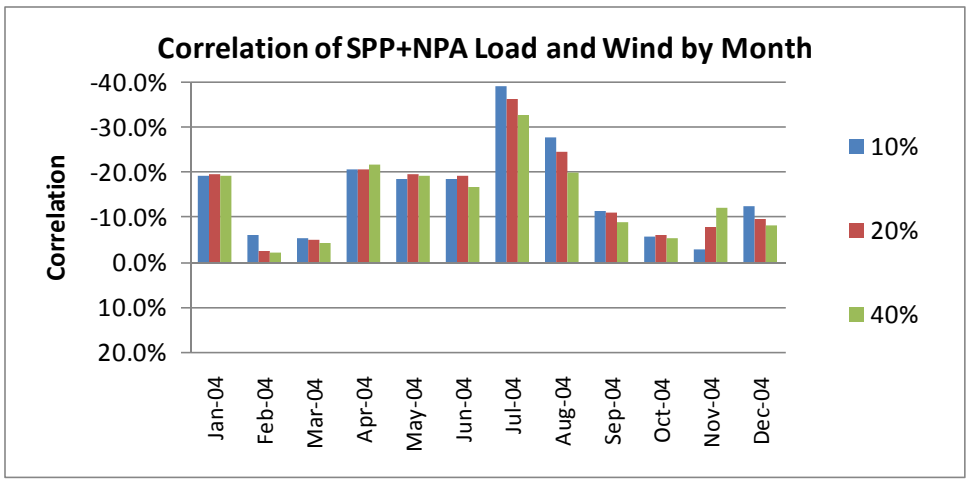

Figure 95: SPP with NPA 2004 Load and Wind Correlation by Month

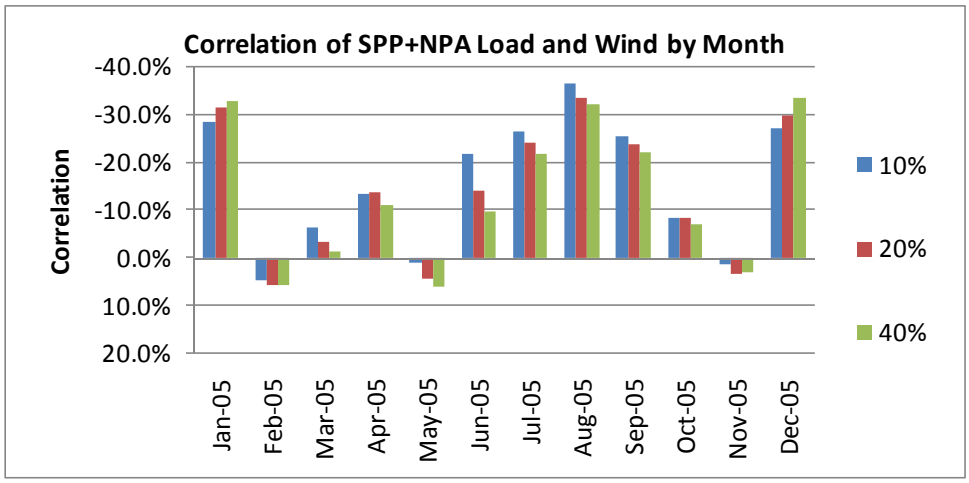

Figure 96: SPP with NPA 2005 Load and Wind Correlation by Month

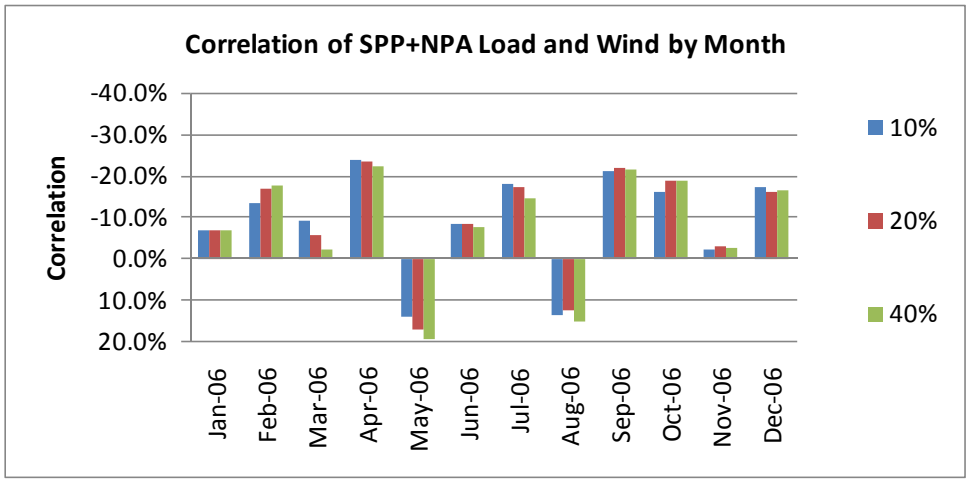

Figure 97: SPP and NPA 2006 Load and Wind Correlation by Month

Section 8.2.3.6 NPA and WAPA Load and Wind Forecast Analysis

The Mean Absolute Error (MAE) for actual wind and day ahead wind forecast was calculated for Nebraska stand alone, WAPA stand alone and for Nebraska and WAPA with combined data. Figure 98- Figure 100 provide MAE analysis for Nebraska at wind penetrations of 10%, 1249 MW nameplate, 20%, 2488 MW nameplate, and 40%, 4727 MW nameplate for each of the three years. The MAE generally reduces some with penetration showing the benefit of aggregation, although much of the aggregation benefit is achieved at the 10% penetration level. Typically at single sites the MAE for the day ahead forecast is at least 15%.

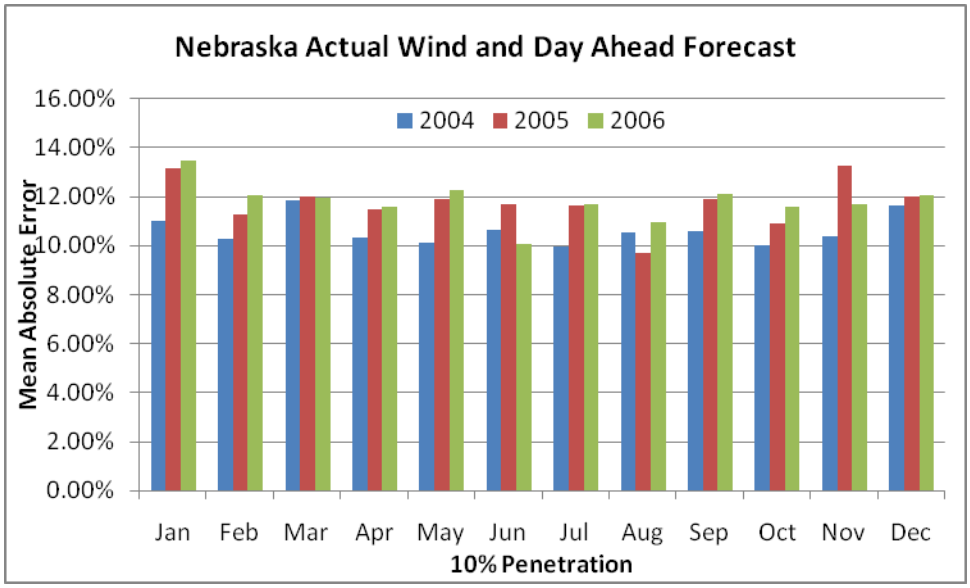

Figure 98: Nebraska Actual Wind and Day Ahead Forecast MAE for 10% Penetration

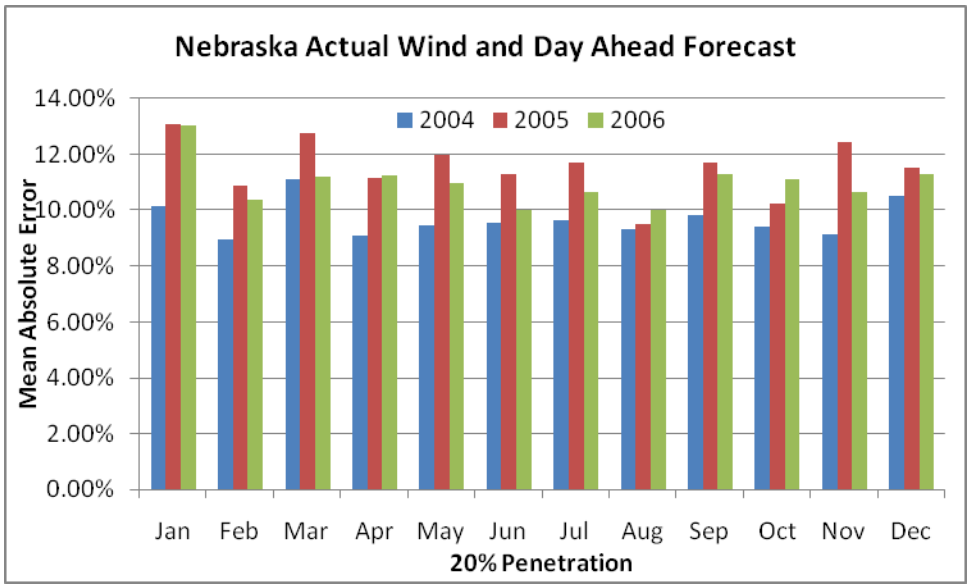

Figure 99: Nebraska Actual Wind and Day Ahead Forecast MAE for 20% Penetration

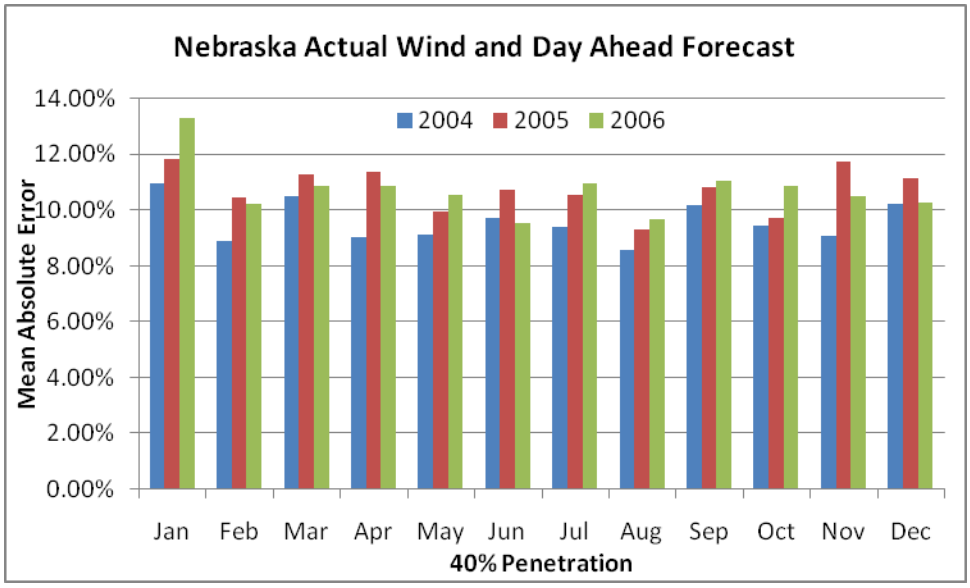

Figure 100: Nebraska Actual Wind and Day Ahead Forecast MAE for 40% Penetration

Figure 101 shows the MAE for Nebraska 2018 Load using a 1 hour persistence forecast. Study profile years for 2004, 2005 and 2006 loads were escalated to the study year, 2018.

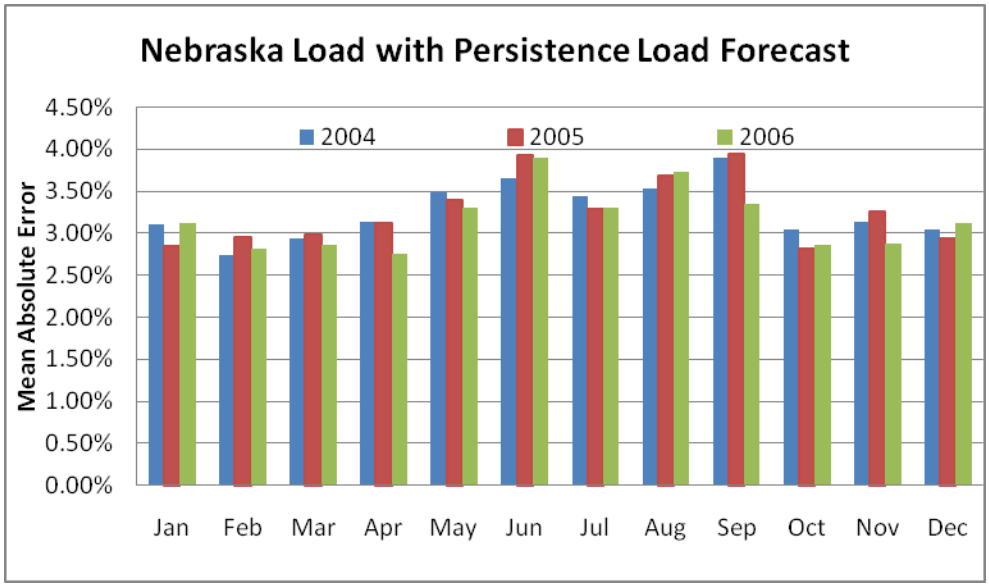

Figure 101: MAE of Nebraska Load with Persistence Forecast

For this study the WAPA wind and load remain constant. Figure 102 shows the wind MAE for each study scenario. Figure 102 shows the MAE for actual wind and day ahead forecast and Figure 103 shows the MAE of the persistence forecast for WAPA wind generation.

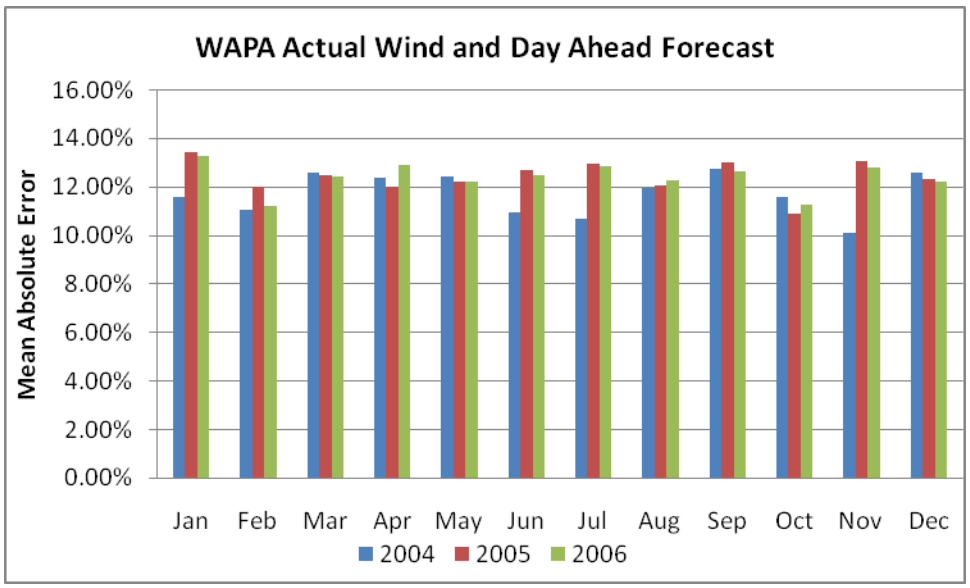

Figure 102: WAPA Actual Wind and Day Ahead Forecast MAE

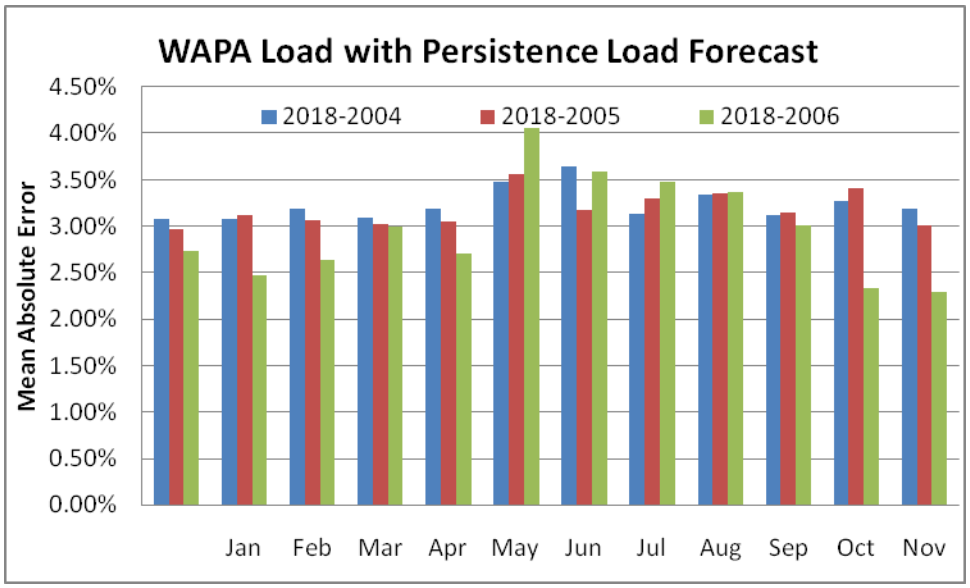

Figure 103: WAPA Load with 1 hr. Persistence Forecast MAE

Figure 104, Figure 105, and Figure 106 show the MAE for combined Nebraska and WAPA actual and day ahead forecast wind with penetration levels and Figure 107 shows the MAE for the persistence forecast for combined Nebraska and WAPA wind generation. The purpose of this investigation of Nebraska/WAPA diversification was to see how much combining the two wind generations from different locations and associated forecasts would reduce MAE. Looking at the MAE results for the day-ahead forecasts for Nebraska 10% (Figure 98) indicates approximately 11.35% MAE and similarly for WAPA (Figure 102) yields 12.26% MAE. In the

combined case (Figure 104) the day-ahead MAE is reduced to 10.89% indicating that some diversity benefits would exist in coordinating Nebraska and WAPA wind generation through forecast reduction.

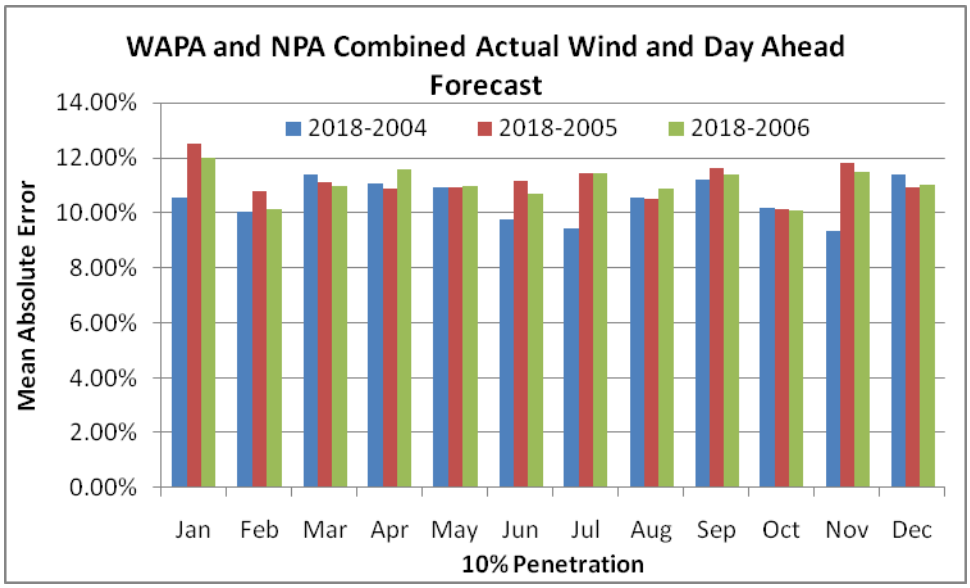

Figure 104: Nebraska and WAPA Actual Wind and Day Ahead Forecast MAE for 10% Penetration

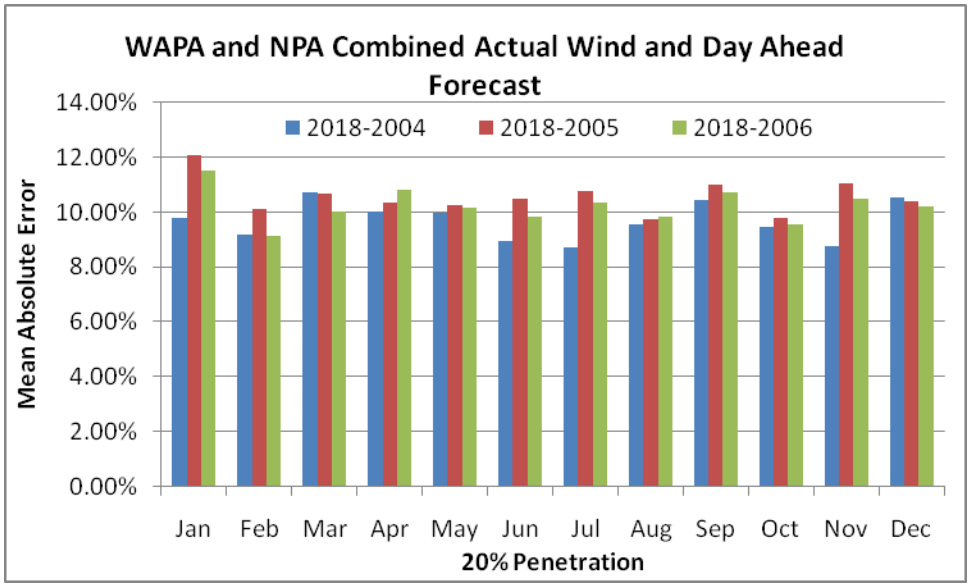

Figure 105: Nebraska and WAPA Actual Wind and Day Ahead Forecast MAE for 20% Penetration

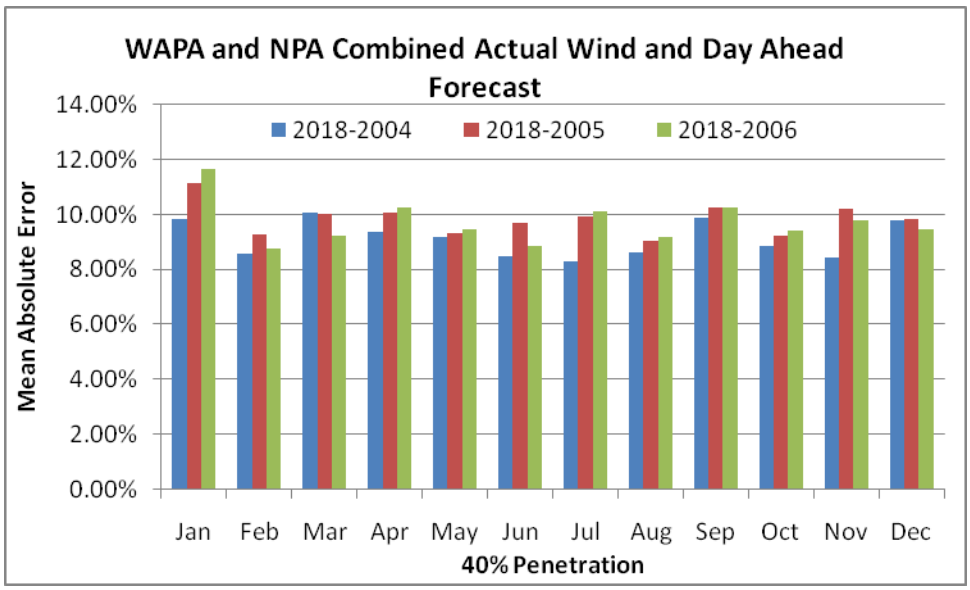

Figure 106: Nebraska and WAPA Actual Wind and Day Ahead Forecast MAE for 40% Penetration

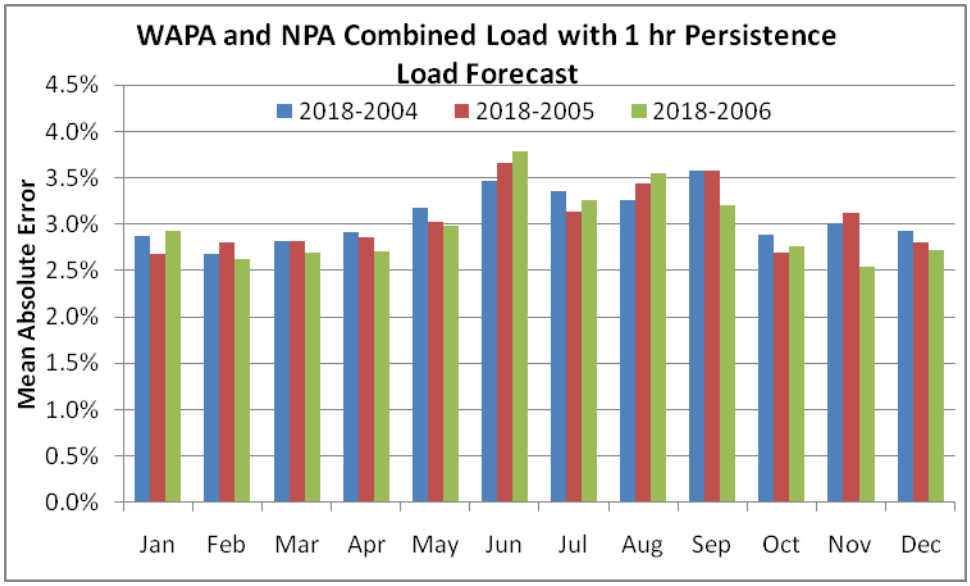

Figure 107: Nebraska and WAPA Load with 1 hr Persistence Forecast MAE

Section 8.2.4 Operational Considerations

The wind generation's variability and uncertainty, as described in earlier tables and charts, affect unit commitment decisions and increase the amount of regulating reserves required. Additionally, the thermal units are required to respond to the wind generation by ramping up and down to adjust to the wind generation output. In this section some of these operational considerations are described.

Section 8.2.4.1 Ramp analysis

The morning ramp-up and night ramp-down rates were examined for Nebraska. The analysis used the Nebraska 20% wind penetration case and focused on monthly and seasonal aggregated data as follows:

Monthly NPA (average, maximum, minimum, 98th percentile)

Figure 108 - Figure 111 morning ramp-up -- 2004

Figure 112 - Figure 115 morning ramp-up -- 2005

Figure 116 - Figure 119 morning ramp-up -- 2006

Seasonal NPA (maximum, minimum, 98th percentile)

Figure 120 - Figure 122 morning ramp-up -- 2004

Figure 123 - Figure 125 morning ramp-up -- 2005

Figure 126 - Figure 128 morning ramp-up -- 2006

Monthly NPA (average, maximum, minimum, 98th percentile)

Figure 129 - Figure 132 evening ramp-down -- 2004

Figure 133 - Figure 136 evening ramp-down -- 2005

Figure 137 - Figure 140 evening ramp-down -- 2006

Seasonal NPA (maximum, minimum, 98th percentile)

Figure 141 - Figure 143 evening ramp-down -- 2004

Figure 144 - Figure 146 evening ramp-down -- 2005

Figure 147 - Figure 149 evening ramp-down -- 2006

	NPA Average Hourly MW Change 2018 - 2004 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	85	73	237	241	410	426	294	290	10	20	11	49	-2	19
Feb	69	88	217	224	401	422	231	223	5	32	-16	31	-28	6
Mar	66	40	219	211	370	367	237	244	68	111	24	66	16	35
Apr	48	65	188	185	362	399	270	280	113	130	65	131	51	119
May	19	76	124	102	235	256	288	330	189	223	155	214	126	179
Jun	1	36	129	108	201	181	342	413	293	344	218	268	201	236
Jul	-38	-3	112	134	194	200	333	500	347	452	289	347	250	298
Aug	-14	-5	156	170	323	370	264	400	259	374	232	337	226	255
Sep	2	-15	157	179	378	429	245	350	156	198	184	285	171	237
Oct	49	48	198	206	398	425	331	413	45	64	52	70	53	139
Nov	70	64	222	217	389	419	268	338	27	53	8	18	4	74
Dec	33	5	213	173	342	318	300	379	7	6	23	29	-10	15

Figure 108: 2004 Profile Monthly Average Hourly MW Change for Hours 5 to 11

	NPA Maximum Hourly Ramp-up MW Change 2018 - 2004 Profile													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	219	310	362	539	623	728	428	846	264	299	267	385	163	258
Feb	155	334	402	501	614	746	361	552	120	390	100	442	52	250
Mar	148	277	314	471	584	663	340	749	281	429	237	404	116	256
Apr	116	493	282	542	510	780	414	786	331	382	187	293	153	308
May	101	532	208	389	426	507	407	746	344	507	323	675	265	600
Jun	93	458	207	390	380	570	620	992	474	670	358	436	317	569
Jul	63	322	246	444	424	595	583	962	565	733	520	646	415	743
Aug	63	292	274	593	533	640	371	937	444	696	420	629	318	528
Sep	132	198	276	450	599	693	421	845	352	613	449	509	356	497
Oct	123	294	305	387	524	723	438	860	200	351	178	365	121	414
Nov	141	336	307	479	556	733	397	797	200	370	129	250	101	339
Dec	145	242	655	426	539	710	489	859	131	381	265	450	148	405

Figure 109: 2004 Profile Monthly Maximum Hourly MW Change for Hours 5 to 11

	NPA Minimum Hourly Ramp-up MW Change 2018 - 2004 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-22	-121	89	23	117	52	100	-212	-166	-255	-110	-156	-80	-335
Feb	-31	-88	20	-19	177	171	120	-65	-132	-324	-116	-164	-87	-258
Mar	-79	-304	55	23	27	-104	71	-221	-94	-192	-69	-325	-83	-406
Apr	-62	-247	23	-96	67	4	66	-111	-38	-128	-63	-164	-48	-79
May	-75	-226	-17	-228	-36	-205	68	-174	31	-66	20	-180	-21	-208
Jun	-56	-202	15	-312	-41	-138	129	2	178	-141	73	71	50	73
Jul	-163	-282	-16	-182	-125	-425	67	-2	134	185	89	45	83	-10
Aug	-96	-241	-1	-43	8	-3	35	-110	64	124	62	-8	74	-107
Sep	-129	-335	-11	-133	16	20	-13	-46	-26	-202	11	-235	31	-197
Oct	-36	-145	-20	-143	117	82	59	113	-34	-184	-36	-175	-41	-92
Nov	10	-223	86	-132	123	118	83	-54	-148	-206	-127	-343	-83	-156
Dec	-929	-1101	51	-127	131	29	153	43	-343	-327	-143	-295	-86	-307

Figure 110: 2004 Profile Monthly Minimum Hourly MW Change for Hours 5 to 11

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2004 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	191.7	275.8	356.7	503.1	622.4	722.2	419.7	642.3	253.7	267.3	221.5	365.4	122.9	243.8
Feb	134.1	312.5	348.9	475	595.2	703.5	333.9	484.8	113.6	312.5	96.78	336.9	38.07	221.6
Mar	146.5	269	305.9	439.2	568.7	619.9	337.5	645.1	246.8	358.1	175.7	350.9	99.9	246
Apr	109	371.6	280.4	460.8	504.3	684	408.4	770.4	313.6	374.8	186.4	292.4	141.7	286.5
May	94.52	482.3	206.6	314.6	401.5	486	400.6	713.3	326.5	444.1	302.3	574.9	242.6	499.6
Jun	80.76	432.6	206.4	370.7	354	533.2	550.3	854.3	459.9	655.7	340.7	431.8	305	495.5
Jul	62.18	281.2	236.6	409.9	388	547.4	566.8	890.9	540.2	700.1	490.2	619.1	392.8	604.5
Aug	54.22	269.9	260.6	539.7	512.4	637.4	364.1	827.8	391.2	675.9	361.6	592.5	316.8	502.6
Sep	106.7	185.8	275.1	436.3	586.6	683.4	408.9	690.7	352.1	605.2	415.5	503.3	335.5	482.8
Oct	112.8	246.3	295.6	365.9	523	695.6	437.1	844.3	168	320.4	172.8	299.4	119.9	405
Nov	133.6	289.6	306.3	456.4	544.2	715.1	389	784.5	187.7	315.4	123	225.2	75.08	330
Dec	135.1	231.7	447.2	381.5	528.3	628.4	478.7	825.5	128	329.5	250	394.9	101.6	378.3

Figure 111: 2004 Profile Monthly 98 Percentile Hourly MW Change for Hours 5 to 11

	NPA Average Hourly MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	66	39	196	152	388	346	320	327	-7	9	5	-12	-9	16
Feb	84	78	260	240	423	417	246	262	23	32	6	-13	-14	-21
Mar	59	34	209	169	375	371	244	291	59	74	9	-12	4	40
Apr	50	61	203	223	375	421	276	333	105	134	63	125	46	95
May	23	-10	159	149	240	224	282	320	182	225	136	179	111	160
Jun	-15	-1	93	87	173	151	323	404	301	358	263	313	221	241
Jul	-41	-20	65	82	137	163	289	447	340	514	285	372	227	296
Aug	-21	-25	136	176	302	378	252	398	279	456	261	342	241	266
Sep	-2	-18	150	146	342	357	238	335	152	242	183	256	192	282
Oct	50	59	203	209	385	397	264	300	37	71	34	68	39	113
Nov	78	33	238	233	431	413	215	276	71	96	17	-9	29	90
Dec	69	56	203	180	342	329	255	289	22	51	8	-5	-14	-30

Figure 112: 2005 Profile Monthly Average Hourly MW Change for Hours 5 to 11

	NPA Maximum Hourly Ramp-up MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	143	458	288	590	552	687	451	791	159	297	146	261	98	331
Feb	142	305	399	506	655	738	338	655	264	490	254	405	96	314
Mar	147	251	335	416	561	649	402	558	222	405	128	321	110	397
Apr	179	277	327	496	647	730	427	769	235	410	225	420	134	390
May	112	341	294	363	393	409	416	598	307	490	253	442	214	418
Jun	92	360	195	543	301	664	518	750	426	783	424	673	353	662
Jul	34	392	185	406	262	533	428	926	482	933	438	761	374	931
Aug	138	189	365	507	612	781	419	694	521	916	538	829	443	793
Sep	85	242	273	443	575	680	395	545	400	700	418	516	391	550
Oct	131	332	364	408	564	751	385	854	201	329	193	509	96	516
Nov	217	239	345	546	628	939	364	733	460	442	212	317	152	306
Dec	139	348	314	430	552	602	357	905	184	595	155	350	90	235

Figure 113: 2005 Profile Monthly Maximum Hourly MW Change for Hours 5 to 11

	NPA Minimum Hourly Ramp-up MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	1	-239	15	-222	106	40	127	-111	-133	-376	-119	-318	-114	-203
Feb	-35	-282	120	-104	179	23	137	-91	-95	-211	-101	-496	-80	-314
Mar	-11	-326	55	-254	76	-54	54	-111	-131	-148	-128	-374	-58	-389
Apr	-78	-171	43	-105	1	-146	47	-179	-36	-218	-7	-352	-94	-117
May	-91	-533	-4	-116	-67	-100	78	-37	1	-299	-39	-243	19	-111
Jun	-113	-332	-49	-299	-130	-130	113	-103	158	-216	116	27	95	-58
Jul	-141	-367	-92	-368	-143	-337	98	-22	73	204	28	-100	-11	-25
Aug	-134	-343	-69	-170	-63	-145	37	-71	126	91	85	-13	119	20
Sep	-103	-299	-54	-348	-10	-247	17	-50	-39	-124	-12	-120	-32	-62
Oct	-62	-144	11	-129	113	93	110	-11	-55	-140	-59	-202	-53	-399
Nov	5	-322	83	-88	167	126	-490	-521	-79	-271	-112	-460	-52	-258
Dec	15	-174	68	-152	155	-103	105	-9	-114	-263	-134	-286	-110	-364

Figure 114: 2005 Profile Monthly Minimum Hourly MW Change for Hours 5 to 11

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	135.4	361.1	280.9	463.9	524.3	616.2	440	639.8	141.5	281.2	144	253.5	89.76	322.7
Feb	138.9	297.4	387.3	495	627.2	715.6	334	582.1	257.2	405.2	238.3	367.9	93.15	290.1
Mar	122.6	197.6	333.3	395.8	558.5	634.5	394.9	537.5	211.9	354.9	119.7	266.7	97.9	344.4
Apr	138.2	265.9	319.5	465.8	619.6	724.2	418.9	690.7	231.2	402.6	185.1	362.6	123.8	315
May	101	254	282.6	348.3	392.2	399.2	414.6	571.4	294.4	461	241.1	431.5	201.6	399.1
Jun	67.03	276.4	193.8	478.9	297.1	570	509.9	719.6	420.1	777.9	423.5	622.9	344.1	611.4
Jul	31.66	334.1	163.5	322	258.6	470.7	409	850.8	469.8	873.1	432.4	707.4	359.5	701.4
Aug	104.5	179.6	303.8	495.2	580.7	754.2	407.3	684.6	494.1	782	497.9	793	419.6	612.6
Sep	80.26	224.2	271.5	442.3	561.5	643.3	374	540.4	381.9	623.9	392.7	502.6	368.1	494.8
Oct	119.8	264.1	337.3	368.6	546.1	663.1	370	685.5	199.1	307.3	162.2	376.9	95.56	498.8
Nov	192.3	229.5	339.9	474.3	618.2	832.6	351.4	592.6	335.2	376.9	196.3	316.6	140.1	294.9
Dec	136.8	315.6	309.4	391	538	586.7	356.4	682.8	172	430.3	142.5	278.7	82.86	232.9

Figure 115: 2005 Profile Monthly 98 Percentile Hourly MW Change for Hours 5 to 11

	NPA Average Hourly MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	66	73	211	204	430	445	364	396	-42	-48	-34	-73	-11	14
Feb	85	80	259	253	423	424	213	230	-7	-9	-15	-29	-22	6
Mar	71	43	219	204	348	344	208	214	63	75	14	-1	6	27
Apr	39	64	165	191	334	319	218	286	109	173	58	86	65	98
May	22	-24	120	80	212	218	272	272	181	216	127	168	123	187
Jun	-23	-28	83	49	159	160	280	423	270	406	234	275	248	242
Jul	-39	-56	67	62	142	162	292	437	321	501	283	387	219	289
Aug	-16	-8	157	195	330	354	262	365	270	380	250	341	239	281
Sep	28	36	153	166	373	394	231	311	136	199	135	300	136	202
Oct	49	31	199	198	394	412	264	344	31	45	33	19	37	119
Nov	72	69	220	213	375	413	205	245	31	55	-4	42	-2	48
Dec	76	116	197	214	364	384	269	269	10	48	5	34	-7	59

Figure 116: 2006 Profile Monthly Average Hourly MW Change for Hours 5 to 11

	NPA Maximum Hourly Ramp-up MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	136	434	315	533	625	699	511	1113	196	346	157	242	113	224
Feb	161	355	395	651	643	866	349	721	170	398	116	188	71	240
Mar	134	272	314	610	592	676	358	673	247	388	165	356	81	308
Apr	109	400	265	511	494	659	388	606	283	485	190	442	174	514
May	81	335	226	489	374	582	397	674	367	728	329	395	275	522
Jun	60	219	158	271	302	521	411	886	374	625	374	490	442	602
Jul	31	344	187	241	310	367	436	801	474	801	502	696	439	664
Aug	87	255	405	434	632	741	402	670	419	787	421	639	340	941
Sep	99	238	267	450	586	659	398	661	352	523	393	674	328	583
Oct	133	440	291	472	535	676	407	572	191	302	206	318	151	573
Nov	146	390	334	463	547	738	304	640	236	412	155	424	94	442
Dec	160	398	319	450	530	699	395	495	140	350	195	473	107	322

Figure 117: 2006 Profile Monthly Maximum Hourly MW Change for Hours 5 to 11

	NPA Minimum Hourly Ramp-up MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-17	-333	24	-214	105	-167	123	-84	-254	-373	-224	-463	-116	-309
Feb	-21	-73	55	32	119	16	73	-410	-116	-420	-112	-307	-94	-182
Mar	-39	-138	59	-22	57	-11	98	-4	-97	-366	-155	-264	-56	-238
Apr	-41	-364	17	-156	51	13	77	-161	-48	-259	-56	-280	-55	-462
May	-89	-439	-80	-320	-103	-229	96	-24	75	-206	9	-95	34	-46
Jun	-97	-293	-76	-138	-54	-223	15	68	167	70	-27	-110	74	-206
Jul	-138	-391	-65	-303	-146	-355	111	-64	-23	135	59	-83	-38	23
Aug	-111	-308	-76	-206	-43	-163	58	110	108	120	78	108	93	12
Sep	-150	-177	-8	-159	2	5	-12	-314	-15	-129	6	-70	40	-74
Oct	-126	-296	26	-114	68	-14	64	-46	-75	-370	-59	-402	-31	-264
Nov	3	-366	67	-41	146	38	46	-119	-106	-194	-161	-235	-108	-429
Dec	-65	-172	31	-54	120	-66	147	-242	-139	-262	-141	-541	-106	-235

Figure 118: 2006 Profile Monthly Minimum Hourly MW Change for Hours 5 to 11

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	127.1	382.5	307.1	477.6	607.8	696.8	502.8	946.1	177.1	325.4	155.2	216.4	92	221.1
Feb	156.7	360.2	394.2	605.7	634.3	765	348.5	601.6	158.6	314.6	97.17	175.2	58.09	216.8
Mar	125.6	231	311.7	546.6	553.1	634.3	322.4	577.4	241.7	376.6	156.5	299.1	75.58	292.1
Apr	105.5	356.5	255.9	507.3	485.3	627.8	358.8	606	255.5	480.8	185.6	426.3	158.3	396.6
May	79.54	292.1	218.3	400.3	373.9	544.5	396.3	636.3	356	579.8	283.5	354.4	250.2	518.4
Jun	34.36	198.5	158	221.5	283	468.5	398.5	857	363.7	624.7	348.7	483.3	402.7	556.7
Jul	22.9	311.2	180.9	228.4	309.6	352	429.4	768.3	472.6	775.6	470.8	675.6	401.2	561.4
Aug	81.6	211.8	345	430.5	605	698.1	388.9	623.3	412.7	712.3	399.6	609.9	327	659.9
Sep	94.53	223.9	258.3	418.1	577.5	642.9	381.6	626.6	318.9	476.5	313.2	658.6	276.9	527.9
Oct	119.3	332.4	284.5	447.1	533.1	667.9	398.3	568.6	179.7	255.7	194.9	294.4	128.9	471.7
Nov	137.6	328.5	323.2	456.9	534.3	714.1	301.2	581.1	210.8	400.4	123.7	404.6	72.55	390.8
Dec	155.1	314.1	309.6	438.4	530.3	643.2	377.1	493.8	136.7	341.1	167.1	415.9	93.82	302.6

Figure 119: 2006 Profile Monthly 98 Percentile Hourly MW Change for Hours 5 to 11

	NPA Maximum Hourly Ramp-up MW Change 2018 - 2004 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	219	334	655	539	623	746	489	859	264	390	267	450	163	405
Spring	148	532	314	542	584	780	414	786	344	507	323	675	265	600
Summer	93	458	274	593	533	640	620	992	565	733	520	646	415	743
Fall	141	336	307	479	599	733	438	860	352	613	449	509	356	497
Year	219	532	655	593	623	780	620	992	565	733	520	675	415	743

Figure 120: 2004 Profile Seasonal Maximum Hourly MW Change for Hours 5 to 11

	NPA Minimum Hourly Ramp-up MW Change 2018 - 2004 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-929	-1101	20	-127	117	29	100	-212	-343	-327	-143	-295	-87	-335
Spring	-79	-304	-17	-228	-36	-205	66	-221	-94	-192	-69	-325	-83	-406
Summer	-163	-282	-16	-312	-125	-425	35	-110	64	-141	62	-8	50	-107
Fall	-129	-335	-20	-143	16	20	-13	-54	-148	-206	-127	-343	-83	-197
Year	-929	-1101	-20	-312	-125	-425	-13	-221	-343	-327	-143	-343	-87	-406

Figure 121: 2004 Profile Seasonal Minimum Hourly MW Change for Hours 5 to 11

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2004 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	159	298	371	484	616	721	437	813	167	317	246	398	108	280
Spring	124	466	292	439	519	634	406	759	321	413	288	498	224	416
Summer	65	339	247	455	497	603	561	942	510	681	429	606	370	536
Fall	129	264	305	442	568	706	435	836	333	515	373	482	299	453
Year	141	333	323	466	583	700	478	841	444	627	388	529	322	471

Figure 122: 2004 Profile Seasonal 98 Percentile Hourly MW Change for Hours 5 to 11

	NPA Maximum Hourly Ramp-up MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	143	458	399	590	655	738	451	905	264	595	254	405	98	331
Spring	179	341	335	496	647	730	427	769	307	490	253	442	214	418
Summer	138	392	365	543	612	781	518	926	521	933	538	829	443	931
Fall	217	332	364	546	628	939	395	854	460	700	418	516	391	550
Year	217	458	399	590	655	939	518	926	521	933	538	829	443	931

Figure 123: 2005 Profile Seasonal Maximum Hourly MW Change for Hours 5 to 11

	NPA Minimum Hourly Ramp-up MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-35	-282	15	-222	106	-103	105	-111	-133	-376	-134	-496	-114	-364
Spring	-91	-533	-4	-254	-67	-146	47	-179	-131	-299	-128	-374	-94	-389
Summer	-141	-367	-92	-368	-143	-337	37	-103	73	-216	28	-100	-11	-58
Fall	-103	-322	-54	-348	-10	-247	-490	-521	-79	-271	-112	-460	-53	-399
Year	-141	-533	-92	-368	-143	-337	-490	-521	-133	-376	-134	-496	-114	-399

Figure 124: 2005 Profile Seasonal Minimum Hourly MW Change for Hours 5 to 11

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2005 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	140	315	368	490	582	689	425	685	234	367	170	339	92	315
Spring	126	277	327	444	600	720	415	634	263	430	226	423	188	388
Summer	84	307	260	491	519	720	499	759	477	848	467	763	379	686
Fall	140	240	338	442	611	752	368	605	375	561	367	496	346	493
Year	137	296	350	480	596	719	430	724	431	715	424	584	349	492

Figure 125: 2005 Profile Seasonal 98 Percentile Hourly MW Change for Hours 5 to 11

	Nebraska Maximum Hourly Ramp-up MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	161	434	395	651	643	866	511	**1113**	196	398	195	473	113	**322**
Spring	134	400	314	610	592	676	397	674	367	728	329	442	275	522
Summer	87	344	405	434	632	741	436	886	474	801	502	696	442	941
Fall	146	440	334	472	586	738	407	661	352	523	393	674	328	583
Year	161	440	405	651	643	866	511	**1113**	474	801	502	696	442	941

Figure 126: 2006 Profile Seasonal Maximum Hourly MW Change for Hours 5 to 11

	NPA Minimum Hourly Ramp-up MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-65	-333	24	-214	105	-167	73	-410	-254	-420	-224	-541	-116	-309
Spring	-89	-439	-80	-320	-103	-229	77	-161	-97	-366	-155	-280	-56	-462
Summer	-138	-391	-76	-303	-146	-355	15	-64	-23	70	-27	-110	-38	-206
Fall	-150	-366	-8	-159	2	-14	-12	-314	-106	-370	-161	-402	-108	-429
Year	-150	-439	-80	-320	-146	-355	-12	-410	-254	-420	-224	-541	-116	-462

Figure 127: 2006 Profile Seasonal Minimum Hourly MW Change for Hours 5 to 11

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2006 Profile 20% Wind													
	Hr 5		Hr 6		Hr 7		Hr 8		Hr 9		Hr 10		Hr 11	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	155	374	376	541	626	699	496	759	165	347	155	375	90	285
Spring	112	324	294	507	514	628	388	636	293	483	208	415	228	515
Summer	72	267	299	390	550	633	413	807	464	764	427	654	387	613
Fall	132	308	314	455	558	680	394	609	248	440	229	630	233	505
Year	146	364	343	484	586	690	456	725	405	634	382	623	345	516

Figure 128: 2006 Profile Seasonal 98 Percentile Hourly MW Change for Hours 5 to 11

The following tables show the results of the down-ramp for hours 21 through hour 3.

	NPA Average Hourly MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-64	-78	-139	-184	-260	-286	-337	-396	-204	-236	-98	-121	-36	-32
Feb	-70	-118	-130	-162	-257	-281	-308	-343	-185	-195	-81	-96	-30	-34
Mar	-43	-25	-110	-149	-285	-276	-319	-313	-192	-226	-91	-119	-42	-66
Apr	166	113	-204	-49	-307	-354	-372	-424	-225	-221	-110	-115	-57	-57
May	-42	-99	-157	56	-287	-292	-391	-420	-278	-351	-150	-188	-99	-146
Jun	-128	-92	-157	-40	-252	-306	-455	-506	-339	-322	-222	-228	-129	-132
Jul	-136	-170	-104	-161	-267	-372	-441	-533	-378	-400	-281	-306	-194	-151
Aug	-59	-143	-119	-180	-403	-533	-467	-517	-382	-411	-243	-268	-159	-143
Sep	17	-92	-76	-297	-365	-440	-423	-484	-310	-305	-198	-210	-122	-118
Oct	-64	-79	-97	-215	-283	-372	-320	-394	-226	-258	-109	-132	-55	-58
Nov	-91	-135	-192	-259	-287	-355	-312	-393	-201	-259	-94	-126	-33	-89
Dec	-56	-124	-217	-182	-243	-296	-326	-373	-234	-290	-91	-149	-39	-98

Figure 129: 2004 Profile Monthly Average Hourly MW Change for Hours 21 to 3

	NPA Maximum Hourly Ramp-down MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-133	-408	-193	-693	-346	-536	-461	-965	-335	-582	-154	-523	-183	-290
Feb	-115	-388	-185	-481	-334	-718	-413	-755	-238	-496	-143	-337	-103	-182
Mar	-142	-319	-217	-571	-393	-669	-419	-696	-316	-543	-174	-640	-107	-335
Apr	5.4	-308	-117	-425	-421	-652	-686	-847	-406	-456	-257	-417	-114	-398
May	-243	-423	-234	-473	-419	-833	-482	-759	-677	-621	-252	-549	-526	-414
Jun	-299	-391	-200	-503	-385	-775	-601	-798	-476	-550	-399	-430	-204	-443
Jul	-330	-375	-255	-515	-511	-746	-577	-815	-515	-843	-376	-769	-323	-413
Aug	-167	-465	-210	-499	-565	-980	-564	-898	-458	-732	-315	-511	-221	-421
Sep	-92.8	-354	-276	-824	-468	-1016	-539	-900	-446	-588	-282	-439	-229	-289
Oct	-161	-300	-222	-479	-380	-635	-417	-814	-351	-787	-198	-408	-148	-431
Nov	-179	-365	-246	-635	-374	-603	-423	-674	-260	-541	-148	-403	-68.3	-474
Dec	-129	-469	-212	-541	-333	-635	-439	-774	-398	-765	-156	-576	-96.7	-290

Figure 130: 2004 Profile Monthly Maximum Hourly MW Change for Hours 21 to 3

	NPA Minimum Hourly Ramp-down MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	311.6	358.3	-82.5	88.95	-136	-51.4	-248	-72.9	-90.5	-73.8	-10.4	159.4	37.2	249.6
Feb	-34.8	322.6	-47.9	106.5	-148	-109	-203	-47.2	-124	-9.62	13.1	118	40.5	76.32
Mar	30.3	254.4	-59.8	335.6	-130	23.02	-226	111.5	-96.6	71.53	-25.9	119.2	0.6	183.4
Apr	326	424.7	122.3	470.1	-171	81.73	-216	204.5	217.2	206	32.6	209.1	21.3	281.3
May	80.1	273.7	151.6	696.3	-111	181	-224	3.267	-158	-131	-81.4	-14.3	-25	185.8
Jun	94	428.3	179	270.8	-78.9	79.3	-322	-65.9	-26.7	104	-107	71.63	-30.6	117.6
Jul	-6.9	242	122.8	169.5	-131	59	-234	-271	-156	-26.4	-163	-25.6	-48.8	110.5
Aug	108.5	261.3	66.1	166.8	-288	-109	-240	-227	-261	-151	-137	-4.67	-80.2	132.4
Sep	81.3	281.1	-105	77.22	-229	79.32	-229	-159	-231	-82.1	-135	60.35	-20.3	81.92
Oct	28.6	354.7	-59.7	241.8	-160	3.317	-215	-117	56.8	20.8	49.6	92.62	41.5	215.6
Nov	12.9	156.8	-52.8	-78.9	-132	-111	-185	-122	-93.5	-10.1	-56	127.5	-2	139.4
Dec	248.9	339.3	-3.8	68.18	-106	-16.3	-166	-85.4	-132	7.3	4.3	127	8.3	101.8

Figure 131: 2004 Profile Monthly Minimum Hourly MW Change for Hours 21 to 3

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	129	214	-83	51	-142	-57	-249	-80	-54	-44	-21	157	25	237
Feb	-36	213	-56	58	-155	-119	-205	-107	-131	-31	-2	110	24	75
Mar	29	248	-70	269	-166	14	-234	34	-115	50	-33	118	-2	119
Apr	296	395	120	396	-180	48	-235	41	14	120	-13	133	11	249
May	71	205	142	579	-134	167	-256	-122	-161	-154	-93	-15	-29	90
Jun	60	336	137	258	-120	62	-322	-133	-108	-20	-132	14	-53	59
Jul	-17	143	113	121	-147	8	-247	-278	-241	-103	-188	-33	-78	88
Aug	91	194	53	157	-292	-185	-285	-241	-270	-157	-141	-31	-82	90
Sep	77	243	-132	45	-234	4	-253	-203	-245	-101	-144	12	-22	78
Oct	23	349	-79	211	-168	-79	-226	-132	-60	-8	12	51	24	180
Nov	-6	106	-72	-85	-141	-164	-196	-158	-117	-47	-58	118	-2	128
Dec	106	189	-12	63	-110	-47	-201	-138	-134	-38	-7	82	6	76

Figure 132: 2004 Profile Monthly 98 Percentile Hourly MW Change for Hours 21 to 3

	NPA Average Hourly MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-98	-113	-164	-190	-268	-263	-296	-267	-164	-151	-77	-68	-27	-24
Feb	-62	-96	-136	-176	-279	-271	-337	-352	-157	-150	-97	-104	-47	-78
Mar	-66	-111	-178	-217	-299	-270	-286	-239	-182	-146	-71	-68	-17	-20
Apr	167	150	-37	-32	-305	-294	-371	-420	-231	-275	-112	-120	-47	-55
May	-24	15	51	88	-262	-263	-385	-370	-293	-296	-156	-178	-99	-110
Jun	-169	-147	-52	-95	-240	-299	-446	-501	-376	-424	-247	-212	-152	-78
Jul	-156	-241	-64	-222	-237	-398	-388	-501	-383	-432	-253	-274	-178	-171
Aug	-87	-171	-99	-234	-363	-487	-456	-559	-367	-429	-257	-244	-168	-139
Sep	1	-129	-202	-343	-356	-448	-425	-499	-327	-384	-199	-214	-131	-89
Oct	-41	-122	-135	-205	-235	-298	-314	-398	-208	-225	-117	-106	-64	-35
Nov	-88	-199	-152	-288	-277	-315	-334	-435	-223	-312	-137	-199	-33	-58
Dec	-68	-96	-126	-183	-248	-263	-321	-318	-213	-208	-131	-141	-26	-46

Figure 133: 2005 Profile Monthly Average Hourly MW Change for Hours 21 to 3

	NPA Maximum Hourly Ramp-down MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-173	-300	-237	-473	-386	-805	-373	-669	-224	-488	-125	-266	-125	-256
Feb	-141	-343	-212	-550	-767	-718	-418	-761	-338	-508	-157	-378	-532	-676
Mar	-195	-494	-289	-742	-396	-749	-414	-674	-386	-454	-179	-306	-70	-248
Apr	19.1	-260	-189	-400	-449	-729	-476	-965	-356	-601	-180	-404	-128	-219
May	-201	-401	-124	-748	-422	-676	-594	-739	-443	-614	-315	-393	-167	-342
Jun	-270	-498	-151	-409	-394	-791	-547	-1137	-479	-894	-406	-555	-210	-425
Jul	-279	-595	-217	-535	-491	-806	-605	-928	-697	-768	-339	-809	-247	-425
Aug	-218	-581	-209	-635	-540	-833	-588	-980	-509	-845	-368	-582	-294	-575
Sep	-79.7	-346	-295	-793	-436	-814	-523	-794	-549	-657	-316	-539	-237	-305
Oct	-120	-471	-186	-483	-332	-575	-375	-781	-319	-620	-215	-349	-260	-244
Nov	-164	-435	-223	-636	-375	-743	-445	-966	-331	-806	-233	-644	-80.8	-477
Dec	-121	-337	-212	-584	-373	-726	-665	-725	-467	-507	-613	-728	-114	-284

Figure 134: 2005 Profile Monthly Maximum Hourly MW Change for Hours 21 to 3

	NPA Minimum Hourly Ramp-down MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-45.5	173.7	-96	151.4	-129	242.6	-218	262.3	-82.1	147.8	-28.4	104.3	23	198.1
Feb	-6.5	326.5	-82	215.3	-157	54.05	-282	-101	359.9	365.7	-23.2	170.8	55.2	136.1
Mar	46.6	226.9	-70.2	229.8	-112	230.7	-109	166.1	-73.9	70.42	6.4	160.5	54.2	234.4
Apr	299.3	559.3	118.8	415	-163	135.4	-219	1.933	-117	219.8	-32.8	114.9	26.3	142.3
May	126.7	573.3	219.8	822.4	-145	146.6	-162	271	-132	114.1	-48.4	152.2	-2.2	259.8
Jun	37.3	202.7	131.3	244.1	-131	188.4	-320	33.15	-203	-62.8	-113	22.4	-82.6	298.9
Jul	-70.1	69.35	31	75.87	-102	110.2	-200	-4.13	-271	-156	-103	114.5	-96.9	214.9
Aug	36.1	117.1	64.7	205.4	-197	7.083	-251	-70.9	141.9	212.8	-81.3	59.52	-90.6	224.9
Sep	86.4	121.3	-117	193	-234	81.72	-307	-143	-201	-131	-26.9	143.6	-16.5	277.6
Oct	33.6	75.83	-70.3	304.7	-119	158	-233	43.78	21.8	44.08	-47	81.67	30.5	209.8
Nov	-7.5	61.23	-55.1	81.18	-164	205.7	-237	47.98	-149	83.98	-57.5	80.22	29.8	180.1
Dec	4.5	163.9	-6.3	92.85	-89.6	98.65	-184	164.7	-44.3	-3.83	-2.4	71.6	262.9	272.9

Figure 135: 2005 Profile Monthly Minimum Hourly MW Change for Hours 21 to 3

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-50	113	-106	92	-136	135	-220	233	-49	103	-34	103	21	193
Feb	-23	269	-92	160	-161	33	-283	-104	295	310	-40	141	44	121
Mar	13	201	-73	196	-153	211	-151	143	-89	43	-2	112	38	169
Apr	271	432	105	371	-174	124	-246	-53	-143	69	-36	68	3	111
May	124	481	201	738	-147	138	-189	260	-159	6	-52	48	-8	146
Jun	-12	182	102	232	-152	141	-333	-39	-224	-84	-153	20	-85	189
Jul	-74	34	27	70	-107	-16	-207	-88	-274	-178	-145	21	-107	153
Aug	33	117	52	175	-199	-121	-296	-157	-121	30	-114	25	-91	210
Sep	79	111	-129	79	-240	35	-311	-166	-223	-139	-58	50	-37	258
Oct	19	74	-86	158	-143	45	-252	-83	-63	-2	-61	79	20	174
Nov	-28	52	-69	27	-176	133	-246	-17	-154	26	-62	60	29	146
Dec	-9	106	-27	65	-97	77	-194	34	-100	-20	-29	64	112	166

Figure 136: 2005 Profile Monthly 98 Percentile Hourly MW Change for Hours 21 to 3

	NPA Average Hourly MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-105	-154	-179	-279	-284	-327	-294	-310	-155	-184	-82	-130	-24	-51
Feb	-69	-59	-120	-180	-250	-344	-309	-394	-197	-269	-86	-141	-22	-56
Mar	-65	-76	-157	-197	-255	-298	-287	-317	-173	-222	-79	-99	-27	-50
Apr	127	97	-36	-78	-257	-311	-334	-352	-200	-195	-106	-72	-47	-56
May	-35	-31	15	60	-278	-208	-365	-303	-276	-266	-148	-138	-84	-99
Jun	-206	-319	-66	-192	-273	-391	-439	-449	-347	-319	-216	-151	-137	-65
Jul	-164	-318	-65	-248	-228	-314	-398	-424	-360	-397	-261	-203	-187	-180
Aug	-78	-240	-93	-271	-365	-442	-477	-494	-367	-353	-274	-192	-185	-108
Sep	69	0	-191	-280	-353	-441	-384	-406	-246	-255	-159	-147	-72	-70
Oct	-43	-79	-133	-219	-243	-307	-300	-364	-233	-335	-104	-160	-52	-87
Nov	-84	-152	-148	-199	-258	-312	-278	-311	-185	-237	-90	-117	-38	-48
Dec	-72	-168	-138	-161	-273	-281	-335	-400	-228	-296	-120	-117	-47	-33

Figure 137: 2006 Profile Monthly Average Hourly MW Change for Hours 21 to 3

	NPA Maximum Hourly Ramp-down MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-161	-551	-250	-674	-420	-927	-391	-705	-203	-481	-184	-455	-116	-281
Feb	-460	-451	-214	-599	-354	-758	-471	-900	-400	-652	-186	-393	-115	-291
Mar	-134	-396	-231	-590	-333	-688	-356	-639	-237	-640	-138	-807	-119	-462
Apr	-20.7	-604	-161	-671	-350	-612	-422	-622	-306	-516	-186	-429	-125	-241
May	-220	-507	-91.1	-429	-518	-757	-540	-606	-667	-808	-242	-394	-219	-342
Jun	-302	-706	-212	-878	-376	-843	-564	-913	-488	-544	-287	-406	-220	-312
Jul	-258	-633	-148	-609	-340	-746	-542	-871	-430	-799	-321	-547	-288	-436
Aug	-224	-582	-197	-757	-502	-807	-620	-902	-481	-779	-383	-437	-284	-370
Sep	-39.1	-465	-309	-698	-561	-1008	-508	-914	-397	-777	-308	-464	-177	-304
Oct	-89.1	-622	-213	-546	-330	-745	-431	-948	-718	-707	-242	-433	-186	-561
Nov	-147	-488	-232	-555	-337	-777	-383	-611	-303	-467	-181	-430	-87.2	-404
Dec	-160	-502	-248	-511	-384	-680	-481	-837	-522	-650	-184	-422	-158	-319

Figure 138: 2006 Profile Monthly Maximum Hourly MW Change for Hours 21 to 3

	NPA Minimum Hourly Ramp-down MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-5.2	169.4	-64	193.8	-113	98.47	-192	140.5	-82.9	176.7	-29.6	140.6	21.7	221.3
Feb	-4.1	358.5	134.5	164.1	-134	-21.1	-180	124.3	-105	94.63	-39.9	87.13	76.3	265.4
Mar	-17.3	303.7	-49.8	173.4	-151	127.2	-196	274.9	-116	47.28	-24.7	188.2	20.3	302.4
Apr	273.6	595.8	66.1	481.7	-21.5	41.78	-237	-51.4	-63.9	181.1	-34.5	514.6	16	235
May	143.7	444.2	141	524.6	-146	196.9	-198	15.32	-167	103.6	-54.7	152.3	-0.5	81.08
Jun	-82.8	98.2	102.8	255.9	-91.8	-4.32	-300	-91.9	-228	124.4	-112	172.5	-31	235.3
Jul	-43	-82.5	6.5	90.12	-25.7	268.3	-213	72.77	-297	-55.2	-118	125.6	-95.2	171.8
Aug	101.6	137.1	32.5	163.6	-193	91.25	-275	-56.3	317.3	231.4	-171	176.9	-62.5	430.2
Sep	198.7	364.7	-54.9	82.18	-177	88.65	-264	50.23	234.7	184.3	-55.4	152.6	33	230.1
Oct	21	468.1	-29	180.4	-136	62.73	-197	62.48	-99.2	-131	-17.9	32.13	24.7	223.9
Nov	-11.4	118.4	-35.7	176.5	-135	9.833	-181	26.02	-79.1	-35	-39.6	134.3	31.3	112.7
Dec	9.6	108.9	-11.9	245.4	-73.4	236.6	0	102.5	24.9	67.22	-4.5	460.5	48.3	238

Figure 139: 2006 Profile Monthly Minimum Hourly MW Change for Hours 21 to 3

	NPA 98 Percentile Ramp-up Hourly MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Jan	-18	132	-79	105	-142	88	-200	53	-50	150	-31	107	17	164
Feb	-7	319	36	120	-151	-41	-190	-17	-108	23	-41	82	55	201
Mar	-18	278	-72	116	-170	104	-203	88	-119	25	-30	183	20	222
Apr	246	489	44	392	-90	-11	-243	-62	-94	177	-50	403	7	155
May	123	377	113	523	-148	120	-221	9	-176	80	-71	126	-18	81
Jun	-94	67	55	224	-127	-40	-310	-111	-235	27	-132	124	-54	210
Jul	-67	-122	2	87	-62	73	-229	-1	-302	-83	-163	56	-117	73
Aug	80	66	19	157	-214	34	-313	-87	-25	152	-172	155	-81	220
Sep	193	314	-56	27	-182	64	-271	-8	2	121	-63	152	6	213
Oct	6	402	-58	177	-154	38	-201	-45	-120	-131	-31	29	18	174
Nov	-16	99	-63	93	-148	-24	-191	21	-92	-36	-42	121	22	101
Dec	7	108	-36	195	-84	227	-108	47	0	21	-30	255	43	233

Figure 140: 2006 Profile Monthly 98 Percentile Hourly MW Change for Hours 21 to 3

	NPA Maximum Hourly Ramp-down MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-133	-469	-212	-693	-346	-718	-461	-965	-398	-765	-156	-576	-183	-290
Spring	-243	-423	-234	-571	-421	-833	-686	-847	-677	-621	-257	-640	-526	-414
Summer	-330	-465	-255	-515	-565	-980	-601	-898	-515	-843	-399	-769	-323	-443
Fall	-179	-365	-276	-824	-468	-1016	-539	-900	-446	-787	-282	-439	-229	-474
Year	-330	-469	-276	-824	-565	-1016	-686	-965	-677	-843	-399	-769	-526	-474

Figure 141: 2004 Profile Season Maximum Hourly MW Change for Hours 21 to 3

	NPA Minimum Hourly Ramp-down MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	312	358	-4	107	-106	-16	-166	-47	-91	7	13	159	41	250
Spring	326	425	152	696	-111	181	-216	204	217	206	33	209	21	281
Summer	109	428	179	271	-79	79	-234	-66	-27	104	-107	72	-31	132
Fall	81	355	-53	242	-132	79	-185	-117	57	21	50	128	42	216
Year	326	428	179	696	-79	181	-166	204	217	206	50	209	42	281

Figure 142: 2004 Profile Season Minimum Hourly MW Change for Hours 21 to 3

	NPA 98 Percentile Ramp-down Hourly MW Change 2018 - 2004 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-120	-392	-189	-503	-333	-620	-432	-759	-315	-527	-152	-401	-129	-280
Spring	-171	-398	-197	-473	-419	-659	-476	-786	-406	-605	-228	-435	-144	-398
Summer	-268	-390	-209	-500	-512	-838	-578	-801	-482	-719	-366	-599	-295	-414
Fall	-145	-323	-248	-638	-434	-705	-537	-825	-385	-574	-247	-405	-193	-389
Year	-213	-389	-240	-513	-481	-751	-564	-798	-454	-617	-328	-507	-234	-396

Figure 143: 2004 Profile Season 98 Percentile Hourly MW Change for Hours 21 to 3

	NPA Maximum Hourly Ramp-down MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-173	-343	-237	-584	-767	-805	-665	-761	-467	-508	-613	-728	-532	-676
Spring	-201	-494	-289	-748	-449	-749	-594	-965	-443	-614	-315	-404	-167	-342
Summer	-279	-595	-217	-635	-540	-833	-605	-1137	-697	-894	-406	-809	-294	-575
Fall	-164	-471	-295	-793	-436	-814	-523	-966	-549	-806	-316	-644	-260	-477
Year	-279	-595	-295	-793	-767	-833	-665	-1137	-697	-894	-613	-809	-532	-676

Figure 144: 2005 Profile Season Maximum Hourly MW Change for Hours 21 to 3

	NPA Minimum Hourly Ramp-down MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	5	326	-6	215	-90	243	-184	262	360	366	-2	171	263	273
Spring	299	573	220	822	-112	231	-109	271	-74	220	6	161	54	260
Summer	37	203	131	244	-102	188	-200	33	142	213	-81	115	-83	299
Fall	86	121	-55	305	-119	206	-233	48	22	84	-27	144	31	278
Year	299	573	220	822	-90	243	-109	271	360	366	6	171	263	299

Figure 145: 2005 Profile Season Minimum Hourly MW Change for Hours 21 to 3

	NPA 98 Percentile Ramp-down Hourly MW Change 2018 - 2005 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-145	-338	-222	-551	-376	-734	-402	-719	-292	-495	-178	-398	-123	-293
Spring	-165	-369	-264	-651	-431	-729	-487	-828	-437	-601	-228	-391	-164	-306
Summer	-266	-513	-209	-565	-497	-798	-578	-937	-484	-807	-344	-596	-241	-425
Fall	-135	-434	-277	-647	-427	-782	-508	-807	-400	-674	-284	-515	-222	-303
Year	-223	-435	-259	-614	-463	-778	-545	-864	-461	-718	-323	-505	-229	-355

Figure 146: 2005 Profile Season 98 Percentile Hourly MW Change for Hours 21 to 3

	NPA Maximum Hourly Ramp-down MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-460	-551	-250	-674	-420	-927	-481	-900	-522	-652	-186	-455	-158	-319
Spring	-220	-604	-231	-671	-518	-757	-540	-639	-667	-808	-242	-807	-219	-462
Summer	-302	-706	-212	-878	-502	-843	-620	-913	-488	-799	-383	-547	-288	-436
Fall	-147	-622	-309	-698	-561	-1008	-508	-948	-718	-777	-308	-464	-186	-561
Year	-460	-706	-309	-878	-561	-1008	-620	-948	-718	-808	-383	-807	-288	-561

Figure 147: 2006 Profile Season Maximum Hourly MW Change for Hours 21 to 3

	NPA Minimum Hourly Ramp-down MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	10	358	135	245	-73	237	0	141	25	177	-5	460	76	265
Spring	274	596	141	525	-22	197	-196	275	-64	181	-25	515	20	302
Summer	102	137	103	256	-26	268	-213	73	317	231	-112	177	-31	430
Fall	199	468	-29	180	-135	89	-181	62	235	184	-18	153	33	230
Year	274	596	141	525	-22	268	0	275	317	231	-5	515	76	430

Figure 148: 2006 Profile Season Minimum Hourly MW Change for Hours 21 to 3

	NPA 98 Percentile Ramp-down Hourly MW Change 2018 - 2006 Profile 20% Wind													
	Hr 21		Hr 22		Hr 23		Hr 24		Hr 1		Hr 2		Hr 3	
	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind	Load	Load Net Wind
Winter	-160	-463	-248	-596	-386	-735	-451	-835	-417	-601	-184	-399	-116	-296
Spring	-188	-451	-210	-543	-355	-664	-485	-622	-370	-586	-219	-408	-169	-310
Summer	-280	-641	-183	-712	-490	-800	-581	-904	-469	-787	-324	-443	-259	-378
Fall	-134	-470	-291	-618	-483	-901	-491	-798	-377	-671	-243	-435	-158	-420
Year	-251	-578	-250	-647	-475	-773	-555	-854	-443	-704	-310	-433	-228	-376

Figure 149: 2006 Profile Season 98 Percentile Hourly MW Change for Hours 21 to 3

The contour plot in Figure 150 shows the changes in load net wind from one hour to the next. Along the vertical axis plot displays the change in load net wind for each hour of the day while the horizontal axis is each day of the year. Increase in load net wind is represented by yellow, orange and red colors with red being the largest increase in hourly load net wind change. Colors green, light blue and dark blue indicate decrease in load net wind from one hour to the next with dark blue being the largest decrease. On examination of the plot it can be seen that increases in hourly load net wind change tend to occur during early morning hours between 6

and 7 am on days 1 through 120 and days 240 through 365 (winter, spring and fall). On days 120 through 240 (summer) the increase in load net wind is later in the morning between hours 7 and 10. The largest decrease in load net wind tends to be between the hours of 21 and 1. This plot also shows the spread of hourly load net wind increases (hours 5-17) during the summer time period (days 140 and 250).

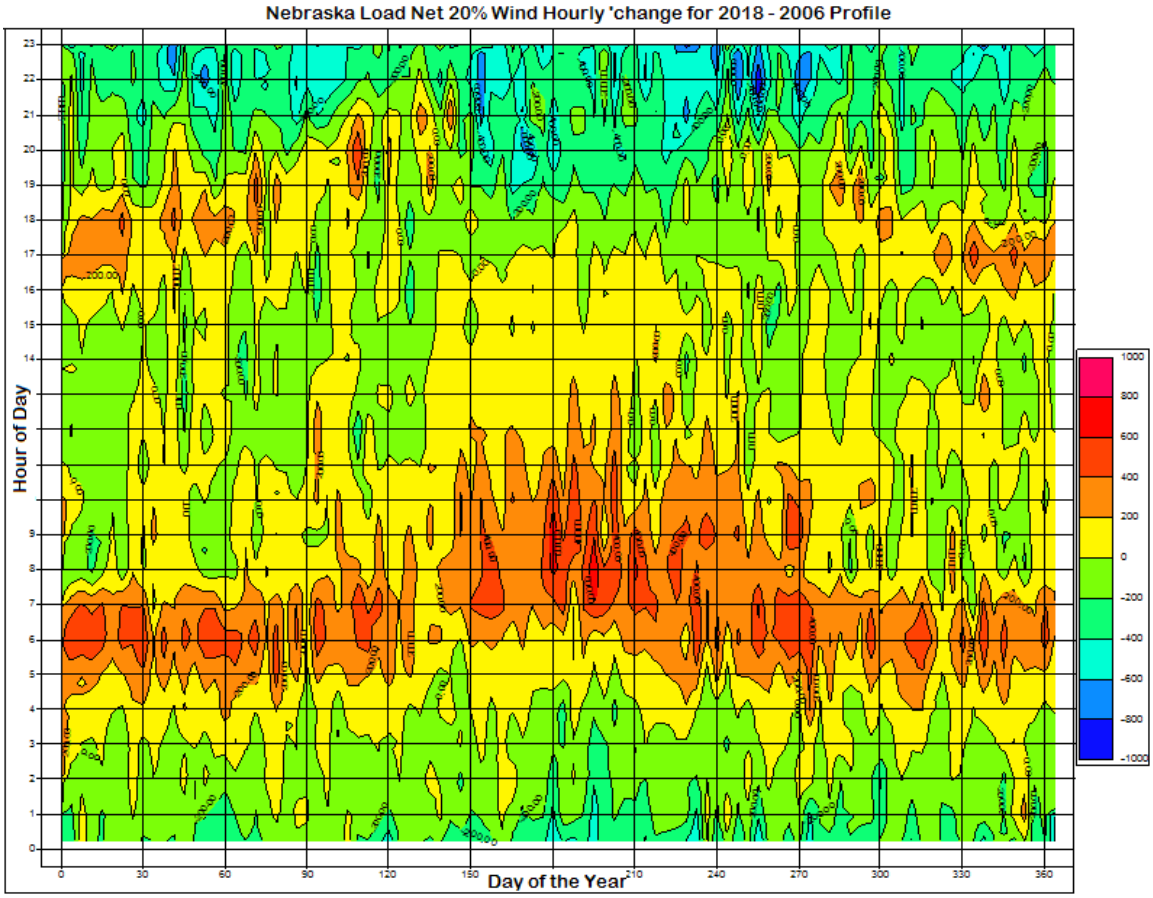

Figure 150: Contour plot of Nebraska Load Net Wind Hourly Changes with 20% Penetration for 2006 profile.