DOCKET NO. 46936

APPLICATION OF SOUTHWESTERN PUBLIC SERVICE COMPANY FOR: A CERTIFICATE OF CONVENIENCE AND NECESSITY AUTHORIZING CONSTRUCTION AND OPERATION OF WIND GENERATION AND ASSOCIATED FACILITIES IN HALE COUNTY, TEXAS AND ROOSEVELT COUNTY, NEW MEXICO, AND RELATED RATEMAKING PRINCIPLES; AND APPROVAL OF A PURCHASED POWER AGREEMENT TO OBTAIN WIND GENERATED ENERGY	**§ § § § § § § § § § § § § §**	**PUBLIC UTILITY COMMISSION OF TEXAS**

DIRECT TESTIMONY
of
DAVID P. DELUCA

on behalf of

SOUTHWESTERN PUBLIC SERVICE COMPANY

(*Filename:* DeLucaTXDirect.doc; *Total Pages:* 96)

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GLOSSARY OF ACRONYMS AND DEFINED TERMS

Acronym/Defined Term	**Meaning**
AWS Truepower	AWS Truepower, LLC
GW	Gigawatts
GWh	Gigawatt hour
Hale	Hale Wind Project
m	Meters
MCP	Measure-Correlate-Predict
m/s	Meters per Second
met towers	Meteorological Towers
MW	Megawatt
NCF	Net Capacity Factor
Sagamore	Sagamore Wind Project
SPS	Southwestern Public Service Company, a New Mexico corporation
SUNY	State University of New York
Xcel Energy	Xcel Energy Inc.

LIST OF ATTACHMENTS

Attachment	Description
DPD-1	Energy Production Report for the Proposed Sagamore Wind Project (*non-native format*)
DPD-2	Preliminary Energy Assessment for the Proposed Hale Wind Project (*non-native format*)

DIRECT TESTIMONY
OF
DAVID DELUCA

I. WITNESS IDENTIFICATION AND QUALIFICATIONS

Q. Please state your name and business address.

A. My name is David P. DeLuca. My business address is 463 New Karner Road, Albany, New York 12205.

Q. On whose behalf are you testifying in this proceeding?

A. I am filing testimony on behalf of Southwestern Public Service Company, a New Mexico corporation ("SPS") and wholly-owned electric utility subsidiary of Xcel Energy Inc. ("Xcel Energy").

Q. By whom are you employed and in what position?

A. I am employed by AWS Truepower, LLC ("AWS Truepower") as Director, Energy Services – North America.

Q. Please describe AWS Truepower and what work the company does in the wind industry.

A. AWS Truepower, a UL company, acquired in 2016, is a global renewable energy firm providing quality, innovative energy engineering and advisory services, testing, inspection, and certification to project developers and operators, investors, utilities, government agencies, and manufacturers. Through our expertise in engineering services, energy and resource solutions, and software and data platforms, we have helped develop, acquire, and support over 200 gigawatts ("GW") of wind and solar projects worldwide.

AWS Truepower has led the renewable energy industry for over 30 years. Our wind and solar staff is comprised of over 150 engineers, meteorologists and environmental specialists. We have worked in over 100 countries, advised over 90% of the industry's top project developers and plant owners, worked with 85% of the top original equipment manufacturers, and provided forecasts for over 55 GW of installed renewable energy projects. Our expert advice, reliable assessments, and innovative tools have helped renewable energy projects evolve into durable operating assets, which are reducing humanity's global carbon footprint. Together with UL, AWS Truepower offers an extensive solutions and data tools portfolio, making us an even larger powerhouse in renewable energy.

Q. Please describe your role as Director, Energy Services with AWS Truepower.

A. As Director, Energy Services with AWS Truepower, I currently lead a team of 30 engineers, scientists, project managers, and business development staff working on renewable energy projects across North America. The Energy Services business unit offers services to support the development and operational lifecycle for wind and solar farms, including pre- and post-construction resource and energy assessments in support of project financings and acquisitions.

In addition, I am also responsible for the overall management of a number of key client accounts including scope and budget development, as well as managing overall project execution with the technical teams.

Q. Please describe your educational background.

A. I graduated from the State University of New York ("SUNY"), Albany in 2002, receiving a Bachelor of Sciences degree in Atmospheric Sciences and earned a Master of Sciences degree in Atmospheric Sciences from SUNY, Albany in 2004.

Q. Please describe your professional experience.

A. I have over 12 years of experience in renewable energy development, project management, and business development. In that time, I have been employed by AWS Truepower in various roles including Renewable Energy Analyst, Senior Project Manager, Assistant Director of Business Development, Director of Wind Developer Services, and Director of Client Services. In 2017, I was named to my present position as Director, Energy Services – North America.

II. ASSIGNMENT AND SUMMARY OF TESTIMONY

Q. What is your assignment for this testimony?

A. My assignment in this testimony is to describe AWS Truepower's independent analysis of the Sagamore wind project ("Sagamore") and Hale wind project ("Hale") sites, which AWS Truepower understands will be acquired by SPS subject to receiving regulatory approval. Additionally, based on this analysis, my testimony discusses the estimated net capacity factors ("NCF") for the Sagamore and Hale sites.

Q. Please briefly summarize your testimony.

A. Based on AWS Truepower's analyses, which are presented in my Attachments DPD-1 and DPD-2, the expected level of net generation for each of the Sagamore and Hale wind facilities is within the range of 2,000 Gigawatt hours ("GWh")/year to 2,400 GWh/year. The Sagamore site is expected to produce 2,389 GWh on an annual basis, which equates to a NCF of 52.2%. The Hale site is expected to produce 2,077 GWh on an annual basis, which equates to a NCF of 49.6%. These are net amounts of generation, after taking into account real world effects under which wind farms can lose energy, including availability issues, wake effects, electrical losses, turbine performance, blade soiling, degradation, icing, and the other losses listed in the reports. In determining expected generation amounts, AWS Truepower also factored in uncertainties surrounding generation prediction. AWS Truepower believes that it is reasonable that the Sagamore and Hale projects will generate according to the stated probabilities in AWS Truepower's reports. Included in the appendices to Attachments DPD-1 and DPD-2, however, are the energy production and uncertainty estimates for the

Sagamore and Hale projects assuming turbine availability losses provided by Xcel Energy.

Q. Were Attachments DPD-1 and DPD-2 prepared by you or under your direct supervision and control?

A. Yes. Attachments DPD-1 and DPD-2 were prepared by the technical team at AWS Truepower, and I managed those teams' preparation of the reports contained therein.

III. <u>AWS TRUEPOWER'S ANAYSIS</u>

Q. What work was AWS Truepower asked to perform regarding the Sagamore and Hale wind projects?

A. AWS Truepower was retained by SPS to evaluate the long-term wind resource and energy production potential of the proposed Sagamore wind project, located in eastern New Mexico with a rated capacity of 522 megawatts ("MW"), and Hale wind project, located in Hale County, Texas, with the potential for installation of 478 MW of wind capacity. The reports setting forth AWS Truepower's analysis are included as Attachments DPD-1 ("Energy Production Report for the Proposed Sagamore Wind Project dated March 10, 2017") ("Sagamore Report") and, Attachment DPD-2 ("Preliminary Energy Assessment for the Proposed Hale Wind Project dated March 10, 2017") ("Hale Report") to my direct testimony. The purpose of these reports is to characterize the expected generation and associated uncertainties surrounding the generation predictions for each project.

AWS Truepower's evaluation of the Sagamore wind project used a process that combines onsite measurements and a coupling of mesoscale and microscale wind flow models to create a long term simulation of the wind resource characteristics for the project. For Hale, onsite measurements were not available at the time of AWS Truepower's analysis, so the mesoscale and microscale wind flow model was run using a coarser final resolution and validation using regional experience. A study of the Hale site using onsite measurements is currently in process and is anticipated to be completed by May 2017.

Once the wind resource model had been run, the resource grid file was imported into Openwind (an AWS Truepower application used to estimate wake losses) to define the final wind resource for the project areas. Turbine power curves were then used to estimate gross energy output. An analysis of site conditions was also considered to estimate overall project losses. The final result is a realistic simulation of expected annual production. Detailed quality control steps are taken all along the way, including final review by multiple senior technical staff.

In addition to the estimate of expected generation, an uncertainty analysis was undertaken. Uncertainty of every step of the process is considered and modeled and used to make output predictions at various probability levels.

Q. Please describe how data was collected from the meteorological towers located at the Sagamore site, and how that data was used in AWS Truepower's analysis.

A. For the Sagamore site, data was collected from six meteorological towers, which are also known as "met towers." Data from three of the six met towers was used for the final analysis due to a number of sensor failures and poor data quality. Data was collected over a period of about six years at Sagamore, spanning the years of 2010-2016. The met towers were installed and maintained by the developer and consisted of 58-meter ("m"), lattice towers with wind speed and direction sensors at multiple levels on each tower. Because the towers were 20 m less than the turbine hub height, data were extrapolated vertically in a process called wind shear extrapolation. These quality-controlled, 80 m wind speed and direction data sets are the observational basis for the modeling process.

Numerical wind flow models are then used to calculate the wind resource variation across a project area due to changes in terrain and surface roughness. AWS Truepower has developed the SiteWind system to perform these calculations. SiteWind employs both mesoscale and microscale models to simulate the wind climate over a wide range of scales. The mesoscale model assesses regional climate conditions and simulates complex meteorological phenomena such as katabatic (downslope) mountain winds, channeling through mountain passes, lake and sea breezes, low-level jets, and temperature inversions. The microscale model accounts for the localized influences of topography and surface roughness changes and produces a detailed wind resource map and grid. As a final step, the predicted speed and direction are adjusted with onsite data from masts within the project area. This method has been found to be more accurate on the whole than microscale wind flow models alone.

Q. Please describe what data was used for the Hale site, and how that data was used in AWS Truepower's analysis.

A. For the Hale site, no on-site meteorological data was available, thus modeled wind data was used to estimate the long-term wind resource and energy production potential of the site. AWS Truepower's widely used and validated MesoMap system, which uses numerical weather prediction models to simulate wind and weather conditions in any region, was used to produce the wind resource maps that were used to analyze the Hale wind site. The MesoMap system is the most advanced, tested and validated wind mapping system in use today. It has several advantages over traditional wind resource assessment methods. First, it operates without the need for local surface wind data – an important attribute for many projects because of the limited availability of high-quality wind measurements from tall towers. Second, it simulates important meteorological phenomena not captured in most other models, such as katabatic (downslope) mountain winds, channeling through mountain passes, lake and sea breezes, low-level jets, temperature inversions, and surface roughness effects.

Q. Based on AWS Truepower's analysis, what are the expected levels of net generation for the Sagamore and Hale sites?

A. The Sagamore site has a predicted 80 m project average wind speed of 8.68 meters per second ("m/s"). For a layout consisting of 26 Vestas V110-2.0 MW turbines and 235 Vestas V116-2.0 MW turbines, the annualized gross generation is predicted to be 2,962.6 GWh, and after losses the annualized net generation is expected to be 2,389.4 GWh, for a NCF of 52.2%. NCF characterizes the performance of the plant in the real world rather than in an idealized situation and is derived by taking the energy the plant is calculated to generate, taking account of the wind resource at the site allowing for the relevant loss factors, and dividing by the amount the plant could generate if operated at full output for an entire year.

The Hale wind site has a predicted 80 m project average wind speed of 8.62 m/s. For a layout consisting of 23 Vestas V110-2.0 MW turbines and 216 Vestas V116-2.0 MW turbines, the annualized gross generation is predicted to be

2,592.6 GWh, and after losses net generation is expected to be 2,076.9 GWh. This translates into a 49.6% NCF.

Additionally, AWS Truepower has provided an analysis, contained in the appendices of Attachments DPD-1 and DPD-2, that shows the NCF of the Sagamore and Hale wind sites, respectively, using specific loss factor values provided by Xcel Energy. I understand that SPS utilized these NCF values in its analysis of the projects, with certain modifications discussed in the direct testimony of SPS witness Riley Hill.

Q. In AWS Truepower's reports, the Sagamore and Hale sites are shown to have gross GWh Generation (and consequently Gross NCF) at higher levels than net generation and net NCF.[1] Please explain how the "loss factors" reduce the expected level of generation.

A. Gross generation is considered an estimate of ideal or nominal generation. The initial modeling steps create the wind resource data. Using the turbine supplier provided power curve, AWS Truepower simulated the wind turbines operating in this environment, which yielded gross generation. However, there are many real world effects that cause a project to produce less energy than this ideal simulation. Upstream wind turbines will reduce the amount of available wind for downstream turbines – these are known as Wake Losses. Electrical losses, blade soiling, and other environmental effects also reduce the real energy production. In addition, sub-optimal operations and availability losses and outages can reduce energy production. All of these are considered in what is called loss analysis. AWS

[1] Attachment DPD-1 at 6; Attachment DPD-2 at 9.

Truepower attempted to estimate all the typical ways that the wind farms can lose energy. These losses are combined to compute net energy generation. This will always be less than the ideal energy generation.

Q. Please provide a high-level overview of the loss factors section of AWS Truepower's analysis and how these factors were combined into the aggregate loss factor.

A. The plant losses for Sagamore were estimated based on AWS Truepower's assessment of the actual performance of operating wind plants and an analysis of site-specific conditions. Our loss estimates for six broad categories for Sagamore are provided in Attachment DPD-1; a detailed breakdown and explanation for each is contained below. Project losses for the Hale site were estimated using the same categories, but with fewer site specific inputs given the lack of onsite meteorological data. The losses for Hale were estimated based on previous regional experience. Our loss estimates for these six broad categories for Hale are provided in Attachment DPD-2.

The following is a short description of each loss category that was included in AWS Truepower's assessment:

Wake Effect

- Wind turbines alter the free stream wind flow which may reduce the energy production of a wind project. Losses due to this wake effect are divided into the following categories:
    - <u>Internal Wake Effect of the Project</u>: This loss accounts for the wake effect from turbines within the project being analyzed.

- Wake Effect of Existing or Planned Projects: This loss accounts for the wake effect of existing or planned projects located adjacent to the project being analyzed for which sufficient information was available to make a precise estimate of their impact on the project being studied.

Availability

- Availability losses occur when some turbines in a project, or an entire project, are inoperative for some reason. Data reviewed by AWS Truepower shows that a typical wind plant within North America is likely to average 95% time-based availability in long-term operation. Of the implied 5% downtime, the availability losses are divided into the categories described below, with an additional correlation loss to adjust from time-based to energy-based availability.
  - Contractual Availability of Wind Turbines: Turbine downtime traditionally covered under availability warranties (while in effect); AWS Truepower typically assumes a baseline time-weighted turbine availability of 97%.
  - Non-Contractual Availability of Wind Turbines: AWS Truepower attributes an additional 1.3% of turbine downtime as a result of force majeure events, scheduled maintenance, and repair delays due to high winds or lack of spare parts, which are typically not covered under traditional warranties.

- Long-term Availability Correlation with High Wind Events: This factor accounts for the likelihood that the turbines will experience shutdowns more often in high winds than at other times, resulting in energy losses not accounted for by downtime alone. AWS Truepower's estimate of this loss, which depends upon the turbine type, expected downtime, and capacity factor, is based on detailed study of losses in operating wind projects.
- Availability of Collection and Substation: This loss accounts for outages of the collection system and substation. It is typically assigned a value of 0.2%, which corresponds to two events per year of eight hours average duration.
- Availability of Utility Grid: This loss accounts for outages of the utility grid. It is typically assigned a value of 0.3%, which corresponds to four events per year of six hours average duration.
- Plant Restart after Grid Outage: This loss is typically assigned a value of 0.2%, which assumes that four utility grid outages per year are accompanied by a 5-hour average standby period while the turbine components are brought within temperature, humidity, and other operating specifications.
- First-Year Plant Availability: This value is typically set to 4% to account for the additional turbine and plant downtime that is often observed during the first year of operation.

Electrical

- Electrical Efficiency: Losses are experienced in all electrical components of the wind project, including the padmount transformer, electrical collection system, and substation transformer. These losses are established in the electrical system design. The typical 2% value assumed here is intended to account for losses between the low-voltage terminals of the generator in the turbine (where the output is measured in a power curve test) and the revenue meter located on the high-voltage side of the on-site substation. If the revenue meter is to be placed at a distance from the on-site substation, a loss should be added to account for the length of high-voltage transmission line between the sub-station and the revenue meter.
- Power Consumption of Extreme Weather Package: This loss is intended to account for the energy consumed by the equipment included in an extreme weather package, if the turbines are so equipped. Power consumption for site lighting, operation and maintenance facilities, and other site facilities not associated with the turbines are not included as loss items and should be considered in the project's financial modeling.

Turbine Performance

- Sub-Optimal Operation: This factor accounts for shortfalls from ideal performance due to suboptimal turbine settings. Typical examples include yaw misalignments, control anemometer calibration, blade pitch inaccuracies or misalignments, and other control setting issues.

- Power Curve Adjustment: This loss accounts for expected turbine performance relative to the modeled performance using the advertised power curve.
- High Wind Control Hysteresis: For most turbines, once the wind speed exceeds the turbine's design cut-out speed and the machine shuts down, the control software waits until the speed drops below a lower speed threshold (the reset-from-cut-out speed) before allowing the turbine to restart. This loss accounts for the energy lost in this hysteresis loop. It is calculated from wind data collected at the site and the manufacturer's specified cut-out and reset-from-cut-out speeds.
- Inclined Flow: This loss has been included to account for the estimated impact of inclined (non-horizontal) flow on power production.

Environmental

- Icing: This loss reflects decreased rotor aerodynamic efficiency caused by the accumulation of ice on the turbines during plant operation, as well as turbine shutdowns caused by excessive ice accumulation. The icing losses are estimated from site weather data, including the expected frequency and duration of freezing precipitation and rime ice formation.
- Blade Degradation: This loss reflects changes to the aerodynamic efficiency of the turbine blades over time and consists of long- and short-term components.

- Low/High Temperature Shutdown: This loss value is calculated based on the energy that will be lost when the turbine shuts down due to temperatures outside the operating design envelope.
- Site Access: Severe weather can limit access to some sites, which can reduce energy production because response times for repairs are increased. This loss is estimated based on weather data and other site specific information.
- Lightning: Lightning can damage turbine components and cause electrical faults resulting in shutdowns. This loss is estimated from meteorological data indicating the likely frequency of lightning at the site.

Curtailments

- Directional Curtailment: If turbines are spaced closer than three rotor diameters from each other, a directional curtailment strategy may be imposed by the manufacturer to limit the fatigue losses on the affected turbines caused by wake-induced turbulence. For such layouts, AWS Truepower estimates a representative loss until a detailed curtailment strategy is specified by the manufacturer. At that time, a more detailed calculation of this loss can be performed.
- Purchased Power Agreement Curtailment: If the wind farm is forced to curtail production, loss of revenue could result from the sale of energy and or loss of production incentives. Typically, this loss is set to zero unless loss data is supplied by the client.

- Environmental Curtailment: If the wind farm is required to comply with certain operational standards due to environmental constraints, an environmental curtailment loss may be estimated. This loss is normally set to zero unless specific restrictions are supplied by the client.

Q. Is AWS Truepower confident that the net capacity factors it determined for the Sagamore and Hale wind facilities take into account real world effects under which wind farms can lose energy?

A. Yes. AWS Truepower took into account each of the effects described in its reports, including availability issues, wake effects, electrical losses, turbine performance, blade soiling, degradation, icing, and other losses listed in the respective reports.

Q. The standard error of the 10-year estimate is listed as 6.4% for Sagamore and 20% for Hale.[2] Please provide an overview of how these standard error estimates relate to the uncertainty analysis section of AWS Truepower's analysis.

A. In discussing standard error estimates with respect to Sagamore and Hale, uncertainty is defined as the standard error for a normal probability distribution. The following explanation is a summary of the uncertainty elements associated with the wind speed and energy production estimates for Sagamore.

- **Site Documentation and Verification:** This uncertainty addresses the quality and independence of the available information describing the site characteristics and monitoring equipment. Specific items

[2] Attachment DPD-1 at 20; Attachment DPD-2 at 6.

considered include the quality and comprehensiveness of tower commissioning and verification documents; the quality and number of photographs depicting each mast and its surroundings; and information regarding obstacles potentially affecting the wind flow at each mast.

- **Wind Speed Measurements:** This is the uncertainty in anemometer readings of the free-stream wind speed. It reflects not just uncertainty in the sensitivity of the instruments when operating under wind-tunnel conditions, but also uncertainty in their performance in the field, where they may be subject to turbulent and off-horizontal winds, tower effects, and problems such as icing that may be missed in the validation. In addition, where applicable, the uncertainty in empirical adjustments applied to account for factors such as turbulence or the impact of wakes from existing turbines on observed wind speeds is considered.
- **Long-Term Average Speed:** This uncertainty addresses how accurately the site data, after the measure-correlate-predict ("MCP") adjustment, may represent the historical average wind resource. AWS Truepower has undertaken a study of wind speed interannual variability and has produced an interannual variability map using the global ERA-Interim reanalysis dataset. The map suggests that the standard deviation of annual mean wind speeds for the Sagamore Wind Project is about 3.9%. It is assumed that the annual mean varies randomly according to the normal distribution, and thus the error

margin varies inversely with the square root of the number of years. The estimated uncertainty accounts also for the degree of correlation between the target and reference stations, the length of the reference period of record, and the data recovery at each mast.

- **Evaluation Period Wind Resource:** This uncertainty is associated with how closely the wind resource over the evaluation period may match the long-term site average. The estimated value assumes a 10-year evaluation period, 3.9% interannual variation in the mean speed, and 0.5% uncertainty associated with possible climate oscillations and trends.
- **Wind Shear:** The wind shear uncertainty includes the uncertainty in the observed shear due to possible measurement errors and the uncertainty in the change in shear above mast height. The estimated value considers the site conditions, anemometer heights, hub height, and measurement uncertainties at the mast.
- **Wind Flow Modeling:** The uncertainty in the array-average free-stream wind speed at the turbines, relative to the masts, depends on the wind climate, terrain complexity and vegetation height and variation, characteristics of the wind flow model, and number of masts used to adjust the resource grid and their placement relative to the turbine layout.
- **Wind Speed Frequency Distribution:** Like the mean speed, the wind speed frequency distribution varies over time. Our research indicates

that the interannual variability of the energy production directly related to the wind speed frequency distribution is typically about 1.4%. The estimated uncertainty in the long-term energy production estimate considers this factor along with the onsite period of record and the length of the evaluation period.

- **Plant Losses:** AWS Truepower has used operational data to quantify the uncertainties associated with our estimates for plant availability, electrical, and turbine performance losses for the evaluation period, as well as for the first year and any subsequent year. When these values are combined with the estimated uncertainties due to environmental factors and directional curtailment, the plant operational loss uncertainty is estimated to be 3.2% over the 10-year evaluation period. (Uncertainties associated with grid curtailment losses are not considered here.) In addition, based on our wake model validation findings, we estimate the uncertainty in the wake loss calculations to be 20% of the total wake loss, or 1.5%. The operational and wake loss uncertainties are combined as the square root of the sum of their squares.

Given the lack of onsite data for Hale, a higher level assessment of the uncertainty elements was completed and is based on general regional experience.

Q. What steps did AWS Truepower take to determine the energy production levels for the Sagamore site at various desired confidence levels (e.g., 95% confidence or P95)?

A. AWS Truepower took the following steps to determine the energy production for the Sagamore site at various desired confidence levels:

- The uncertainty percentages in wind speed were combined as the square root of the sum of squares and multiplied by the predicted array-average mean speed to determine the uncertainty of the array-average mean speed.
- The sensitivity of the project energy output to changes in wind speed was calculated by comparing the energy output of a turbine at the predicted array-average wind speed to the output of a turbine with an average speed equal to the predicted speed minus uncertainty.
- The sensitivity of the project output to changes in wind speed was multiplied by the wind speed uncertainty to estimate the corresponding uncertainty of the project energy output.
- The uncertainty in plant losses and wind speed frequency distribution were combined with the previous total using the square root of the sum of squares.
- Assuming a normal distribution of errors, AWS Truepower calculated the energy production levels that would be exceeded by the project with 50%, 75%, 90%, 95%, and 99% confidence.[3]

Q. How did AWS Truepower determine the energy production levels for the Hale wind site at various desired confidence levels (e.g., 95% confidence or P95)?

A. Given the lack of onsite data available for Hale, the overall energy production uncertainty was estimated by verifying wind map predictions with independent regional surface-based observations and leveraging past experience in the region.

[3] Attachment DPD-1 at 39.

Using this process, AWS Truepower calculated the preliminary energy production levels that would be exceeded by the project with 50%, 75%, 90%, 95%, and 99% confidence.[4]

Q. Can AWS Truepower state within a reasonable degree of probability that the expected levels of net generation for the Sagamore and Hale wind facilities shown in your testimony and its Attachments DPD-1 and DPD-2 are accurate?

A. Yes. AWS Truepower followed its standard process and quality control efforts in developing each analysis. Accordingly, AWS Truepower believes that it is reasonable that the studied wind projects will generate according to the stated probabilities.

Q. Does this conclude your pre-filed direct testimony?

A. Yes, it does.

[4] Attachment DPD-2 at 9.

AFFIDAVIT

STATE OF NEW YORK)
)
COUNTY OF ALBANY)

DAVID P. DELUCA, first being sworn on his oath, states:

I am the witness identified in the preceding testimony. I have read the testimony and the accompanying attachments and am familiar with their contents. Based upon my personal knowledge, the facts stated in the testimony are true. In addition, in my judgment and based upon my professional experience, the opinions and conclusions stated in the testimony are true, valid, and accurate.

DAVID P. DELUCA

Subscribed and sworn to before me this 15th day of March, 2017 by DAVID P. DELUCA.

Doreen M Sangalli

Notary Public, State of New York
My Commission Expires: ______________

DOREEN M. SANGALLI
Notary Public, State of New York
No. 01SA6124414
Qualified in Schenectady County
Commission Expires Mar. 28, 2021

CERTIFICATE OF SERVICE

I certify that on March 21, 2017, this instrument was filed with the Public Utility Commission of Texas, and a true and correct copy of it was served by hand delivery on the Staff of the Public Utility Commission of Texas and the Office of Public Utility Counsel, and by hand delivery, next business day courier delivery, or first class mail on each party of record in SPS's most recent base rate case, Docket No. 45524.

AWS TRUEPOWER

PREPARED FOR
XCEL ENERGY

ENERGY PRODUCTION REPORT

Independent Wind Resource and Energy Assessment

MARCH 10, 2017

FOR THE PROPOSED SAGAMORE WIND PROJECT

ROOSEVELT COUNTY, NEW MEXICO

CLASSIFICATION
CLIENT'S DISCRETION

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DOCUMENT HISTORY

ISSUE	DATE	SUMMARY
A	06 March 2017	Initial Report

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EXECUTIVE SUMMARY

AWS Truepower, LLC, a UL company, was retained by Xcel Energy to evaluate the long-term wind resource and energy production potential of the proposed Sagamore Wind Project, located in eastern New Mexico. The project, which will have a rated capacity of 522 MW, is to consist of 26 Vestas V110-2.0 MW turbines with a rotor diameter of 110 m and 235 Vestas V116-2.0 MW turbines with a rotor diameter of 116 m, both at a hub height of 80 m. This report presents the results of our analysis and discusses the methods used to develop the wind resource, energy production, and uncertainty estimates. The key aspects of the project and a summary of our results are presented in the table below. Appendix B contains the energy production and uncertainty estimates for the same project scenario, but assuming turbine availability losses provided by Xcel.

Project Name	Sagamore	
Project Location	New Mexico	
Rated Capacity	522 MW	
Turbine Model	Vestas V110-2.0 MW Mk10D VCSS 60 Hz Variant 110-m Rotor Diameter Standard Weather Package	Vestas V116-2.0 MW VCSS 60 Hz Variant 116-m Rotor Diameter Standard Weather Package
Hub Height	80 m	80 m
Number of Turbines	26	235
Array-Average Free-Stream Speed	8.68 m/s	
Gross Annual Production	2,962.6 GWh/yr	
Plant, Wake, and Total Losses	Plant – 12.8%; Wake – 7.5%; Total – 19.4%	
Net Annual Production (Capacity Factor)	2,389.4 GWh/yr (52.2%)	
P95 Production (Years 2-10) (Capacity Factor)	2,136.7 GWh/yr (46.7%)	
P99 Production (Annual) (Capacity Factor)	1,942.8 GWh/yr (42.5%)	

AWS Truepower recommends that Xcel Energy submit the layout to the manufacturer for a suitability study for the Vestas V110-2.0 MW (IEC Class IIIA/IIIC) and Vestas V116-2.0 MW (IEC Class IIIA) turbines. This study could recommend wind sector management, changes to the layout, and/or changes in turbine model. These changes will typically affect the energy production estimates. A preliminary analysis conducted by AWS Truepower noted that the turbine spacing within the current layout may not be adequate for the IEC class of the turbine, the expected wind speeds and direction, ambient turbulence intensity, and air density at the site.

1. INTRODUCTION

AWS Truepower, LLC, a UL Company, was retained by Xcel Energy (Xcel) to evaluate the long-term wind resource and energy production potential of the proposed Sagamore Wind Project, located in eastern New Mexico. The project, which will have a rated capacity of 522 MW, is to consist of 26 Vestas V110-2.0 MW turbines with a rotor diameter of 110 m and 235 Vestas V116-2.0 MW turbines with a rotor diameter of 116 m, both at a hub height of 80 m. This report presents the results of our analysis and discusses the methods used to develop the wind resource, energy production, and uncertainty estimates.

2. SITE DESCRIPTION

The proposed Sagamore Wind Project is approximately 125 km to the northeast of Roswell, New Mexico, and 140 km west-northwest of Lubbock, Texas. Its location is indicated on the regional map in Figure 1. The project area is situated in terrain that generally slopes downward from northwest to southeast. The highest elevations are found in the southwest portion of the project boundary. Figure 2 contains a topographic map of the project area. The mean turbine base elevation is about 1277 m with an elevation range of approximately 68 m. AWS Truepower has not conducted a site visit, but photographs provided by Xcel indicate that the land cover primarily consists of grassland with a low surface roughness.

3. WIND MEASUREMENTS

Wind monitoring at the Sagamore project began in December 2008 with the installation of three monitoring masts, designated Masts 8024, 8025, and 8026. In late 2009, three additional masts, designated Mast 9001, 9002 and 9003 were installed. It is unknown if the masts remain in operation. Masts 8024, 8025 and 9003 were not used in this analysis due to numerous sensor failures and questionable data. Our assessment therefore relies on data collected at Masts 8026, 9001 and 9002. The mast locations are indicated in Figure 2. Adams Wind, LLC. installed the masts, WeatherBank, Inc. inspected all masts after installation, while Chermac Energy has been responsible for data collection. Table 1 presents basic information about the masts including their geographic coordinates, elevations, periods of record, and sensor types and heights. Since AWS Truepower did not perform site visits, we relied on information about the masts contained in detailed tower installation forms and site photos provided by Xcel.

Raw binary files from Campbell CR1000 data loggers were received from Xcel; each file contained 10-minute average wind speed, wind direction and temperature measurements, along with their standard deviations. The anemometers used in the measurement program have been calibrated Renewable NRG Systems, Inc. (RNRG) #40. Although the RNRG #40 anemometers used in the measurement campaign were calibrated, we employed the consensus slope (0.765 m/s/Hz) and offset (0.35 m/s) to convert their raw logger counts to speed values based on our research, which indicates that the results agree more closely with Class I anemometers, like the WindSensor P2546-OPR, than when the calibrated (measured) coefficients are used.[1]

Masts 8026, 9001 and 9002 are (were) 58-m, guyed; lattice Rohn 25 towers with a constant face width of 305 mm (12 in). The wind speed has been measured at four heights, ranging from 10 m to 56.2 m;

1 Hale, E., "*Memorandum: NRG #40 Transfer Function Validation and Recommendation*", AWS Truepower, 8 January 2010.

the wind direction at two heights ranging from 43 m to 53 m; and temperature at a single height of 3 m. Two anemometers, oriented roughly west and east are present at the top and 30 m levels; single anemometers, oriented toward the west, are present at the remaining two levels. Each anemometer is mounted at the end of a 1.7-m horizontal boom, which provides a separation distance from the mast that exceeds the IEC recommended minimum of 3.75 face widths from a lattice tower.[2] Figure 3 present a view of the monitoring configuration on Mast 8026 which is representative of Masts 9001 and 9002. No detailed prevailing wind directional photos were supplied by Xcel.

Data Handling and Validation

An experienced AWS Truepower meteorologist inspected the data for completeness and reasonableness. The main issues addressed by the validation process included mast shadow effects and equipment failures. The following is a summary of the equipment failures and maintenance history of the masts.

Mast 8026

- 14 November 2012 – End of Data Record: 56.2-m east-facing intermittent anemometer failure
- 10 December 2012 – End of Data Record: 43-m wind vane failure
- 16 December 2012 – End of Data Record: 56.2-m west-facing anemometer failure
- 03 March 2013 – End of Data Record: 53-m wind vane failure
- 17 May 2013 – End of Data Record: 45.9-m west-facing anemometer failure
- 05 June 2013 – End of Data Record: 30.1-m west-facing anemometer failure
- 27 December 2015 – End of Data Record: 30.1m east-facing anemometer failure
- 28 March 2016 – End of Data Record: 56.2-m east facing anemometer failure.

Mast 9001

- 23 January 2012 – End of Data Record: 56-m west-facing anemometer failure
- 24 March 2013 – End of Data Record: 46-m west-facing anemometer failure
- 27 April 2014 – End of Data Record: 30-m east- and 10-m west-facing anemometer failures, 53-m wind vane failure
- 08 August 2014 – End of Data Record: 43-m wind vane failure
- 03 March 2015 – 3 May 2015: Missing data.

Mast 9002

- 28 March 2011 – 29 September 2011: 46-m west-facing anemometer intermittent failure
- 28 February 2012 – End of Data Record: 56-m west-facing anemometer failure
- 12 June 2013 – End of Data Record: 56-m east-facing anemometer failure
- 27 December 2015 – End of Data Record: 46-m and 30-m west-facing anemometer failures.

The response of RNRG #40 anemometers to turbulence differs from that of Class I anemometers used for turbine power performance testing and certification. High turbulence causes RNRG #40 anemometers to overspeed (measure higher mean speeds) compared to Class I sensors, because they respond more quickly to gusts than to falling wind speeds. Conversely, at very low turbulence, speeds reported by RNRG #40 anemometers tend to be below those reported by Class I sensors. AWS

2 Annex G, IEC 61400-12-1, "*Power Performance Measurements of Electricity Producing Wind Turbines*", Geneva, Switzerland, 2005.

Truepower has computed the following relationship to adjust the RNRG #40 wind speed data to account for turbulence effects:[3]

$$V_{Corrected} = V_{Observed} \, / \, (0.095 * TI + 0.992)$$

The free-stream wind flow at the masts is characterized by low turbulence intensity. As a result, the adjustments, which are roughly –0.1% at all masts, are small. All RNRG #40 wind speed values in this report include this adjustment. Table 2 lists the mean adjustments applied to data from each top-level RNRG #40 anemometer(s).

For each mast, at measurement heights where two anemometers are present, a series of direction-based regression equations was developed using valid data from both sensors; the equations were used to reconstruct invalid readings at the same height whenever possible.

Due to variations in lattice tower specifications, the aerodynamic effects of the mast on measured wind speeds can vary and are difficult to simulate. However, the use of multiple independent valid observations from collocated anemometers typically reduces the measurement uncertainty and biases associated with tower effects. Therefore, AWS Truepower has averaged all valid wind speed data samples at monitoring heights where two anemometers are employed; for direction sectors where one anemometer is shadowed by the tower, only valid wind speed observations from the unwaked anemometer are retained in the data stream.

Satellite imagery and publicly available data indicate operational turbines, associated with the Roosevelt and Milo Wind Projects, located at a minimum of 10.3 km to the north of the masts. Available information indicates that the projects became operational in December 2015 and consist of a total of 150 Vestas V100-2.0 MW turbines at a hub height of 80 m. While these turbines were operating during the mast periods of record, the distance between the turbines and the three masts is sufficient for negligible wake impacts on the observed wind speeds. Additionally, mast data from December 2015 to the end of the data record was not even used due to sensor failures.

After data validation, the wind speed data recovery fractions ranged from 34.2% (56.2 m) at Mast 8026 to 62.5% (56.0 m) at Mast 9001. The low data recovery rates are due to sensor failures following the first few years of data collection at each of the masts.

4. WIND RESOURCE CHARACTERISTICS

Table 3 presents the observed monthly mean wind speeds and data recovery fractions for each mast. Table 4 summarizes the wind resource characteristics observed over the periods of record at the onsite masts. The characteristics include the average and annualized average wind speeds, data recoveries, shear exponents, turbulence intensities, Weibull parameters, and air densities. The observed mean wind speeds ranged from 7.84 m/s (56.0 m) at Mast 9001 to 8.29 m/s (56.2 m) at Mast 8026. The annualized mean speeds, which take into account repeated months in the data record and weights each calendar month by its number of days, ranged from 7.85 m/s (56.0 m) at Mast 9001 to 8.41 m/s (56.2 m) at Mast 8026.

The wind shear exponent represents the rate of increase of wind speed with height above ground according to the power law (described in Section 6). The annualized shear exponents, which ranged

3 Filippelli, M.V., et al., "*Adjustment of Anemometer Readings for Energy Production Estimates*", Proceedings of Windpower 2008, June 2008.

from 0.245 (Mast 9001) to 0.278 (Mast 8026), were calculated from the mean wind speeds at the monitoring levels listed in Table 4 based on concurrent valid records at both heights. Only wind speeds greater than 4 m/s, the range of interest for energy production, were used in the calculations.

The turbulence intensity measures fluctuations in the wind speed recorded by the anemometer in each 10-minute interval as a fraction of the average speed. The observed turbulence intensities at 15 m/s, which ranged from 0.091 (56.2 m) at Mast 8026 to 0.094 (56.0 m) at Mast 9002, are low and consistent with the site's surface roughness.

The Weibull function is an analytical curve that describes the wind speed frequency distribution, or number of observations in specific wind speed ranges. Its two adjustable parameters allow a reasonably good fit to a wide range of actual distributions. *A* is a scale parameter related to the mean wind speed while *k* controls the width of the distribution. Values of *k* typically range from 1 to 3.5, the higher values indicating a narrower distribution. The annual *k* values, which ranged from 2.78 (56.0 m) at Mast 9001 to 3.01 (56.2 m) at Mast 8026, indicate a reasonable steady wind resource. Figure 4 contains a chart showing the observed annual frequency distribution and fitted Weibull curve for Mast 9001.

Monthly patterns of variation are also useful indicators of the wind resource. The observed pattern of monthly mean wind speeds at Mast 9001 is presented in Figure 5. Also plotted in this figure are the concurrent and historical monthly mean wind speeds from the NASA MERRA-2 dataset.[4] The concurrent wind speeds from the two datasets track each other reasonably well. The historical record of MERRA-2 indicates that the strongest winds normally occur during the spring, while the weakest winds occur during the summer. The range of variation in the observed monthly average wind speeds at Mast 9001 is about 2.9 m/s.

Figure 6 depicts the variation in average wind speed with time of day at Mast 9001 at 56.0 m, along with the variation in mean wind shear exponent. The mast data indicate the average wind speed is highest during the late night hours while the average wind shear exponent varies from a minimum during the midday to a maximum during the early morning hours. Considering the mean speed and shear patterns, it is likely that energy production at this site will ordinarily peak during the late night hours.

The directional distribution of the wind resource is an important factor to consider when designing the wind project to minimize the wake interference between turbines. The annual wind frequency and energy by direction plots (wind rose) for each mast are shown in Figure 7. The wind roses indicate that the prevailing wind direction is from the south through west.

The air density directly affects the energy production: the greater the density, the greater the power output of a wind turbine for the same speed distribution. The estimated energy-weighted air density at Mast 9001, 1.044 kg/m^3, was calculated from the following equation:

$$\rho = \frac{P_o e^{\left[-\frac{gz(1.0397-0.000025z)}{RT}\right]}}{RT}$$

where

4 See Section 5 for a complete description of the global dataset.

ρ = Air density (kg/m³)
P_0 = Standard sea-level atmospheric pressure in Pascals (101325 Pa)
R = Specific gas constant for dry air (287 J/Kg·K)
T = Air temperature (K)
g = Acceleration due to gravity (9.8 m/sec^2)
z = Elevation of temperature sensor (m)

This equation was applied to each 10-minute data record, and a weighted average was calculated in which the weight was proportional to the energy content of the wind.

5. ESTIMATION OF LONG-TERM MEAN WIND SPEED AT MAST HEIGHT

Since the wind climate can vary considerably over time scales of months to years, it is important to adjust the data collected at a site to represent historical wind conditions as closely as possible. The method we used to make this adjustment is known as measure-correlate-predict, or MCP. In MCP, a linear regression or other relationship is established between two meteorological stations (or other sources of wind data, such as modeled data). One, the target site, spans a relatively short period and the other(s), the reference site(s), spans a much longer period. The complete record at the reference station would then be applied to this relationship to estimate the long-term historical wind climate at the target site.

Normally, the most important factor determining the success of MCP is the choice of reference station(s), particularly the quality of its relationship with the target site (which should ideally be linear with a high correlation coefficient) and the consistency and length of the reference data record.[5] In addition, when much less than a full year of data is available from the target site, it is necessary to consider the possibility that a seasonal change in the relationship between the target site and reference may bias the climatological adjustment.

We obtained historical wind speed data from the following monitoring stations that are part of the National Weather Service (NWS) Automated Surface Observing System (ASOS), Federal Aviation Administration (FAA) Automated Weather Observing System (AWOS), and the Western Regional Climate Center (WRCC) Remote Automatic Weather Station (RAWS) monitoring networks and assessed their suitability as long-term references:

- Amarillo, Texas ASOS: January 1997 – November 2016
- Artesia, New Mexico AWOS: January 1999 – November 2016
- Carlsbad, New Mexico ASOS: December 2000 – November 2016
- Clines Corner, New Mexico ASOS: May 1998 – November 2016
- Eight Mile Draw, New Mexico RAWS: January 1997 – November 2016
- Lubbock, Texas ASOS: January 1997 – November 2016
- Melrose Range, New Mexico AWOS: December 2010 – November 2016
- Roswell, New Mexico ASOS: January 1997 – November 2016
- Tucumcari, New Mexico ASOS: September 2000 – November 2016

5 Taylor, Mark, et al., "*An Analysis of Wind Resource Uncertainty in Energy Production Estimates*", Proceedings of the European Wind Energy Conference, November 2004.

The locations of the potential reference stations are indicated on the regional map in Figure 1. Hourly wind speed, direction, and temperature data for each ASOS station were obtained from the National Climatic Data Center (NCDC). Beginning in September 2002, a nation-wide initiative was conducted to replace the anemometers at the ASOS stations with standard, ultra-sonic, ice-free wind (IFW) sensors. This was done to eliminate the effects that freezing precipitation has on the wind speed and direction measurements. Side-by-side tests indicate that the IFW sensor records lower speeds than the cup anemometer. Unless accounted for, this shift may introduce a positive bias in the long-term adjustment.[6] We therefore adjusted the ASOS wind speed data collected using cup anemometers to the IFW standard by incorporating an empirical relationship developed in-house by AWS Truepower based on side-by-side measurements from the two sensor types.

In addition to these measured data sources, data were also assessed from several global datasets:

- **Modern-Era Retrospective Analysis for Research and Applications (MERRA-2):** MERRA-2, which was developed by the National Aeronautics and Space Administration (NASA), utilizes a variety of observing systems which have been assimilated into a global three-dimensional grid by numerical atmospheric models at a horizontal resolution of 1/2° latitude and 2/3° longitude.
- **ERA-Interim (ERA-I):** ERA-Interim, which was developed by the European Centre for Medium-Range Weather Forecasts (ECMWF), utilizes a variety of observing systems which have been assimilated into a global three-dimensional grid by numerical atmospheric models at a spectral resolution of T255, or an approximate horizontal resolution of 79 km.

The global datasets can be interpolated to the exact location of a meteorological mast. For this analysis, the model output for the four nearest grid cells were interpolated to the location of Mast 9001, the mast with the longest valid period of record.

Although earlier data may exist for each surface station and global dataset, no data prior to January 1997 were utilized in this analysis. For stations with significantly longer data records, this mitigates the potential impact that longer-term trends could have on the climatological adjustment, while still providing the most significant benefit of the MCP process.

Linear regression equations were established using concurrent daily mean wind speeds at Mast 9001 and each potential reference. The strongest correlation was found with the MERRA-2 dataset ($r^2 = 0.79$); the remaining sites had r^2 values between 0.38 (Amarillo and Roswell) and 0.77 (ERA-I). Table 5 contains a summary of the regression results.

Figure 8 presents the respective time series of annual mean wind speeds from Roswell, Tucumcari, Carlsbad and the MERRA-2 dataset between 1997 and 2016. This plot was created to determine whether any abrupt changes or significant trends in mean wind speed occurred during the reference periods of record. A discontinuity in the surface-based data could indicate a problem with the measurement equipment or a relocation of the anemometry, whereas a statistically significant trend or abrupt changes in wind speed could be a sign of changing conditions around the station, such as tree growth/removal, or poor maintenance of the anemometer. A discontinuity or abnormal trend in modeled data could indicate a change in the source data or the analytical techniques used to estimate the wind speed. Any of these conditions would call into question the validity of the climatological adjustment. The Tucumcari ASOS station was eliminated from consideration since it observed higher

6 Lewis, R. and J. Dover, "*Field and Operational Tests of a Sonic Anemometer for the Automated Surface Observing System*", Eighth Symposium on Integrated Observing and Assimilation Systems for Atmosphere, Ocean, and Land Surface, Jan. 10-15, Amer. Meteor. Soc., Seattle, WA.

wind speeds relative to the other reference sources beginning around calendar year 2010. The time series of the other references track each other reasonably well and show no inconsistent trends. We therefore selected MERRA-2 to estimate the long-term mean wind speed at Mast 9001. The regression equation between Mast 9001 and MERRA-2 is as follows.

Mast 9001 56-m Wind Speed = (MERRA-2 50-m Wind Speed * 1.010) + 0.902 m/s.

The annualized mean wind speed at MERRA-2 is 6.75 m/s. Substitution of this value into the above equation yields a 56-m long-term mean wind speed of 7.72 m/s at Mast 9001. This value is about 1.8% lower than the observed annualized mean wind speed, indicating that the wind speeds recorded during the measurement period were above the climatological average during the reference period of record. A scatterplot showing the relationship between the observed daily mean wind speeds at Mast 9001 and from the MERRA-2 dataset is contained in Figure 9.

The climate-adjusted wind speeds at the remaining masts were estimated using a similar technique, but with Mast 9001 now serving as the reference. The regressions were performed using concurrent hourly wind speeds; the r^2 values are 0.91 (Mast 8026) and 0.93 (Mast 9002). Substitution of the estimated long-term speed at Mast 9001 into the respective regression equations yields long-term mean wind speeds of 7.88 m/s at Mast 8026 (56.2-m) and 7.75 m/s at Mast 9002 (56-m). The equations and speed projections are summarized in Table 6.

Satellite imagery and publicly available data indicate existing turbines associated with a nearby operational wind farm located north and northwest of the proposed Sagamore Wind Project. These turbines, the nearest of which is located approximately 10 km from Masts 8026 and 9002, have been operating since December 2015, which is after to mast installation. The Openwind® software Deep Array Wake Model – described in more detail in Section 7 – was used to model the impact these turbines have on the observed speeds at the onsite mast location. The modeling results suggest that the observed mean wind speeds at the masts were not reduced due to the operating wind farm being located in a non-prevailing wind direction. We therefore did not adjust the estimated long-term wind speed at the masts.

We also used MCP – with Roswell serving as the reference – to adjust the temperature data collected at Mast 9001 to the historical average. The historical annual mean temperature at the mast is estimated to be 287.4 K (14.3°C) at 3 m, which is slightly lower than the annualized mean of 287.8 K (14.7°C) observed during the period of record. Assuming the standard atmospheric temperature lapse rate of 6.5 K per 1000 m, the corresponding long-term average at the mean turbine hub height elevation is 287.2 K (14.1°C). This value is an input into the calculation of the long-term site average air density as described in Section 7.

6. EXTRAPOLATION TO HUB HEIGHT

The mean wind speed was extrapolated to the anticipated 80-m hub height using the power law equation:

$$U = U_O(Z/Z_O)^{\rho}$$

where

U = the unknown wind speed at height Z above ground;
U_0 = the known speed at a reference height Z_0; and
p = the shear exponent.

This equation is an empirical relationship that is widely employed in wind resource assessment. Often, the main challenge is to determine the shear exponent between the top anemometer on the mast and the turbine hub height. A common assumption is that the shear exponent does not change with height. We believe this is a reasonable assumption for the project given the low surface roughness and our regional experience. The data recorded at Mast 8026 between the 56.2-m and 30.0-m levels suggested a relatively high wind shear exponent when compared to the other masts. The wind shear exponent was reduced by 10% to better align with the other masts and to prevent its wind speed diverging with height with respect to the other masts. No changes were made to the observed annualized shear exponents at Masts 9001 and 9002.

The shear values were then used to extrapolate the mast top speeds to the requested hub height. The resulting projected 80-m hub-height mean wind speeds ranged from 8.42 m/s at Mast 9001 to 8.61 m/s at Mast 8026. The hub-height wind speed projections are summarized in Table 7. Although we applied constant shears in these calculations, the shear exponents computed for each individual 10-minute record at each mast were used to create the hub-height wind speed frequency distributions for the wind flow modeling and energy production calculations.

7. ESTIMATION OF LONG-TERM ENERGY PRODUCTION

The energy production of the proposed Sagamore Wind Project was estimated using the Openwind software. Openwind was developed by AWS Truepower as an aid for the design, optimization, and assessment of wind power projects.[7] The primary input is a wind resource grid generated by a numerical wind flow model, in this case the SiteWind® system. Other inputs include elements of the project design such as the turbine locations, hub height, power curve, and thrust coefficients, as well as the mast data. The SiteWind system and Openwind software and their applications in this project are briefly described below.

The SiteWind System

Numerical wind flow models are used to calculate the wind resource variation across a project area due to changes in terrain and surface roughness. AWS Truepower has developed the SiteWind system to perform these calculations. SiteWind employs both mesoscale and microscale models to simulate the wind climate over a wide range of scales. The mesoscale model assesses regional climate conditions and simulates complex meteorological phenomena such as katabatic (downslope) mountain winds, channeling through mountain passes, lake and sea breezes, low-level jets, and temperature inversions. The microscale model accounts for the localized influences of topography and surface roughness changes and produces a detailed wind resource map and grid. As a final step, the predicted speed and direction are adjusted with onsite data from masts within the project area. This method has been found to be more accurate on the whole than microscale wind flow models alone.[8]

7 "*Openwind – Theoretical Basis and Validation*", Version 1.3, AWS Truewind, LLC, April 2010.

8 Beaucage, Philippe and Brower, Michael C, "*Wind Flow Model Performance – Do More Sophisticated Models Produce More Accurate Wind Resource Estimates*?", 6 February 2012.

The mesoscale model used for this project was the open-source Weather Research and Forecasting (WRF[9]) model. WRF is a state-of-the-art numerical weather prediction (NWP) model designed to simulate synoptic and mesoscale atmospheric circulations. WRF was developed by several organizations, including NCAR, NOAA (NCEP), AFWA, the Naval Research Lab, the University of Oklahoma, and the FAA in the early 2000's. The WRF model is updated frequently with new versions released twice annually, and can use analysis or reanalysis datasets for initialization.

The WRF simulations were initialized by the ERA-Interim[10] reanalysis dataset. Several studies by AWS Truepower[11] and others[12,13] show that the third generation reanalysis datasets, such as ERA-Interim, have superior accuracy in terms of their correlation to meteorological mast data. AWS Truepower uses a dynamical downscaling approach with nested grids of 27, 9, 3 and 1 km resolution. The 1-km resolution WRF model outputs were then coupled to WindMap – a microscale mass-conserving model – which was run on a grid scale of 50 m.[14] Finally, the WindMap outputs, which include a Wind Resource Grid (WRG), were adjusted to the wind speed and direction distribution at the masts within the project area. This last step was performed within Openwind and the resulting wind resource map is shown in Figure 10.

The SiteWind system performance can be independently validated by adjusting the wind map to the long-term hub-height wind speed at a single mast and comparing the map projections at other onsite locations with the long-term adjusted wind speed estimates. The standard deviation of the map biases at each mast location – called the unbiased map error – is used to quantify the accuracy of the modeled wind map. The unbiased map error, along with an evaluation of the terrain complexity, variation in predicted spatial wind resource, and the location of the meteorological towers with respect to the proposed turbine locations, are all considered when assessing the modeling uncertainty for a given site. The unbiased map error calculation will not produce a statistically significant result if too few data samples are used in the calculation. In the case of Sagamore, the use of the unbiased map error metric is limited due to the number of masts; therefore the other metrics are relied on more heavily.

Openwind

Once the wind resource model has been run, the resource grid file is imported into Openwind to define the wind resource for the project area. The Weibull parameters in the file are converted to directional speed-up ratios relating the wind speed at each grid point to the speed at a reference mast. By associating the model data to a wind speed histogram file for the reference mast, the program is able to adjust the modeled speed distribution to the true speed distribution observed at a point. This method usually produces a more accurate estimate of the energy production than relying on the modeled distributions alone.

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9 Skamarock, W. C. (2004). "Evaluating Mesoscale NWP Models Using Kinetic Energy Spectra". *Mon. Wea. Rev.,* vol. 132, pp. 3019-3032.

10 Dee, D. P., and Coauthors (2011). "The ERA-Interim reanalysis: configuration and performance of the data assimilation system". Q.J.R. Meteorol. Soc., vol. 137, pp. 553–597

11 Brower, M.C, M.S. Barton, L. Lledo, and J. Dubois (2013)."A study of wind speed variability using global reanalysis data". Technical report from AWS Truepower. 11 pp. Available at: https://www.awstruepower.com/knowledge-center/technical-papers/

12 Lileo, S. and O. Petrik (2011). "Investigation on the use of NCEP/NCAR, MERRA and NCEP/CFSR reanalysis data in wind resource analysis". Presentation given at the EWEA conference, Brussels, Belgium

13 Decker, M., M.A. Brunke, Z. Wang, K. Sakaguchi, X. Zeng, and M.G. Bosilovich (2012). "Evaluation of the Reanalysis Products from GSFC, NCEP, and ECMWF Using Flux Tower Observations". Journal of Climate, Vol. 25, pp. 1916-1944

14 WindMap, developed by AWS Truepower, is a mass-conserving model that adjusts an initial wind field, here supplied by WRF, in response to local variations in topography and surface roughness. See, e.g., Michael Brower, "*Validation of the WindMap Model*", Proceedings of WindPower 1999, American Wind Energy Association, June 1999.

A number of reference masts can be used to reduce errors in the predicted spatial variation of the wind resource across the project area. Conventionally, the project area is broken up into sub-regions, each of which is associated with a different mast using a distance-weighted interpolation between all masts. This avoids discontinuities in wind speeds across the boundaries of areas assigned to different masts and produces a more realistic picture of the spatial variation of the wind resource. Within Openwind, the adjusted wind resource grid is divided into sub-regions associated with different masts to capture variations in the observed speed frequency distribution, although the corresponding impact on energy production estimates is usually relatively small.

AWS Truepower uses the Openwind Deep Array Wake Model (DAWM) to calculate wake losses. This model actually contains two separate wake models operating independently. The first is the Eddy Viscosity model, which is based on the thin-shear-layer approximation of the Navier-Stokes equations assuming axisymmetric wakes of Gaussian cross-sectional form, as originally postulated by Ainslie.[15] The model equations ensure that momentum and mass conservation are observed simultaneously. As inputs, the wake model requires the ambient turbulence intensity at hub height, which influences the initial wake deficit behind each turbine and the rate of wake dissipation; the speed and direction frequency distribution, based on a wind resource grid and associated mast files; the locations of the turbines; and the turbine thrust coefficient curves. Validation of the Openwind Eddy Viscosity model is described elsewhere.[7]

In response to evidence that conventional wake models like the Eddy Viscosity model underestimate wake losses in deep (multi-row) arrays of wind turbines, especially offshore, AWS Truepower implemented a second model designed to handle such situations. This model is loosely based on a theory developed by Frandsen,[16] who postulated that the effect of a deep array of wind turbines on the atmosphere could be represented as a region of increased surface drag, represented by a surface roughness length. Where the wind first impinges on the array, an internal boundary layer (IBL) is created, within which the wind profile is determined by the array roughness rather than by the ambient roughness. This IBL grows with downwind distance, and once its height exceeds the turbine hub height, the hub-height speed impinging upon turbines farther downwind is progressively reduced. According to the Frandsen theory, the effective array roughness is in the range of 1 m to 3 m, or typical of a forest, for mid-range speeds and typical turbine spacings. AWS Truepower modified the Frandsen model to treat each turbine as an isolated island of roughness, a necessary change to permit rapid modifications to the turbine layout for array optimization. In addition, the IBL created by each turbine is assumed to be centered on the turbine's hub height.

In combining the two models, the DAWM implicitly defines "shallow" and "deep" zones within a turbine array. In the shallow zone, the direct wake effects of individual turbines dominate, and the unmodified Eddy Viscosity (EV) model is used to calculate wake deficits; in the deep zone, the deep-array effect is more prominent, and thus, the roughness model is employed. The DAWM has been validated at several offshore and onshore projects.[17]

Results

15 Ainslie, J.F., "*Calculating the flowfield in the wake of wind turbines*", Journal of Wind Engineering and Industrial Aerodynamics, 1988, Pages 213-224.

16 Sten Tronæs Frandsen, "*Turbulence and turbulence-generated structural loading in wind turbine clusters*", Risø-R-1188(EN), Risø National Laboratory, January 2007.

17 Brower, Michael C. and Robinson, Nicholas M., "*The openWind Deep Array Wake Model – Development and Validation*", May 2012.

The energy production was simulated for the Vestas V110-2.0 MW turbine with a 110-m rotor diameter and the Vestas V116-2.0 MW turbine with a 116-m rotor diameter, both at an 80-m hub height. The turbine layout, which was provided by Xcel, is shown in Figure 10. Each turbine in the layout was associated with the wind speed and direction distribution file from Mast 8026, the mast closest to the proposed layout.

The average air density was calculated from the wind speed and temperature data at Mast 9001 and adjusted to the mean elevation of the turbines using a standard atmospheric lapse rate. The result was 1.052 kg/m^3, with a range from 1.049 kg/m^3 to 1.056 kg/m^3 across the turbine array. The Vestas V110-2.0 MW[18] and Vestas V116-2.0 MW[19] power curves used as input to Openwind were provided to AWS Truepower by Xcel on 05 July 2016 and 26 January 2017, respectively; these power curves are provided in Table 8 and

18 Power Curve Version: 0059-4888 V01_31May2016

19 Power Curve Version: 0063-8370 V00_04Jan2017

Table 9. Any necessary extrapolations of power curve data to accommodate the site specific air densities were conducted automatically within Openwind based on standard IEC methods.

Plant losses were estimated based on AWS Truepower's assessment of the actual performance of operating wind plants and an analysis of site-specific conditions.[20] Our loss estimates for six broad categories (along with an itemized summary of turbine production) are presented in

Table 10; a detailed breakdown and explanation for each is contained in Appendix A. The wake loss was calculated by Openwind to be 7.5%. This value was estimated by taking into account not only the impact of the proposed turbine wakes on each other, but also the estimated impacts from the operational Roosevelt and Milo turbines. The locations of these surrounding turbines are included in Figure 10. Including other plant losses totaling 12.8%, the total loss is estimated to be 19.4%. Energy consumption of the maintenance building, auxiliary equipment within the substation, and site lighting are not included in this analysis. Typically, these are an insignificant fraction of the plant energy production. Since they are often metered separately from plant production, they are typically treated as an operational cost within the financial model.

8. UNCERTAINTY ANALYSIS

The following is a summary of the uncertainty elements associated with the wind speed and energy production estimates. For this purpose, the uncertainty is defined as the standard error for a normal probability distribution. All uncertainties are associated with Mast 0826.

1. Site Documentation and Verification (0.3%): This uncertainty addresses the quality and independence of the available information describing the site characteristics and monitoring equipment. Specific items considered include the quality and comprehensiveness of tower commissioning and verification documents; the quality and number of photographs depicting each mast and its surroundings; and information regarding obstacles potentially affecting the wind flow at each mast.

2. Wind Speed Measurements (1.0%): This is the uncertainty in anemometer readings of the free-stream wind speed. It reflects not just uncertainty in the sensitivity of the instruments when operating under wind-tunnel conditions, but also uncertainty in their performance in the field, where they may be subject to turbulent and off-horizontal winds, tower effects, and problems such as icing that may be missed in the validation. In addition, where applicable, the uncertainty in empirical adjustments applied to account for factors such as turbulence or the impact of wakes from existing turbines on observed wind speeds is considered.

20 Dan Bernadett, et al., "*2012 Backcast Study: A Review and Calibration of AWS Truepower's Energy Estimation Methods*", AWS Truepower May 2012.

3. Long-Term Average Speed (1.5%): This uncertainty addresses how accurately the site data, after the MCP adjustment, may represent the historical average wind resource. AWS Truepower has undertaken a study of wind speed interannual variability and has produced an interannual variability map using the global ERA-Interim reanalysis dataset.[21] The map suggests that the standard deviation of annual mean wind speeds for the Sagamore Wind Project is about 3.9%. It is assumed that the annual mean varies randomly according to the normal distribution, and thus the error margin varies inversely with the square root of the number of years. The estimated uncertainty accounts also for the degree of correlation between the target and reference stations, the length of the reference period of record, and the data recovery at each mast.

4. Evaluation Period Wind Resource (1.3%): This uncertainty is associated with how closely the wind resource over the evaluation period may match the long-term site average. The estimated value assumes a 10-year evaluation period, 3.9% interannual variation in the mean speed, and 0.5% uncertainty associated with possible climate oscillations and trends.

5. Wind Shear (1.1%): The wind shear uncertainty includes the uncertainty in the observed shear due to possible measurement errors and the uncertainty in the change in shear above mast height. The estimated value considers the site conditions, anemometer heights, hub height, and measurement uncertainties at the mast.

6. Wind Flow Modeling (4.5%): The uncertainty in the array-average free-stream wind speed at the turbines, relative to the masts, depends on the wind climate, terrain complexity and vegetation height and variation, characteristics of the wind flow model, and number of masts used to adjust the resource grid and their placement relative to the turbine layout.

7. Wind Speed Frequency Distribution (1.1%): Like the mean speed, the wind speed frequency distribution varies over time. Our research indicates that the interannual variability of the energy production directly related to the wind speed frequency distribution is typically about 1.4%. The estimated uncertainty in the long-term energy production estimate considers this factor along with the onsite period of record and the length of the evaluation period.

8. Plant Losses (3.5%): AWS Truepower has used operational data to quantify the uncertainties associated with our estimates for plant availability, electrical, and turbine performance losses for the evaluation period, as well as for the first year and any subsequent year.[20] When these values are combined with the estimated uncertainties due to environmental factors and directional curtailment, the plant operational loss uncertainty is estimated to be 3.2% over the 10-year evaluation period. (Uncertainties associated with grid curtailment losses are not considered here.) In addition, based on the DAWM validation findings,[7] we estimate the uncertainty in the wake loss calculations to be 20% of the total wake loss, or 1.5%. The operational and wake loss uncertainties are combined as the square root of the sum of their squares.

The following steps were taken to determine the energy production at various desired confidence levels:

21 Michael C. Brower, et al., "A Study of Wind Speed Variability Using Global Reanalysis Data", AWS Truepower, May 2013.

- The uncertainty percentages in wind speed were combined as the square root of the sum of squares and multiplied by the predicted array-average mean speed to determine the uncertainty of the array-average mean speed. The result is 5.1%, or 0.45 m/s.
- The sensitivity of the project energy output to changes in wind speed was determined to be approximately 5.3% for the given 5.1% uncertainty in mean wind speed. This ratio was calculated by comparing the energy output of a turbine at the predicted array-average wind speed of 8.68 m/s to the output of a turbine with an average speed of 8.23 m/s (predicted speed minus uncertainty).
- The sensitivity of the project output to changes in wind speed was multiplied by the wind speed uncertainty to estimate the corresponding uncertainty of the project energy output.
- The uncertainty in plant losses and wind speed frequency distribution were combined with the previous total using the square root of the sum of squares.
- Assuming a normal distribution of errors, we calculated the energy production levels that would be exceeded by the project with 75%, 90%, 95%, and 99% confidence.

The total and individual uncertainties for the project evaluation period (years 2-10) are shown in Table 11. The overall uncertainty margin in the energy production is 6.4%, or 153.6 GWh/yr. Table 12 presents the estimated net annual energy production and capacity factor at five confidence levels assuming a 9-year mature operation evaluation period and the same for the first year and for any single year thereafter.

9. SUMMARY

The long-term wind resource at the proposed Sagamore Wind Project was estimated using data from three onsite masts and correlation with NASA's MERRA-2 dataset. The site's energy production was simulated using a wind resource grid developed using the SiteWind system, the Openwind software, a wind turbine layout provided by Xcel, and the Vestas V110-2.0 MW turbine with a 110-m rotor diameter and the Vestas V116-2.0 MW turbine with a 116-m rotor diameter, both at an 80-m hub height and site average air density of 1.052 kg/m^3. The total wind plant loss is estimated to be 19.4%. Over the evaluation period, the net plant output is expected to average at least 2,136.7 GWh/yr, or 46.7% capacity factor, with 95% confidence. Following the first year of operation, the annual net plant output in any given year is expected to be at least 1,942.8 GWh, or 42.5% capacity factor, with 99% confidence. The expected average annual net production and capacity factor for the project are 2,389.4 GWh and 52.2%, respectively, and the predicted array-average wind speed is 8.68 m/s.

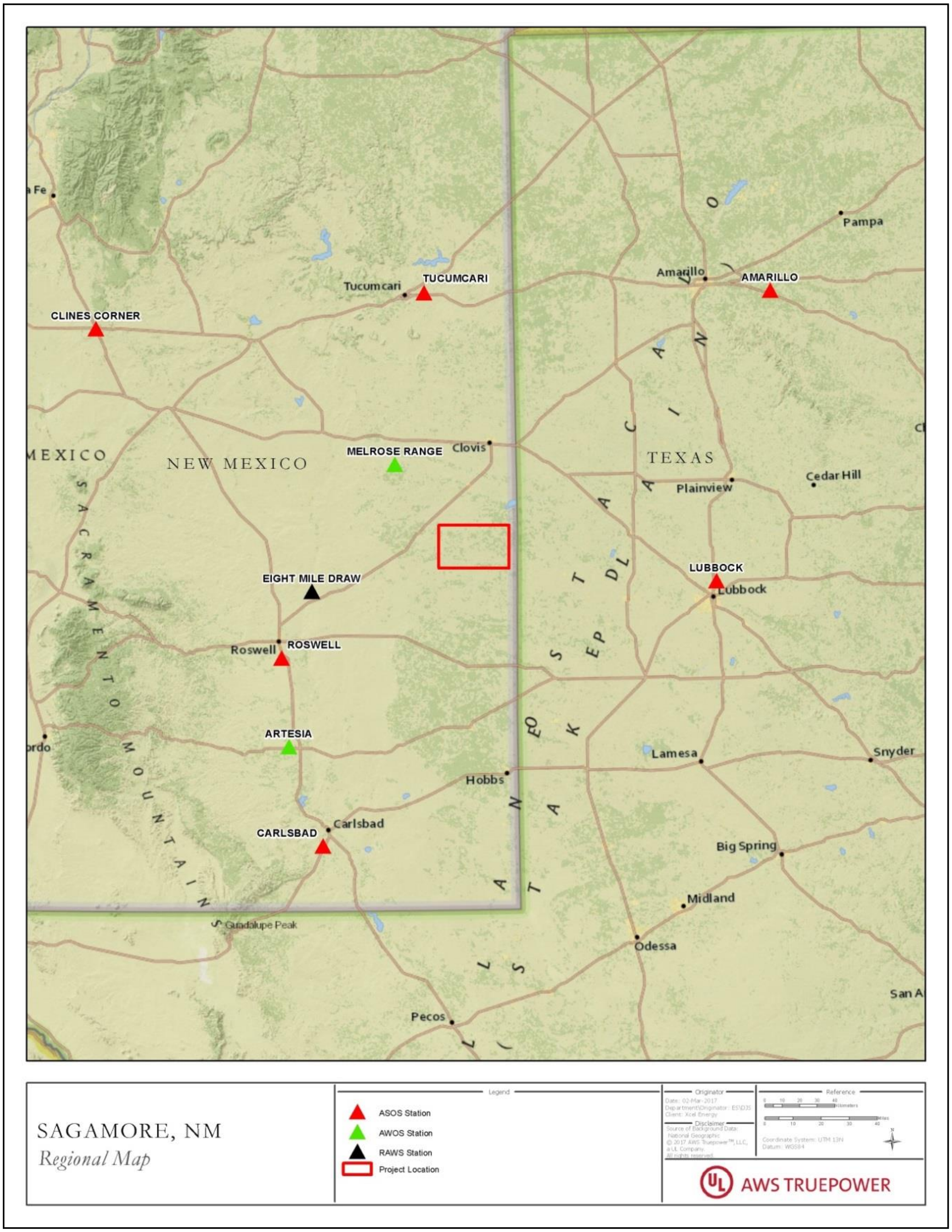


Figure 1. Location of the Proposed Sagamore Wind Project in New Mexico

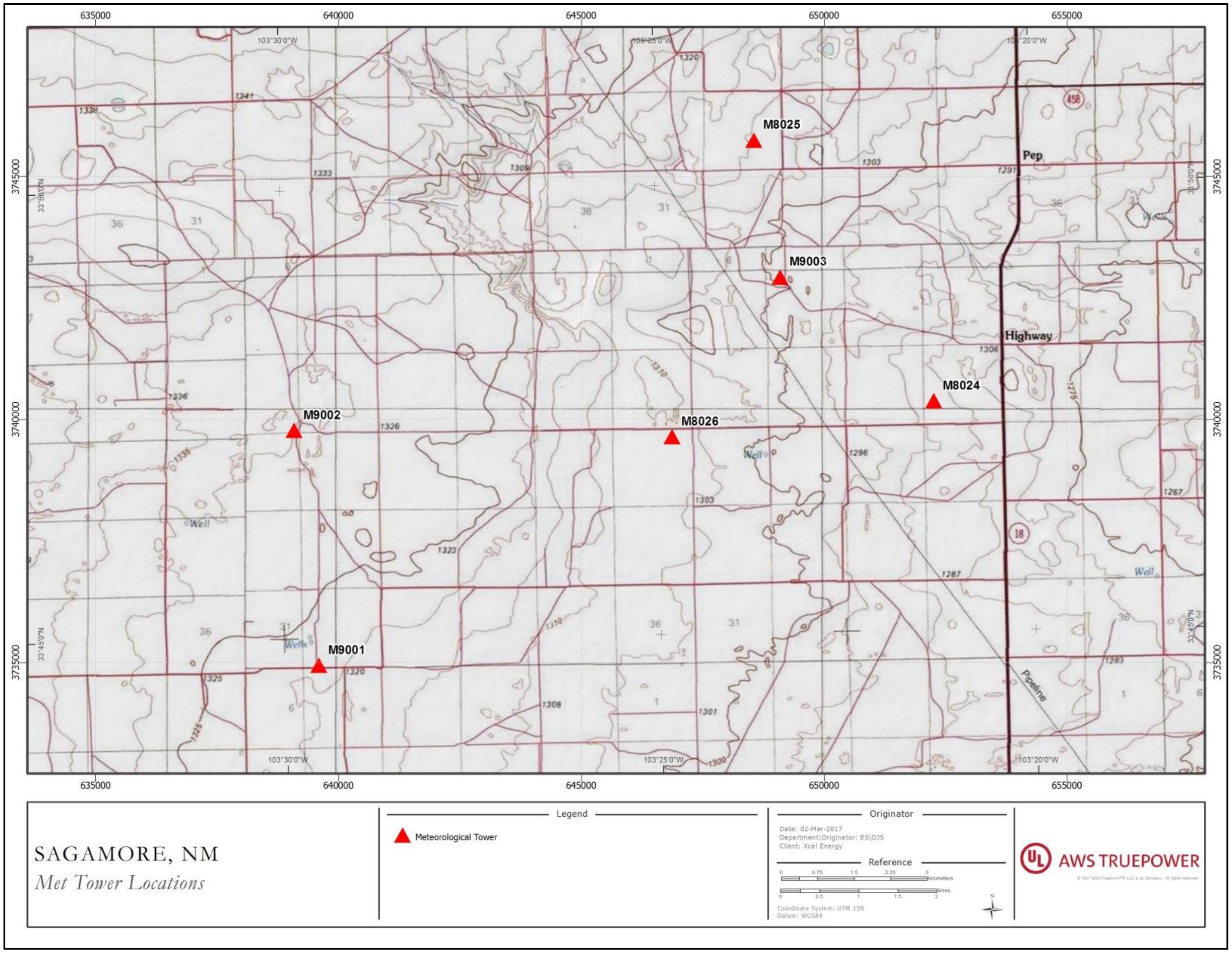


Figure 2. Sagamore Monitoring Mast Locations

Figure 3. Mast 8026 Monitoring Configuration

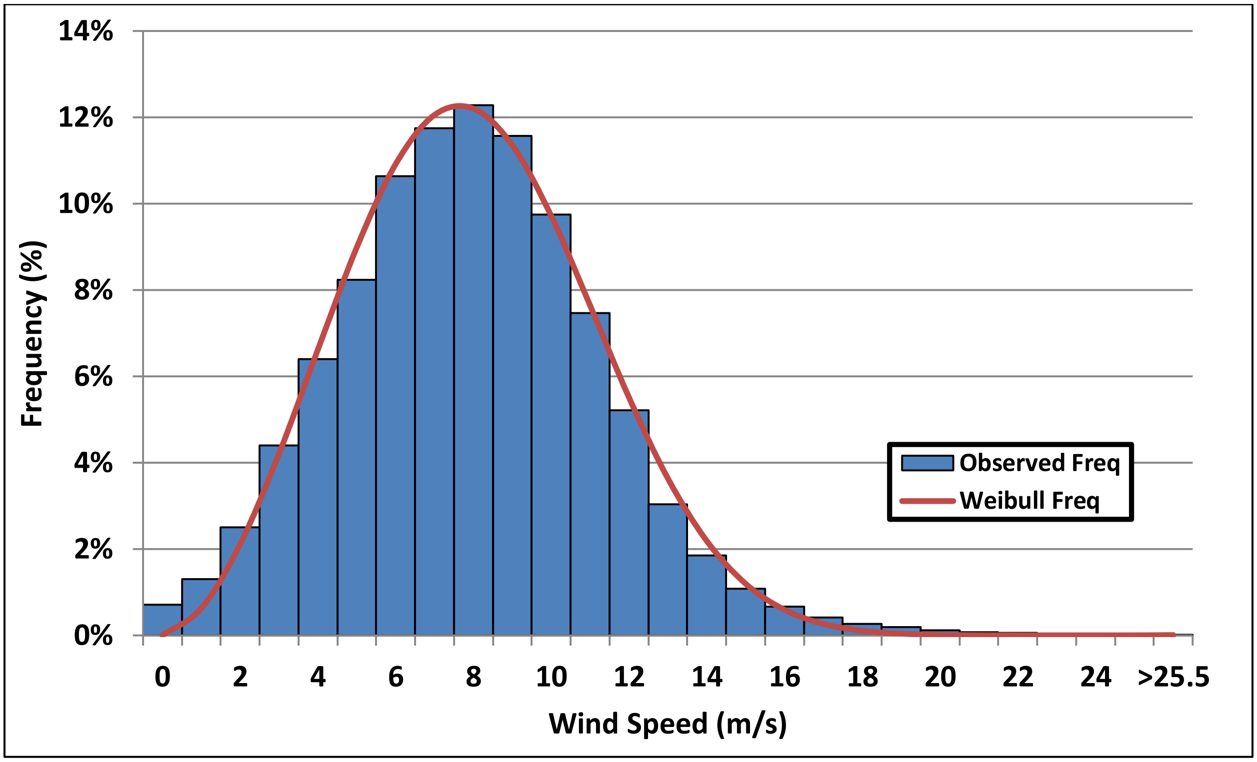


Figure 4. Mast 9001 Mast Observed Annual Wind Frequency Distribution and Fitted Weibull Curve

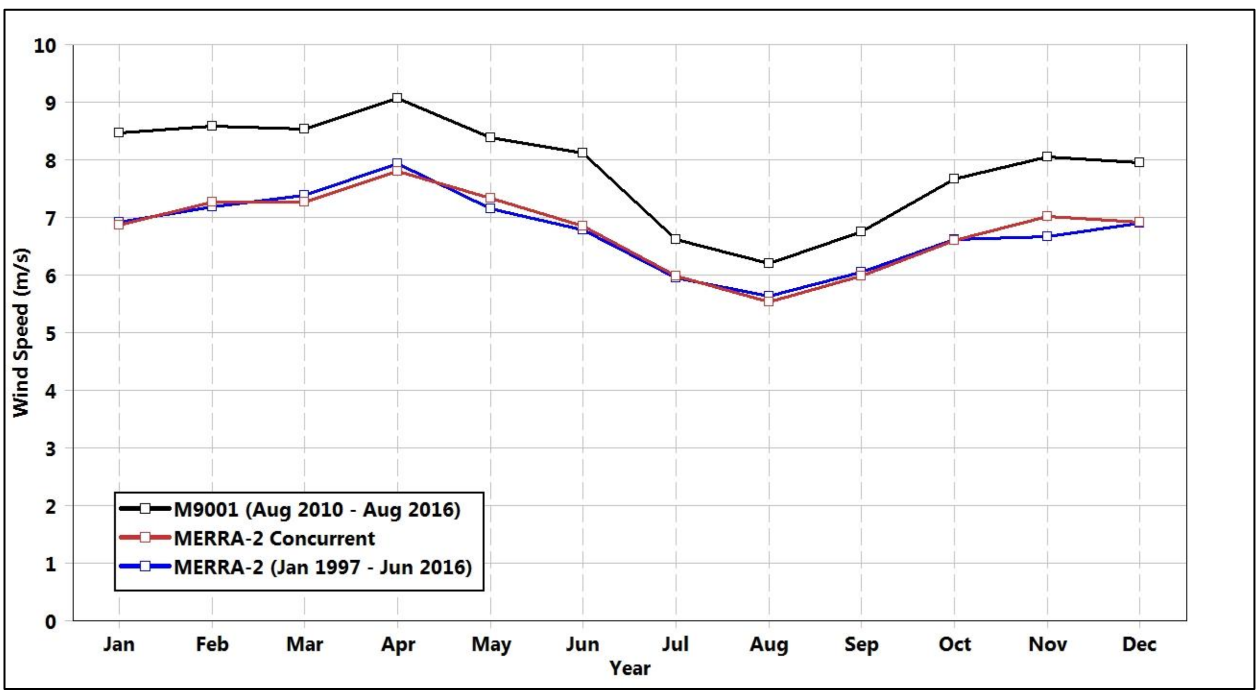


Figure 5. Mast 9001 and MERRA-2 Concurrent and Historical Monthly Mean Wind Speeds

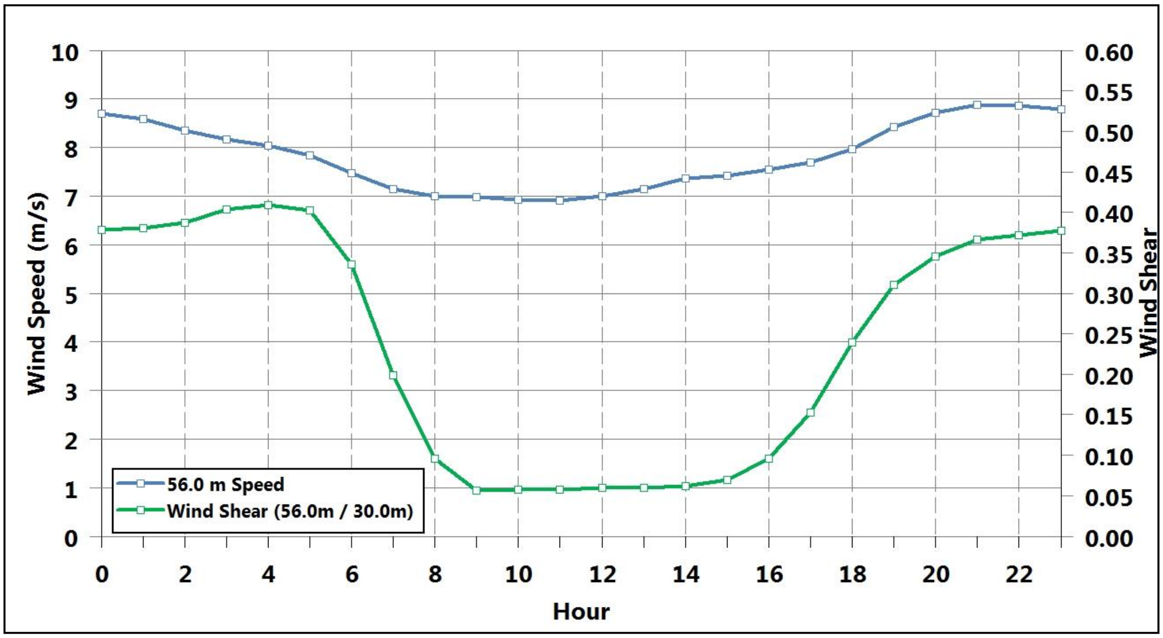
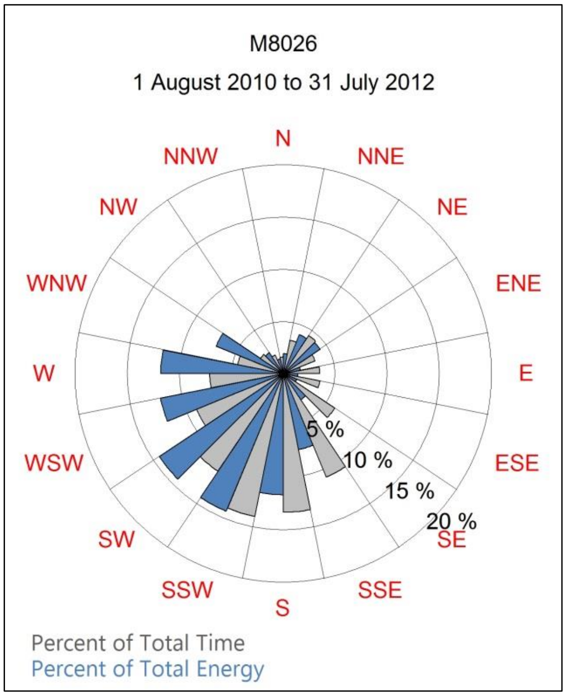
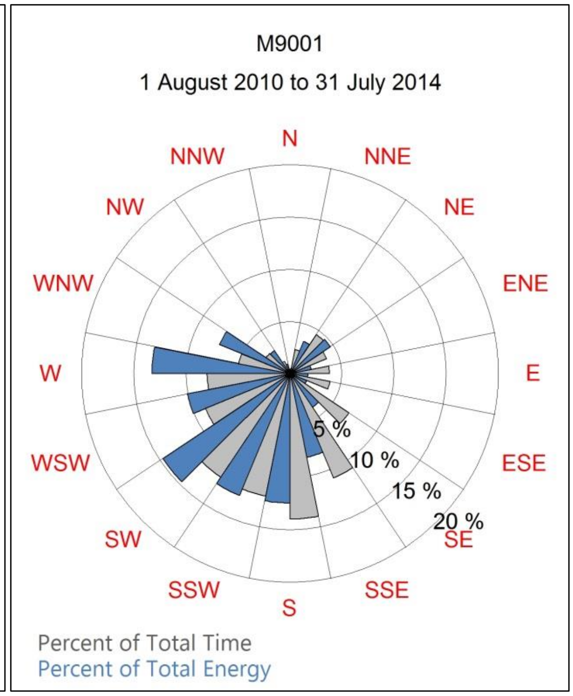


Figure 6. Mast 9001 Annual Diurnal Wind Speed and Shear Patterns





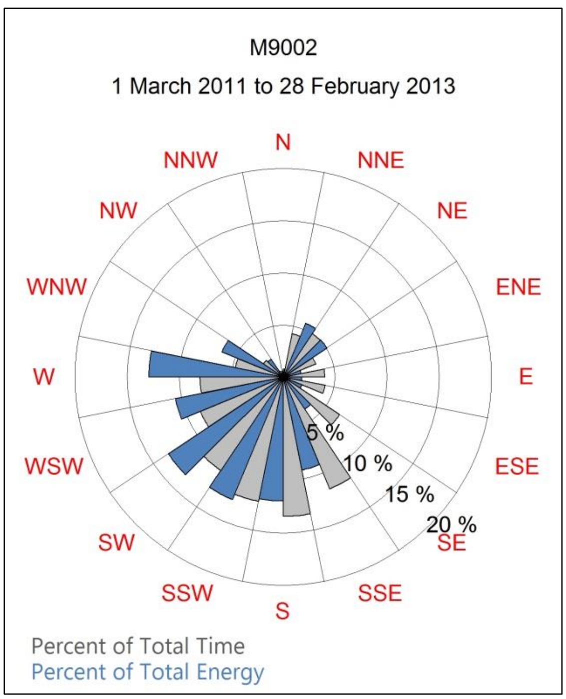


Figure 7. Monitoring Mast Annual Wind Roses

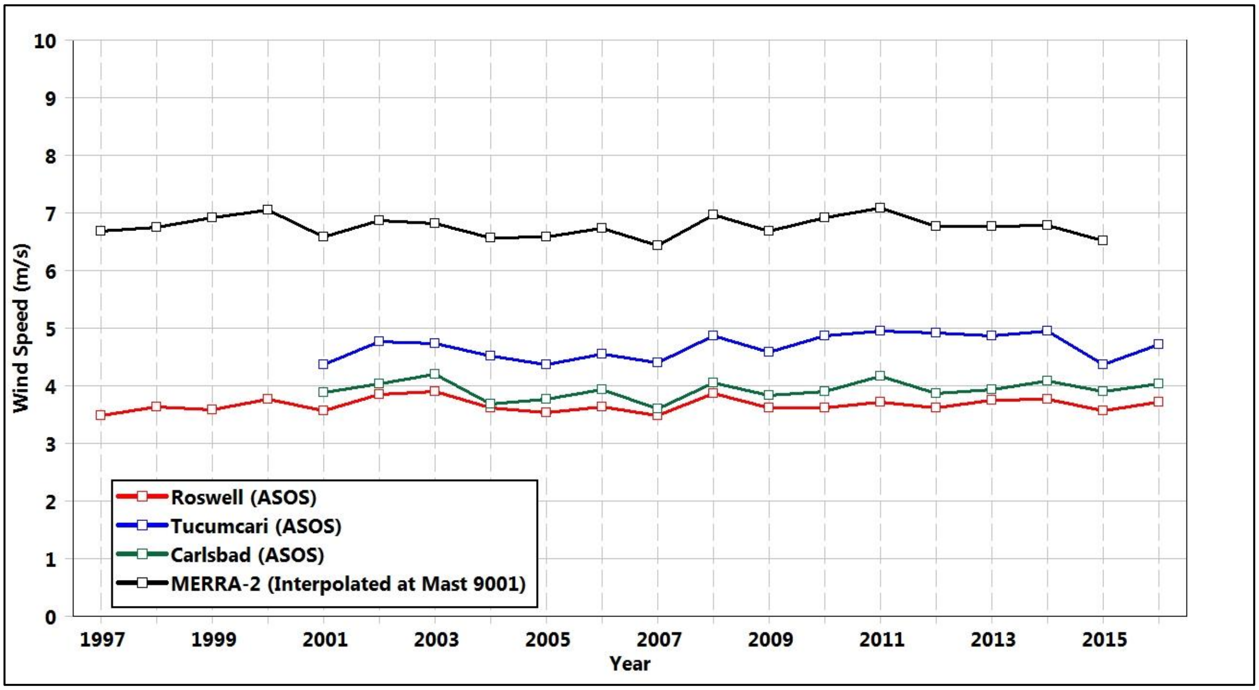


Figure 8. Reference Station Annual Mean Wind Speeds

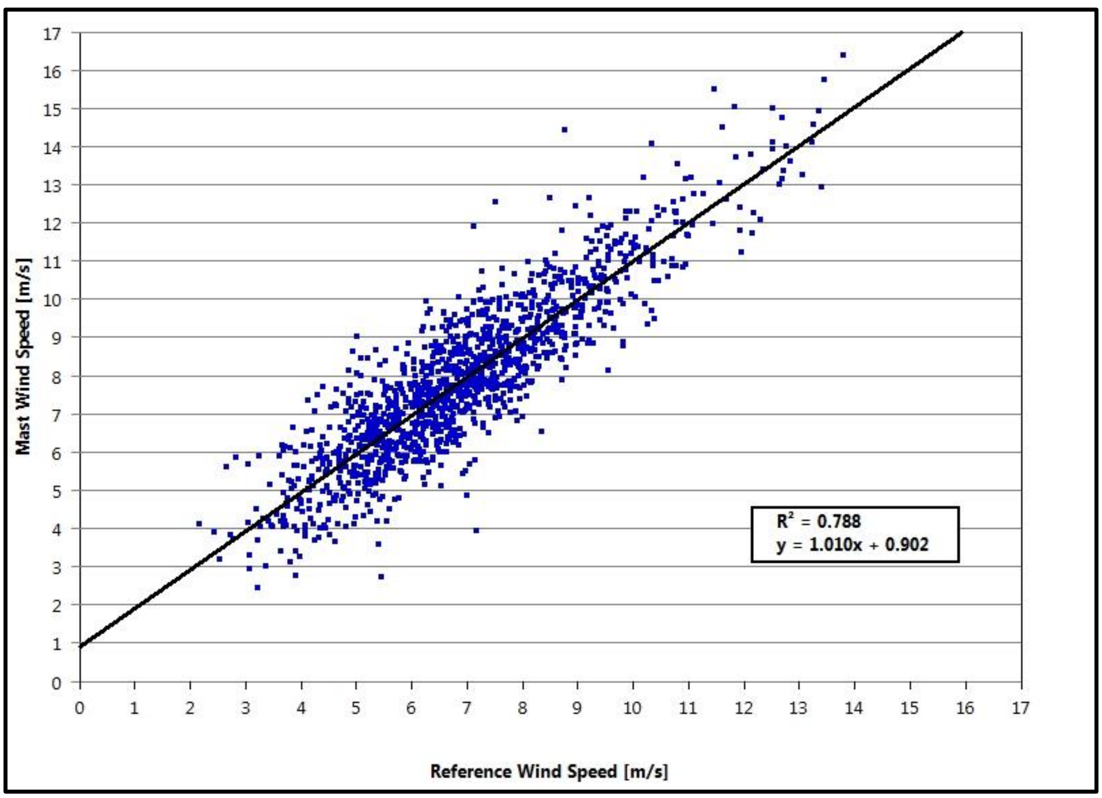


Figure 9. Scatterplot of Mast 9001 and MERRA-2 Daily Mean Wind Speeds

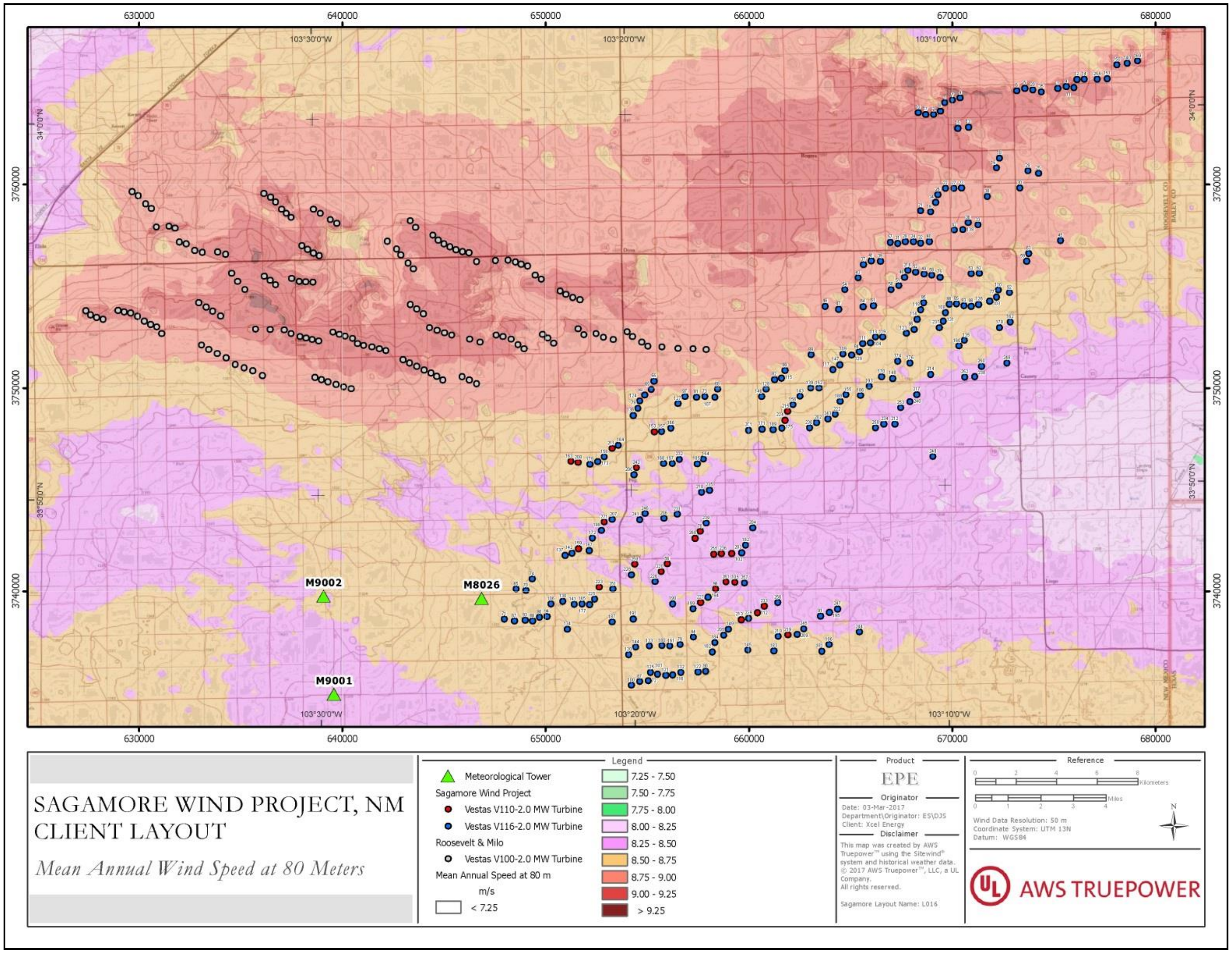


Figure 10. Proposed Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Turbine Layout

Table 1. Monitoring Mast Summary

Mast Name	Site UTM Coordinates (WGS84, Zone 13)		Elevation (m)	Period of Record	Monitoring Heights (m)		
	Easting	Northing			Wind Speed	Wind Direction	Temp
Mast 8026	646868	3739648	1312	8/04/2010 – 8/15/2016	56.2, 45.9, 30.1, 10.1	53, 43.2	3
Mast 9001	639600	3734934	1322	8/04/2010 – 8/10/2016	56, 46, 30, 10	53, 43	3
Mast 9002	639090	3739773	1332	3/28/2011 – 8/15/2016	56, 46, 30, 10	53, 43	3

Table 2. Summary of Top-Level Anemometer Adjustments

Mast	TI
Mast 8026	-0.1%
Mast 9001	-0.1%
Mast 9002	-0.1%

Table 3. Monitoring Mast Monthly Wind Speeds and Data Recoveries

Month-Year	Mast 8026		Mast 9001		Mast 9002	
	56.2-m Speed (m/s)	Data Recovery (%)	56.0-m Speed (m/s)	Data Recovery (%)	56.0-m Speed (m/s)	Data Recovery (%)
Aug-10	6.69	83.5	6.62	89.1	-	-
Sep-10	7.11	92.0	6.85	97.3	-	-
Oct-10	7.69	93.6	7.33	98.8	-	-
Nov-10	8.80	86.7	8.29	93.7	-	-
Dec-10	8.72	92.2	8.16	97.8	-	-
Jan-11	8.58	65.7	8.39	94.2	-	-
Feb-11	9.56	67.3	9.30	93.5	-	-
Mar-11	8.93	71.3	8.36	96.6	7.86	11.2
Apr-11	10.18	89.4	9.76	97.4	9.81	97.5
May-11	9.99	88.3	9.69	97.2	9.68	97.4
Jun-11	9.27	90.6	8.94	99.4	8.84	98.8
Jul-11	7.12	91.7	6.89	98.8	6.92	98.6
Aug-11	6.77	86.6	6.44	98.6	6.41	97.6
Sep-11	6.95	82.9	6.66	97.5	6.61	98.7
Oct-11	8.34	86.5	8.00	94.1	7.97	95.9
Nov-11	8.67	88.8	8.10	93.6	8.26	95.7

Month-Year	Mast 8026		Mast 9001		Mast 9002	
	56.2-m Speed (m/s)	Data Recovery (%)	56.0-m Speed (m/s)	Data Recovery (%)	56.0-m Speed (m/s)	Data Recovery (%)
Dec-11	8.25	76.9	7.59	89.2	7.50	86.0
Jan-12	9.50	93.7	9.18	95.2	9.15	95.8
Feb-12	8.89	88.5	8.49	96.2	8.66	94.2
Mar-12	9.30	91.5	8.95	96.5	8.95	95.0
Apr-12	8.74	93.2	8.57	90.9	8.60	96.8
May-12	8.54	90.2	8.18	93.4	8.20	98.0
Jun-12	8.32	92.3	8.13	98.7	8.28	99.4
Jul-12	6.77	93.8	6.57	97.8	6.65	99.5
Aug-12	6.40	85.5	6.12	95.8	6.26	97.3
Sep-12	7.22	86.7	6.40	89.6	6.83	96.0
Oct-12	8.08	88.2	7.83	94.7	8.08	98.1
Nov-12	8.68	89.4	8.27	95.6	8.38	99.2
Dec-12	9.33	44.9	8.47	92.9	8.71	95.3
Jan-13	-	0.0	7.55	87.3	7.84	95.7
Feb-13	-	0.0	8.90	88.5	9.00	93.9
Mar-13	-	0.0	8.38	92.5	8.67	94.9
Apr-13	-	0.0	8.46	89.6	8.76	96.5
May-13	-	0.0	7.91	91.0	8.39	97.8
Jun-13	-	0.0	7.69	95.0	4.89	37.2
Jul-13	-	0.0	6.40	96.4	-	0.0
Aug-13	-	0.0	5.93	95.8	-	0.0
Sep-13	-	0.0	7.16	70.0	-	0.0
Oct-13	-	0.0	7.52	93.6	-	0.0
Nov-13	-	0.0	7.43	82.1	-	0.0
Dec-13	-	0.0	7.51	90.1	-	0.0
Jan-14	-	0.0	8.67	94.6	-	0.0
Feb-14	-	0.0	7.65	94.3	-	0.0
Mar-14	-	0.0	8.41	88.4	-	0.0
Apr-14	-	0.0	9.42	78.0	-	0.0
May-14	-	0.0	7.67	97.3	-	0.0
Jun-14	-	0.0	7.67	100.0	-	0.0
Jul-14	-	0.0	6.60	99.9	-	0.0
Aug-14	-	0.0	5.03	24.8	-	0.0
Sep-14	-	0.0	-	0.0	-	0.0
Oct-14	-	0.0	-	0.0	-	0.0
Nov-14	-	0.0	-	0.0	-	0.0
Dec-14	-	0.0	-	0.0	-	0.0
Jan-15	-	0.0	-	0.0	-	0.0
Feb-15	-	0.0	-	0.0	-	0.0
Mar-15	-	0.0	-	0.0	-	0.0
Apr-15	-	0.0	-	0.0	-	0.0
May-15	-	0.0	-	0.0	-	0.0

Month-Year	Mast 8026		Mast 9001		Mast 9002	
	56.2-m Speed (m/s)	Data Recovery (%)	56.0-m Speed (m/s)	Data Recovery (%)	56.0-m Speed (m/s)	Data Recovery (%)
Jun-15	-	0.0	-	0.0	-	0.0
Jul-15	-	0.0	-	0.0	-	0.0
Aug-15	-	0.0	-	0.0	-	0.0
Sep-15	-	0.0	-	0.0	-	0.0
Oct-15	-	0.0	-	0.0	-	0.0
Nov-15	-	0.0	-	0.0	-	0.0
Dec-15	-	0.0	-	0.0	-	0.0
Jan-16	-	0.0	-	0.0	-	0.0
Feb-16	-	0.0	-	0.0	-	0.0
Mar-16	-	0.0	-	0.0	-	0.0
Apr-16	-	0.0	-	0.0	-	0.0
May-16	-	0.0	-	0.0	-	0.0
Jun-16	-	0.0	-	0.0	-	0.0
Jul-16	-	0.0	-	0.0	-	0.0
Aug-16	-	0.0	-	0.0	-	0.0
Period of Record	**8.29**	**34.2**	**7.84**	**62.5**	**8.07**	**39.6**
Annualized Speed	**8.41**		**7.85**		**8.01**	

Table 4. Monitoring Mast Observed Wind Resource Characteristics

Parameter	Mast 8026	Mast 9001	Mast 9002
Measurement Height (m)	56.2	56.0	56.0
Mean Wind Speed (m/s)	8.29	7.84	8.07
Annualized Speed (m/s)	8.41	7.85	8.01
Data Recovery (%)	34.2	62.5	39.6
Annualized Wind Shear Exponent* (Heights)	0.278 (56.2 m / 30.1 m)	0.245 (56 m / 30 m)	0.263 (56 m / 30 m)
Turbulence Intensity @15 m/s Speed Bin	0.091	0.093	0.094
Annual Weibull Parameters (A/k)	9.32 m/s / 3.01	8.97 m/s / 2.78	9.11 m/s / 2.87
Annual Prevailing Wind and Energy Direction	SSW / SSW	S / SW	S / SW
Energy-Weighted Air Density (kg/m^3)	1.044	1.044	1.041

*Only Speeds > 4 m/s used in calculation

Table 5. Mast 9001 and Reference Coefficient of Determination Summary

Reference	r^2
MERRA-2	0.79
ERA-I	0.77
Melrose	0.75
Clines Corners	0.54
Lubbock	0.54
Tucumcari	0.50
Artesia	0.44
Eight Mile Draw	0.39
Carlsbad	0.39
Roswell	0.38
Amarillo	0.38

Table 6. Monitoring Mast Long-Term Wind Speed Projection Summary

Mast Name	Monitoring Height (m)	Reference Station	Regression Equation	R^2	Long-Term Wind Speed (m/s)
Mast 8026	56.2	M9001	y = 0.957x + 0.492	0.91	7.88
Mast 9001	56.0	MERRA-2	y = 1.010x + 0.902	0.79	7.72
Mast 9002	56.0	M9001	y = 0.955x + 0.380	0.93	7.75

Table 7. Extrapolation of Climate-Adjusted Speeds to Hub Height

Mast	Monitoring Height (m)	Climate-Adjusted Speed (m/s)	Effective Wind Shear	Projected 80-m Speed (m/s)
Mast 8026	56.2	7.88	0.250	8.61
Mast 9001	56.0	7.72	0.245	8.42
Mast 9002	56.0	7.75	0.263	8.52

Table 8. Vestas V110-2.0 MW Power Curve
Version: 0059-4888 V01_31May2016

Speed Bin (m/s)	Air Density (kg/m^3)			Speed Bin (m/s)	Air Density (kg/m^3)		
	1.025	1.050	1.075		1.025	1.050	1.075
	Power (kW)	Power (kW)	Power (kW)		Power (kW)	Power (kW)	Power (kW)
0	0	0	0	13	2000	2000	2000
0.5	0	0	0	13.5	2000	2000	2000
1	0	0	0	14	2000	2000	2000
1.5	0	0	0	14.5	2000	2000	2000
2	0	0	0	15	2000	2000	2000
2.5	0	0	0	15.5	2000	2000	2000
3	29	30	31	16	2000	2000	2000
3.5	73	76	78	16.5	2000	2000	2000
4	130	134	137	17	2000	2000	2000
4.5	198	203	208	17.5	2000	2000	2000
5	278	285	292	18	2000	2000	2000
5.5	375	384	394	18.5	2000	2000	2000
6	476	489	501	19	2000	2000	2000
6.5	618	634	650	19.5	2000	2000	2000
7	782	802	822	20	2000	2000	2000
7.5	968	992	1017	20.5	2000	2000	2000
8	1177	1206	1235	21	2000	2000	2000
8.5	1400	1433	1463				
9	1623	1657	1686				
9.5	1819	1850	1871				
10	1950	1969	1974				
10.5	1991	1994	1995				
11	1998	1999	1999				
11.5	2000	2000	2000				
12	2000	2000	2000				
12.5	2000	2000	2000				

Table 9. Vestas V116-2.0 MW Power Curve
Version: 0063-8370 V00_04Jan2017

Speed Bin (m/s)	Air Density (kg/m^3)			Speed Bin (m/s)	Air Density (kg/m^3)		
	1.025	1.050	1.075		1.025	1.050	1.075
	Power (kW)	Power (kW)	Power (kW)		Power (kW)	Power (kW)	Power (kW)
0	0	0	0	13	2000	2000	2000
0.5	0	0	0	13.5	2000	2000	2000
1	0	0	0	14	2000	2000	2000
1.5	0	0	0	14.5	2000	2000	2000
2	0	0	0	15	2000	2000	2000
2.5	0	0	0	15.5	2000	2000	2000
3	23	24	25	16	2000	2000	2000
3.5	74	77	79	16.5	2000	2000	2000
4	142	145	149	17	2000	2000	2000
4.5	221	227	233	17.5	2000	2000	2000
5	313	321	329	18	2000	2000	2000
5.5	420	430	441	18.5	2000	2000	2000
6	537	547	560	19	2000	2000	2000
6.5	687	704	723	19.5	2000	2000	2000
7	876	897	919	20	2000	2000	2000
7.5	1083	1110	1136				
8	1309	1340	1369				
8.5	1537	1570	1599				
9	1750	1780	1802				
9.5	1908	1927	1937				
10	1976	1984	1986				
10.5	1995	1997	1998				
11	1999	2000	2000				
11.5	2000	2000	2000				
12	2000	2000	2000				
12.5	2000	2000	2000				

Table 10. Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail

Project:	Xcel Energy - Sagamore Wind Project, NM	
Date:	7-Feb-17	
Comments:	L016 Client Layout With Effects of Surrounding Farms	
Turbine Manufacturer/Model:	Vestas V110-2.0 MW	Vestas V116-2.0 MW
Turbine Rated Power (MW):	2.00	2.00
Hub Height (m):	80	80
Number of Turbines:	26	235
Total Number of Turbines:	261	
Plant Capacity (MW):	522	
Site Air Density (kg/m3):	1.052	1.052

AWS TRUEPOWER

Loss Accounting	
Wake Effect	7.5%
Availability	5.5%
Electrical	2.0%
Turbine Performance	3.6%
Environmental	2.3%
Curtailments	0.0%
Average Total Loss	**19.4%**

Overall Wind Plant Summary	
Average Free Wind Speed (m/s)	8.68
Gross Plant Production (MWh/yr)	2,962,645
Net Plant Production (MWh/yr)	2,389,358
Net Capacity Factor	52.2%

Per Turbine Summary

Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
1	M8026	669637	3764030	9.19	11,996	91.6	8.4	20.2	9,574	34	54.6	7.0	Vestas V116-2.0 MW
2	M8026	669098	3763449	9.22	12,040	93.0	7.0	18.8	9,773	18	55.7	6.7	Vestas V116-2.0 MW
3	M8026	675181	3764734	9.15	11,997	96.4	3.6	15.9	10,090	2	57.6	6.7	Vestas V116-2.0 MW
4	M8026	675607	3764829	9.18	12,032	94.5	5.5	17.6	9,916	10	56.6	6.8	Vestas V116-2.0 MW
5	M8026	673572	3764745	9.19	12,025	94.6	5.4	17.5	9,923	9	56.6	6.7	Vestas V116-2.0 MW
6	M8026	673175	3764621	9.16	11,987	96.2	3.8	16.1	10,063	3	57.4	6.6	Vestas V116-2.0 MW
7	M8026	670016	3764157	9.18	11,980	92.2	7.8	19.6	9,630	25	54.9	6.9	Vestas V116-2.0 MW
8	M8026	669411	3763618	9.19	12,017	91.6	8.4	20.0	9,608	31	54.8	6.8	Vestas V116-2.0 MW
9	M8026	670375	3764259	9.20	12,002	93.7	6.3	18.3	9,802	15	55.9	6.8	Vestas V116-2.0 MW
10	M8026	668333	3763544	9.23	12,030	95.4	4.6	16.7	10,017	6	57.1	6.5	Vestas V116-2.0 MW
11	M8026	675996	3764767	9.14	11,975	94.7	5.3	17.4	9,889	11	56.4	6.7	Vestas V116-2.0 MW
12	M8026	676131	3765184	9.07	11,897	92.7	7.3	19.1	9,625	27	54.9	7.0	Vestas V116-2.0 MW
13	M8026	670801	3762833	8.98	11,787	94.6	5.4	17.5	9,721	21	55.4	6.7	Vestas V116-2.0 MW
14	M8026	676491	3765194	9.03	11,861	94.9	5.1	17.1	9,827	13	56.1	6.9	Vestas V116-2.0 MW
15	M8026	670270	3762777	9.02	11,817	94.8	5.2	17.4	9,767	19	55.7	6.6	Vestas V116-2.0 MW
16	M8026	672185	3760822	9.00	11,816	94.8	5.2	17.3	9,775	17	55.8	6.9	Vestas V116-2.0 MW
17	M8026	668697	3763452	9.05	11,824	93.8	6.2	18.1	9,679	23	55.2	6.7	Vestas V116-2.0 MW
18	M8026	672336	3761304	8.97	11,781	93.1	6.9	18.7	9,573	35	54.6	7.2	Vestas V116-2.0 MW
19	M8026	668953	3758653	8.94	11,744	91.6	8.4	20.1	9,382	56	53.5	7.2	Vestas V116-2.0 MW
20	M8026	673968	3764664	9.00	11,792	94.4	5.6	17.6	9,715	22	55.4	6.7	Vestas V116-2.0 MW
21	M8026	668455	3758721	8.95	11,751	92.5	7.5	19.3	9,478	43	54.1	7.2	Vestas V116-2.0 MW
22	M8026	669664	3759819	8.98	11,785	91.4	8.6	20.3	9,395	54	53.6	7.3	Vestas V116-2.0 MW
23	M8026	670463	3759835	8.93	11,730	92.0	8.0	19.7	9,419	51	53.7	7.3	Vestas V116-2.0 MW
24	M8026	668085	3757204	8.94	11,741	90.1	9.9	21.4	9,227	96	52.6	7.5	Vestas V116-2.0 MW
25	M8026	674246	3760560	8.93	11,734	95.9	4.1	16.3	9,821	14	56.0	6.9	Vestas V116-2.0 MW
26	M8026	669296	3759508	8.97	11,771	89.1	10.9	22.3	9,145	123	52.2	7.6	Vestas V116-2.0 MW
27	M8026	670085	3759821	8.94	11,746	91.1	8.9	20.5	9,340	64	53.3	7.3	Vestas V116-2.0 MW
28	M8026	667696	3757195	8.93	11,729	90.2	9.8	21.3	9,227	97	52.6	7.5	Vestas V116-2.0 MW
29	M8026	673734	3760677	8.96	11,766	95.1	4.9	17.1	9,758	20	55.7	7.0	Vestas V116-2.0 MW
30	M8026	673328	3759843	8.91	11,711	95.9	4.1	16.4	9,794	16	55.9	7.2	Vestas V116-2.0 MW
31	M8026	667318	3757119	8.91	11,698	90.2	9.8	21.3	9,204	103	52.5	7.5	Vestas V116-2.0 MW
32	M8026	668449	3757136	8.91	11,714	90.4	9.6	21.1	9,237	88	52.7	7.5	Vestas V116-2.0 MW
33	M8026	671283	3758024	8.88	11,673	93.6	6.4	18.4	9,528	39	54.3	7.2	Vestas V116-2.0 MW
34	M8026	669176	3759134	8.95	11,752	90.1	9.9	21.4	9,235	89	52.7	7.4	Vestas V116-2.0 MW
35	M8026	674387	3764564	8.83	11,605	95.3	4.7	16.8	9,651	24	55.0	6.9	Vestas V116-2.0 MW
36	M8026	670776	3758129	8.86	11,645	90.1	9.9	21.5	9,147	121	52.2	7.6	Vestas V116-2.0 MW
37	M8026	665635	3756072	8.90	11,672	92.1	7.9	19.6	9,379	57	53.5	7.3	Vestas V116-2.0 MW
38	M8026	671730	3759425	8.83	11,600	94.8	5.2	17.3	9,590	33	54.7	7.2	Vestas V116-2.0 MW
39	M8026	666462	3756231	8.88	11,659	91.7	8.3	20.0	9,332	67	53.2	7.3	Vestas V116-2.0 MW
40	M8026	668869	3757206	8.87	11,665	92.0	8.0	19.8	9,359	59	53.4	7.4	Vestas V116-2.0 MW
41	M8026	666017	3756257	8.90	11,668	90.7	9.3	20.9	9,232	92	52.7	7.4	Vestas V116-2.0 MW
42	M8026	670110	3757765	8.88	11,673	92.6	7.4	19.3	9,426	49	53.8	7.2	Vestas V116-2.0 MW
43	M8026	665374	3755410	8.87	11,630	92.6	7.4	19.2	9,395	53	53.6	7.2	Vestas V116-2.0 MW
44	M8026	657276	3737735	8.57	11,256	93.7	6.3	18.2	9,203	105	52.5	7.4	Vestas V116-2.0 MW
45	M8026	675325	3757258	8.80	11,572	97.5	2.5	15.0	9,838	12	56.1	6.9	Vestas V116-2.0 MW
46	M8026	663750	3754025	8.92	11,684	94.3	5.7	17.7	9,613	30	54.8	7.0	Vestas V116-2.0 MW
47	M8026	664419	3753880	8.88	11,638	93.3	6.7	18.6	9,475	44	54.0	7.2	Vestas V116-2.0 MW
48	M8026	667644	3755434	8.84	11,605	88.2	11.8	23.1	8,925	204	50.9	7.5	Vestas V116-2.0 MW
49	M8026	668621	3755595	8.82	11,574	90.2	9.8	21.3	9,112	140	52.0	7.4	Vestas V116-2.0 MW
50	M8026	666995	3754840	8.81	11,564	91.8	8.2	19.9	9,267	83	52.9	7.2	Vestas V116-2.0 MW

Table 10 (Cont'd). Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail

Per Turbine Summary													
Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
51	M8026	667373	3755028	8.79	11,542	89.9	10.1	21.6	9,046	167	51.6	7.4	Vestas V116-2.0 MW
52	M8026	668192	3755701	8.81	11,565	89.3	10.7	22.1	9,012	176	51.4	7.5	Vestas V116-2.0 MW
53	M8026	670925	3755618	8.77	11,540	92.0	8.0	19.7	9,262	85	52.8	7.2	Vestas V116-2.0 MW
54	M8026	664722	3754839	8.85	11,592	93.3	6.7	18.6	9,431	48	53.8	7.1	Vestas V116-2.0 MW
55	M8026	655324	3750337	8.81	11,566	90.5	9.5	21.1	9,131	130	52.1	7.4	Vestas V116-2.0 MW
56	M8026	655976	3741344	8.44	10,660	90.3	9.7	21.2	8,398	253	47.9	8.3	Vestas V110-2.0 MW
57	M8026	666965	3757174	8.81	11,573	92.0	8.0	19.8	9,281	79	52.9	7.4	Vestas V116-2.0 MW
58	M8026	669007	3755542	8.79	11,545	90.3	9.7	21.2	9,096	152	51.9	7.4	Vestas V116-2.0 MW
59	M8026	673663	3756240	8.78	11,550	95.2	4.8	16.9	9,594	32	54.7	7.0	Vestas V116-2.0 MW
60	M8026	654868	3749649	8.79	11,545	88.8	11.2	22.6	8,940	200	51.0	7.4	Vestas V116-2.0 MW
61	M8026	666126	3754049	8.77	11,506	92.0	8.0	19.7	9,234	90	52.7	7.3	Vestas V116-2.0 MW
62	M8026	671321	3755638	8.70	11,454	91.6	8.4	20.1	9,153	116	52.2	7.3	Vestas V116-2.0 MW
63	M8026	673766	3756612	8.76	11,530	91.8	8.2	19.9	9,234	91	52.7	7.3	Vestas V116-2.0 MW
64	M8026	665614	3754005	8.84	11,583	92.5	7.5	19.3	9,350	62	53.3	7.2	Vestas V116-2.0 MW
65	M8026	648549	3740112	8.64	11,370	94.9	5.1	17.2	9,417	52	53.7	7.2	Vestas V116-2.0 MW
66	M8026	649357	3738542	8.61	11,336	93.9	6.1	18.1	9,283	78	52.9	7.3	Vestas V116-2.0 MW
67	M8026	648468	3738537	8.59	11,316	96.2	3.8	16.1	9,492	42	54.1	7.2	Vestas V116-2.0 MW
68	M8026	658452	3749933	8.73	11,452	90.1	9.9	21.4	8,996	183	51.3	7.3	Vestas V116-2.0 MW
69	M8026	655200	3749916	8.79	11,540	90.1	9.9	21.4	9,069	161	51.7	7.2	Vestas V116-2.0 MW
70	M8026	649030	3740033	8.64	11,371	93.0	7.0	18.8	9,228	95	52.6	7.3	Vestas V116-2.0 MW
71	M8026	647966	3738637	8.61	11,345	97.2	2.8	15.2	9,621	29	54.9	7.1	Vestas V116-2.0 MW
72	M8026	655049	3735589	8.65	11,383	94.1	5.9	17.9	9,343	63	53.3	7.3	Vestas V116-2.0 MW
73	M8026	657845	3749567	8.72	11,443	92.0	8.0	19.7	9,183	108	52.4	7.2	Vestas V116-2.0 MW
74	M8026	649339	3740596	8.56	11,273	93.0	7.0	18.8	9,150	118	52.2	7.5	Vestas V116-2.0 MW
75	M8026	669397	3755443	8.74	11,494	90.9	9.1	20.7	9,119	134	52.0	7.3	Vestas V116-2.0 MW
76	M8026	657609	3742952	8.49	10,733	89.1	10.9	22.3	8,338	259	47.6	8.3	Vestas V110-2.0 MW
77	M8026	672185	3754476	8.72	11,466	91.0	9.0	20.6	9,101	148	51.9	7.3	Vestas V116-2.0 MW
78	M8026	654538	3748997	8.73	11,475	89.3	10.7	22.1	8,938	202	51.0	7.3	Vestas V116-2.0 MW
79	M8026	656615	3737375	8.64	11,348	92.6	7.4	19.2	9,166	114	52.3	7.4	Vestas V116-2.0 MW
80	M8026	649707	3738720	8.60	11,316	92.1	7.9	19.6	9,093	154	51.9	7.4	Vestas V116-2.0 MW
81	M8026	657425	3749544	8.75	11,485	92.5	7.5	19.3	9,269	82	52.9	7.1	Vestas V116-2.0 MW
82	M8026	661262	3750418	8.75	11,470	91.0	9.0	20.6	9,102	147	51.9	7.4	Vestas V116-2.0 MW
83	M8026	670580	3754052	8.68	11,403	91.0	9.0	20.6	9,051	165	51.6	7.7	Vestas V116-2.0 MW
84	M8026	665435	3751775	8.74	11,438	90.2	9.8	21.3	8,998	182	51.3	7.7	Vestas V116-2.0 MW
85	M8026	670215	3754143	8.70	11,433	89.8	10.2	21.6	8,961	192	51.1	7.7	Vestas V116-2.0 MW
86	M8026	668123	3752879	8.70	11,399	91.1	8.9	20.5	9,061	164	51.7	7.7	Vestas V116-2.0 MW
87	M8026	654634	3735552	8.65	11,388	93.7	6.3	18.3	9,308	72	53.1	7.2	Vestas V116-2.0 MW
88	M8026	669860	3754120	8.71	11,437	89.4	10.6	22.0	8,917	206	50.9	7.8	Vestas V116-2.0 MW
89	M8026	663057	3751636	8.77	11,483	93.4	6.6	18.5	9,357	60	53.4	7.5	Vestas V116-2.0 MW
90	M8026	657876	3736065	8.71	11,446	95.2	4.8	17.0	9,501	40	54.2	7.2	Vestas V116-2.0 MW
91	M8026	663519	3738774	8.40	11,017	94.8	5.2	17.3	9,110	144	52.0	8.1	Vestas V116-2.0 MW
92	M8026	672818	3754685	8.66	11,390	94.5	5.5	17.6	9,387	55	53.5	7.3	Vestas V116-2.0 MW
93	M8026	649003	3738580	8.59	11,309	94.8	5.2	17.3	9,352	61	53.3	7.3	Vestas V116-2.0 MW
94	M8026	650075	3738757	8.64	11,380	93.8	6.2	18.1	9,315	70	53.1	7.3	Vestas V116-2.0 MW
95	M8026	668607	3754203	8.71	11,427	88.4	11.6	22.9	8,815	224	50.3	7.9	Vestas V116-2.0 MW
96	M8026	658368	3740114	8.47	10,709	90.9	9.1	20.7	8,493	250	48.4	8.2	Vestas V110-2.0 MW
97	M8026	656853	3749575	8.73	11,454	91.4	8.6	20.3	9,131	131	52.1	7.4	Vestas V116-2.0 MW
98	M8026	670933	3754022	8.67	11,387	91.1	8.9	20.5	9,050	166	51.6	7.7	Vestas V116-2.0 MW
99	M8026	661770	3750867	8.72	11,421	89.0	11.0	22.4	8,863	219	50.6	7.8	Vestas V116-2.0 MW
100	M8026	654216	3735370	8.63	11,377	97.0	3.0	15.4	9,626	26	54.9	7.1	Vestas V116-2.0 MW
101	M8026	655507	3735925	8.67	11,412	92.1	7.9	19.6	9,170	111	52.3	7.3	Vestas V116-2.0 MW
102	M8026	659159	3741850	8.44	10,657	90.1	9.9	21.4	8,375	256	47.8	8.3	Vestas V110-2.0 MW
103	M8026	671833	3754270	8.67	11,401	92.3	7.7	19.5	9,179	110	52.4	7.6	Vestas V116-2.0 MW
104	M8026	665982	3752209	8.69	11,384	89.4	10.6	22.0	8,876	216	50.6	7.8	Vestas V116-2.0 MW
105	M8026	659321	3740440	8.44	10,664	90.5	9.5	21.1	8,413	252	48.0	8.2	Vestas V110-2.0 MW
106	M8026	650264	3739377	8.62	11,347	92.4	7.6	19.4	9,148	120	52.2	7.3	Vestas V116-2.0 MW
107	M8026	658326	3749532	8.70	11,411	92.5	7.5	19.3	9,209	102	52.5	7.3	Vestas V116-2.0 MW
108	M8026	669674	3753703	8.71	11,432	88.3	11.7	23.0	8,804	227	50.2	7.8	Vestas V116-2.0 MW
109	M8026	664623	3751668	8.72	11,420	89.3	10.7	22.1	8,897	211	50.7	7.8	Vestas V116-2.0 MW
110	M8026	672281	3754815	8.64	11,369	87.7	12.3	23.5	8,696	239	49.6	7.7	Vestas V116-2.0 MW
111	M8026	665596	3752185	8.73	11,438	87.9	12.1	23.3	8,776	233	50.1	7.8	Vestas V116-2.0 MW
112	M8026	660423	3738940	8.50	10,750	91.8	8.2	19.9	8,606	243	49.1	7.9	Vestas V110-2.0 MW
113	M8026	666229	3752500	8.71	11,415	88.0	12.0	23.2	8,764	235	50.0	8.0	Vestas V116-2.0 MW
114	M8026	668278	3753386	8.70	11,406	90.0	10.0	21.5	8,952	193	51.1	7.7	Vestas V116-2.0 MW
115	M8026	661617	3750477	8.75	11,466	89.4	10.6	22.0	8,941	198	51.0	7.3	Vestas V116-2.0 MW
116	M8026	656262	3735878	8.64	11,364	93.7	6.3	18.2	9,290	75	53.0	7.3	Vestas V116-2.0 MW
117	M8026	664133	3750903	8.72	11,421	91.7	8.3	20.0	9,137	128	52.1	7.6	Vestas V116-2.0 MW
118	M8026	668456	3753853	8.70	11,416	89.3	10.7	22.1	8,895	212	50.7	7.8	Vestas V116-2.0 MW
119	M8026	666577	3752507	8.72	11,422	90.7	9.3	20.9	9,038	169	51.6	7.7	Vestas V116-2.0 MW
120	M8026	654095	3736886	8.67	11,412	94.9	5.1	17.2	9,444	47	53.9	7.2	Vestas V116-2.0 MW

Table 10 (Cont'd). Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail

Per Turbine Summary													
Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
121	M8026	655907	3735864	8.66	11,388	93.6	6.4	18.3	9,302	73	53.1	7.3	Vestas V116-2.0 MW
122	M8026	657500	3736025	8.69	11,420	96.0	4.0	16.3	9,559	37	54.5	7.1	Vestas V116-2.0 MW
123	M8026	667749	3752682	8.66	11,350	92.4	7.6	19.4	9,148	119	52.2	7.6	Vestas V116-2.0 MW
124	M8026	654635	3749349	8.73	11,472	88.2	11.8	23.1	8,828	223	50.4	7.5	Vestas V116-2.0 MW
125	M8026	655163	3736009	8.65	11,388	90.0	10.0	21.5	8,939	201	51.0	7.4	Vestas V116-2.0 MW
126	M8026	671292	3754113	8.67	11,390	92.0	8.0	19.8	9,141	127	52.1	7.6	Vestas V116-2.0 MW
127	M8026	656510	3749226	8.69	11,406	92.3	7.7	19.5	9,185	106	52.4	7.5	Vestas V116-2.0 MW
128	M8026	660839	3749940	8.66	11,351	89.7	10.3	21.7	8,885	214	50.7	7.8	Vestas V116-2.0 MW
129	M8026	665043	3751614	8.73	11,435	90.7	9.3	20.9	9,046	168	51.6	7.7	Vestas V116-2.0 MW
130	M8026	650849	3739512	8.63	11,350	93.7	6.3	18.3	9,275	81	52.9	7.2	Vestas V116-2.0 MW
131	M8026	669560	3753288	8.67	11,381	88.6	11.4	22.7	8,794	230	50.2	7.8	Vestas V116-2.0 MW
132	M8026	656649	3736017	8.65	11,378	94.4	5.6	17.6	9,373	58	53.5	7.3	Vestas V116-2.0 MW
133	M8026	655114	3737308	8.64	11,355	93.2	6.8	18.7	9,230	94	52.6	7.3	Vestas V116-2.0 MW
134	M8026	651077	3738132	8.59	11,313	97.0	3.0	15.4	9,571	36	54.6	7.4	Vestas V116-2.0 MW
135	M8026	670597	3752336	8.61	11,287	91.1	8.9	20.5	8,969	189	51.2	7.7	Vestas V116-2.0 MW
136	M8026	654302	3748655	8.71	11,437	92.9	7.1	19.0	9,264	84	52.8	7.3	Vestas V116-2.0 MW
137	M8026	650952	3741763	8.59	11,299	93.9	6.1	18.1	9,250	87	52.8	7.5	Vestas V116-2.0 MW
138	M8026	670529	3757776	8.80	11,572	91.2	8.8	20.5	9,204	104	52.5	7.4	Vestas V116-2.0 MW
139	M8026	663038	3749997	8.67	11,351	91.6	8.4	20.1	9,075	160	51.8	7.6	Vestas V116-2.0 MW
140	M8026	678614	3765973	9.04	11,899	96.5	3.5	15.8	10,019	5	57.1	6.7	Vestas V116-2.0 MW
141	M8026	651420	3739364	8.65	11,375	93.6	6.4	18.3	9,288	76	53.0	7.3	Vestas V116-2.0 MW
142	M8026	651302	3741882	8.59	11,297	90.6	9.4	21.0	8,922	205	50.9	7.6	Vestas V116-2.0 MW
143	M8026	662514	3749585	8.66	11,343	91.0	9.0	20.6	9,002	181	51.3	7.7	Vestas V116-2.0 MW
144	M8026	654433	3737251	8.65	11,377	92.4	7.6	19.4	9,165	115	52.3	7.3	Vestas V116-2.0 MW
145	M8026	659946	3737098	8.65	11,359	97.1	2.9	15.3	9,624	28	54.9	7.2	Vestas V116-2.0 MW
146	M8026	660618	3749568	8.64	11,327	92.2	7.8	19.5	9,115	139	52.0	7.6	Vestas V116-2.0 MW
147	M8026	664464	3751149	8.63	11,315	90.0	10.0	21.5	8,884	215	50.7	7.8	Vestas V116-2.0 MW
148	M8026	667075	3750475	8.62	11,277	92.7	7.3	19.1	9,119	136	52.0	7.6	Vestas V116-2.0 MW
149	M8026	658984	3738130	8.68	11,391	90.7	9.3	20.9	9,005	180	51.4	7.5	Vestas V116-2.0 MW
150	M8026	678097	3765906	9.03	11,880	96.9	3.1	15.5	10,041	4	57.3	6.7	Vestas V116-2.0 MW
151	M8026	677630	3765219	9.00	11,866	96.6	3.4	15.8	9,997	7	57.0	6.7	Vestas V116-2.0 MW
152	M8026	663453	3749990	8.65	11,329	91.3	8.7	20.3	9,028	171	51.5	7.7	Vestas V116-2.0 MW
153	M8026	655339	3747855	8.65	10,975	92.1	7.9	19.7	8,815	225	50.3	7.5	Vestas V110-2.0 MW
154	M8026	657775	3746500	8.50	11,140	90.5	9.5	21.1	8,793	231	50.2	8.1	Vestas V116-2.0 MW
155	M8026	664771	3749659	8.63	11,292	90.8	9.2	20.8	8,945	196	51.0	7.7	Vestas V116-2.0 MW
156	M8026	662174	3749178	8.63	11,307	89.7	10.3	21.8	8,842	222	50.4	7.8	Vestas V116-2.0 MW
157	M8026	655706	3747860	8.60	11,300	90.7	9.3	20.9	8,940	199	51.0	7.9	Vestas V116-2.0 MW
158	M8026	652897	3746609	8.60	11,297	90.7	9.3	20.8	8,942	197	51.0	7.9	Vestas V116-2.0 MW
159	M8026	651607	3742100	8.57	10,868	90.2	9.8	21.3	8,554	247	48.8	7.7	Vestas V110-2.0 MW
160	M8026	670327	3752072	8.56	11,226	93.3	6.7	18.7	9,130	132	52.1	7.7	Vestas V116-2.0 MW
161	M8026	656107	3737305	8.61	11,307	91.2	8.8	20.4	8,995	185	51.3	7.5	Vestas V116-2.0 MW
162	M8026	672858	3753245	8.55	11,236	95.3	4.7	16.9	9,339	65	53.3	7.4	Vestas V116-2.0 MW
163	M8026	651248	3746383	8.60	10,902	94.4	5.6	17.7	8,973	188	51.2	7.8	Vestas V110-2.0 MW
164	M8026	653589	3747177	8.61	11,309	90.7	9.3	20.9	8,950	194	51.0	8.0	Vestas V116-2.0 MW
165	M8026	651790	3739378	8.61	11,323	92.0	8.0	19.8	9,084	157	51.8	7.5	Vestas V116-2.0 MW
166	M8026	656162	3748019	8.62	11,316	91.2	8.8	20.5	8,996	184	51.3	8.0	Vestas V116-2.0 MW
167	M8026	652138	3742011	8.56	11,259	92.5	7.5	19.4	9,080	158	51.8	7.6	Vestas V116-2.0 MW
168	M8026	655807	3746276	8.57	11,242	92.9	7.1	19.0	9,106	146	51.9	7.9	Vestas V116-2.0 MW
169	M8026	679128	3766082	9.06	11,910	97.5	2.5	14.9	10,132	1	57.8	6.7	Vestas V116-2.0 MW
170	M8026	666529	3750559	8.62	11,285	92.6	7.4	19.2	9,119	137	52.0	7.6	Vestas V116-2.0 MW
171	M8026	660652	3747981	8.61	11,286	94.0	6.0	18.0	9,253	86	52.8	7.5	Vestas V116-2.0 MW
172	M8026	652315	3742619	8.52	11,198	92.2	7.8	19.5	9,010	177	51.4	7.9	Vestas V116-2.0 MW
173	M8026	652565	3746375	8.55	11,237	91.1	8.9	20.5	8,932	203	50.9	8.0	Vestas V116-2.0 MW
174	M8026	667325	3751325	8.63	11,311	92.4	7.6	19.4	9,116	138	52.0	7.6	Vestas V116-2.0 MW
175	M8026	661625	3748025	8.54	11,188	92.4	7.6	19.4	9,022	172	51.5	8.0	Vestas V116-2.0 MW
176	M8026	667925	3751225	8.58	11,240	93.3	6.7	18.6	9,145	125	52.2	7.5	Vestas V116-2.0 MW
177	M8026	652168	3739345	8.60	11,306	92.3	7.7	19.5	9,100	149	51.9	7.4	Vestas V116-2.0 MW
178	M8026	672329	3752965	8.53	11,192	95.1	4.9	17.0	9,287	77	53.0	7.6	Vestas V116-2.0 MW
179	M8026	652172	3746237	8.56	11,246	93.5	6.5	18.5	9,170	112	52.3	7.9	Vestas V116-2.0 MW
180	M8026	655725	3737320	8.63	11,339	92.1	7.9	19.7	9,108	145	51.9	7.4	Vestas V116-2.0 MW
181	M8026	663592	3737060	8.54	11,217	96.8	3.2	15.6	9,471	45	54.0	7.2	Vestas V116-2.0 MW
182	M8026	658211	3737024	8.60	11,296	94.7	5.3	17.4	9,333	66	53.2	7.3	Vestas V116-2.0 MW
183	M8026	661226	3737068	8.56	11,237	96.9	3.1	15.5	9,495	41	54.2	7.3	Vestas V116-2.0 MW
184	M8026	658333	3737475	8.58	11,274	91.7	8.3	20.0	9,016	175	51.4	7.5	Vestas V116-2.0 MW
185	M8026	657467	3746271	8.53	11,179	92.4	7.6	19.4	9,007	178	51.4	8.0	Vestas V116-2.0 MW
186	M8026	665480	3749628	8.56	11,203	93.3	6.7	18.6	9,119	135	52.0	7.8	Vestas V116-2.0 MW
187	M8026	653272	3738483	8.60	11,303	96.1	3.9	16.2	9,471	46	54.0	7.1	Vestas V116-2.0 MW
188	M8026	664483	3749331	8.60	11,260	91.3	8.7	20.4	8,968	191	51.2	7.6	Vestas V116-2.0 MW
189	M8026	661199	3747947	8.59	11,250	93.2	6.8	18.7	9,145	124	52.2	7.7	Vestas V116-2.0 MW
190	M8026	656251	3739390	8.45	11,087	94.0	6.0	18.0	9,089	155	51.8	8.1	Vestas V116-2.0 MW

Table 10 (Cont'd). Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail

Per Turbine Summary

Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
191	M8026	654313	3738641	8.57	11,269	94.7	5.3	17.4	9,310	71	53.1	7.4	Vestas V116-2.0 MW
192	M8026	659845	3742277	8.44	11,069	90.0	10.0	21.5	8,688	240	49.6	8.3	Vestas V116-2.0 MW
193	M8026	665916	3750079	8.58	11,231	92.1	7.9	19.7	9,020	173	51.4	7.8	Vestas V116-2.0 MW
194	M8026	657983	3739707	8.55	11,219	90.8	9.2	20.8	8,886	213	50.7	8.2	Vestas V116-2.0 MW
195	M8026	663948	3738967	8.37	10,971	93.1	6.9	18.8	8,910	208	50.8	8.2	Vestas V116-2.0 MW
196	M8026	663941	3737377	8.52	11,196	95.0	5.0	17.2	9,276	80	52.9	7.5	Vestas V116-2.0 MW
197	M8026	656246	3746277	8.55	11,215	91.1	8.9	20.5	8,912	207	50.8	8.1	Vestas V116-2.0 MW
198	M8026	652737	3742991	8.46	11,107	91.5	8.5	20.2	8,867	218	50.6	8.2	Vestas V116-2.0 MW
199	M8026	657251	3739142	8.54	11,218	93.2	6.8	18.7	9,122	133	52.0	7.6	Vestas V116-2.0 MW
200	M8026	654341	3745729	8.54	11,212	93.2	6.8	18.7	9,111	142	52.0	8.0	Vestas V116-2.0 MW
201	M8026	659982	3747926	8.60	11,270	94.8	5.2	17.3	9,318	69	53.1	7.8	Vestas V116-2.0 MW
202	M8026	663319	3748293	8.57	11,219	91.7	8.3	20.1	8,969	190	51.2	7.7	Vestas V116-2.0 MW
203	M8026	659650	3741900	8.43	11,057	91.1	8.9	20.6	8,784	232	50.1	8.3	Vestas V116-2.0 MW
204	M8026	660185	3743120	8.45	11,072	94.1	5.9	17.9	9,093	153	51.9	8.1	Vestas V116-2.0 MW
205	M8026	658768	3737842	8.59	11,286	92.4	7.6	19.4	9,098	150	51.9	7.3	Vestas V116-2.0 MW
206	M8026	655820	3743587	8.51	11,167	93.4	6.6	18.5	9,097	151	51.9	8.1	Vestas V116-2.0 MW
207	M8026	653271	3743527	8.52	11,192	91.3	8.7	20.4	8,910	209	50.8	8.2	Vestas V116-2.0 MW
208	M8026	651599	3746336	8.59	10,885	92.1	7.9	19.6	8,747	237	49.9	7.9	Vestas V110-2.0 MW
209	M8026	662374	3737863	8.52	11,175	93.9	6.1	18.1	9,152	117	52.2	7.5	Vestas V116-2.0 MW
210	M8026	661451	3737774	8.53	11,194	94.5	5.5	17.5	9,231	93	52.7	7.4	Vestas V116-2.0 MW
211	M8026	653270	3747029	8.60	10,893	90.4	9.6	21.1	8,591	244	49.0	8.0	Vestas V110-2.0 MW
212	M8026	667175	3748225	8.46	11,074	95.1	4.9	17.1	9,181	109	52.4	7.7	Vestas V116-2.0 MW
213	M8026	659617	3738606	8.50	10,756	93.4	6.6	18.6	8,759	236	50.0	7.8	Vestas V110-2.0 MW
214	M8026	668950	3750675	8.52	11,159	95.5	4.5	16.7	9,294	74	53.0	7.7	Vestas V116-2.0 MW
215	M8026	661904	3748841	8.55	10,800	88.2	11.8	23.1	8,303	260	47.4	8.0	Vestas V110-2.0 MW
216	M8026	667825	3755775	8.80	11,557	87.3	12.7	23.8	8,804	228	50.2	7.7	Vestas V116-2.0 MW
217	M8026	668250	3749675	8.50	11,120	93.1	6.9	18.7	9,035	170	51.5	7.8	Vestas V116-2.0 MW
218	M8026	657675	3744875	8.46	11,094	92.5	7.5	19.3	8,948	195	51.0	8.0	Vestas V116-2.0 MW
219	M8026	661920	3737854	8.51	10,761	93.1	6.9	18.8	8,740	238	49.9	7.5	Vestas V110-2.0 MW
220	M8026	655692	3740968	8.45	10,672	90.6	9.4	21.0	8,434	251	48.1	8.3	Vestas V110-2.0 MW
221	M8026	652883	3743402	8.50	10,754	89.2	10.8	22.2	8,364	257	47.7	8.3	Vestas V110-2.0 MW
222	M8026	664250	3748700	8.57	11,216	92.2	7.8	19.6	9,019	174	51.4	7.6	Vestas V116-2.0 MW
223	M8026	652627	3740195	8.55	10,829	91.2	8.8	20.4	8,619	242	49.2	7.9	Vestas V110-2.0 MW
224	M8026	661774	3748419	8.50	10,739	88.1	11.9	23.1	8,256	261	47.1	8.2	Vestas V110-2.0 MW
225	M8026	652424	3739618	8.59	11,292	90.0	10.0	21.5	8,861	220	50.5	7.7	Vestas V116-2.0 MW
226	M8026	655375	3740475	8.46	11,103	93.8	6.2	18.2	9,084	156	51.8	8.1	Vestas V116-2.0 MW
227	M8026	657625	3739454	8.45	10,677	90.1	9.9	21.4	8,392	254	47.9	8.3	Vestas V110-2.0 MW
228	M8026	654225	3740808	8.56	11,231	94.1	5.9	17.9	9,218	100	52.6	7.7	Vestas V116-2.0 MW
229	M8026	659993	3738676	8.52	11,181	92.1	7.9	19.7	8,983	187	51.2	7.9	Vestas V116-2.0 MW
230	M8026	662999	3748045	8.54	11,175	94.2	5.8	17.8	9,183	107	52.4	7.8	Vestas V116-2.0 MW
231	M8026	656478	3743784	8.50	11,149	93.2	6.8	18.7	9,066	162	51.7	8.1	Vestas V116-2.0 MW
232	M8026	656588	3746486	8.49	11,146	90.3	9.7	21.3	8,775	234	50.1	8.1	Vestas V116-2.0 MW
233	M8026	660758	3739265	8.48	10,722	91.5	8.5	20.2	8,555	246	48.8	7.9	Vestas V110-2.0 MW
234	M8026	666625	3748225	8.38	10,960	92.7	7.3	19.1	8,868	217	50.6	8.0	Vestas V116-2.0 MW
235	M8026	658050	3744975	8.47	11,109	91.4	8.6	20.3	8,855	221	50.5	8.1	Vestas V116-2.0 MW
236	M8026	658650	3741850	8.47	10,699	89.4	10.6	22.1	8,339	258	47.6	8.3	Vestas V110-2.0 MW
237	M8026	669369	3752967	8.64	11,339	92.5	7.5	19.3	9,147	122	52.2	7.5	Vestas V116-2.0 MW
238	M8026	671103	3750558	8.45	11,072	94.9	5.1	17.2	9,168	113	52.3	7.8	Vestas V116-2.0 MW
239	M8026	657900	3743350	8.45	11,088	91.1	8.9	20.5	8,814	226	50.3	8.2	Vestas V116-2.0 MW
240	M8026	667925	3749325	8.48	11,103	93.0	7.0	18.9	9,006	179	51.4	7.8	Vestas V116-2.0 MW
241	M8026	654634	3743522	8.47	11,121	92.7	7.3	19.2	8,989	186	51.3	8.1	Vestas V116-2.0 MW
242	M8026	654470	3746080	8.51	10,761	89.3	10.7	22.1	8,388	255	47.8	8.2	Vestas V110-2.0 MW
243	M8026	663882	3748487	8.55	11,194	93.0	7.0	18.9	9,079	159	51.8	7.8	Vestas V116-2.0 MW
244	M8026	665427	3738000	8.50	11,165	98.0	2.0	14.5	9,545	38	54.4	7.4	Vestas V116-2.0 MW
245	M8026	662710	3738149	8.50	11,152	93.2	6.8	18.7	9,062	163	51.7	7.8	Vestas V116-2.0 MW
246	M8026	654896	3743815	8.50	11,157	90.4	9.6	21.2	8,795	229	50.2	8.2	Vestas V116-2.0 MW
247	M8026	664359	3739133	8.46	11,101	94.4	5.6	17.7	9,133	129	52.1	8.0	Vestas V116-2.0 MW
248	M8026	672689	3751231	8.47	11,108	97.2	2.8	15.2	9,421	50	53.7	7.6	Vestas V116-2.0 MW
249	M8026	669050	3746625	8.35	10,937	97.7	2.3	14.8	9,320	68	53.2	7.7	Vestas V116-2.0 MW
250	M8026	671434	3751071	8.48	11,127	94.2	5.8	17.8	9,145	126	52.2	7.7	Vestas V116-2.0 MW
251	M8026	653307	3740109	8.56	11,250	93.9	6.1	18.1	9,218	101	52.6	7.7	Vestas V116-2.0 MW
252	M8026	670622	3750536	8.46	11,090	95.3	4.7	16.8	9,222	99	52.6	7.7	Vestas V116-2.0 MW
253	M8026	667475	3749025	8.49	11,106	94.1	5.9	18.0	9,111	141	52.0	7.7	Vestas V116-2.0 MW
254	M8026	677143	3765188	9.00	11,845	96.3	3.7	16.0	9,954	8	56.8	6.7	Vestas V116-2.0 MW
255	M8026	658275	3741825	8.47	10,702	91.9	8.1	19.9	8,574	245	48.9	8.2	Vestas V110-2.0 MW
256	M8026	661426	3739448	8.45	11,083	94.2	5.8	17.8	9,110	143	52.0	8.1	Vestas V116-2.0 MW
257	M8026	659794	3740406	8.43	11,058	92.3	7.7	19.5	8,897	210	50.7	8.2	Vestas V116-2.0 MW
258	M8026	666225	3748050	8.49	11,113	95.1	4.9	17.0	9,223	98	52.6	7.8	Vestas V116-2.0 MW
259	M8026	654384	3741331	8.48	10,722	91.2	8.8	20.5	8,526	249	48.6	8.1	Vestas V110-2.0 MW
260	M8026	657350	3742611	8.48	10,712	92.4	7.6	19.5	8,627	241	49.2	8.1	Vestas V110-2.0 MW
261	M8026	658878	3740452	8.44	10,661	91.8	8.2	19.9	8,538	248	48.7	8.2	Vestas V110-2.0 MW

Table 11. Wind Speed and Energy Production Uncertainty Summary (Evaluation Period [Years 2-10])

Uncertainty Source	Wind Speed		Energy Equivalent	
	%	m/s	%	GWh/Yr
Wind Resource				
Site Documentation and Verification	0.3	0.03	0.3	7.3
Wind Speed Measurements	1.0	0.08	1.0	23.5
Long-Term Average Speed	1.5	0.13	1.5	36.1
Evaluation Period Wind Resource	1.3	0.12	1.4	32.6
Wind Shear	1.1	0.10	1.1	27.0
Wind Flow Modeling	4.5	0.39	4.6	110.2
Total Wind Resource Uncertainty	**5.1**	**0.45**	**5.3**	**125.9**
Performance				
Wind Speed Frequency Distribution			1.1	25.9
Total Plant Losses			3.5	84.1
Total Energy Uncertainty			**6.4**	**153.6**

Table 12. Estimated Energy Production and Net Capacity Factor at Five Confidence Levels (Evaluation Period [Years 2-10], Annual, and First Year)

Probability of Exceedance	Evaluation Period Average Energy Production (GWh)	Evaluation Period Average Capacity Factor (%)	Annual Energy Production (GWh)	Annual Capacity Factor (%)	First Year Energy Production (GWh)	First Year Capacity Factor (%)
P50	2389.4	52.2	2389.4	52.2	2305.4	50.4
P75	2285.8	50.0	2259.9	49.4	2145.0	46.9
P90	2192.5	47.9	2143.3	46.8	2000.7	43.7
P95	2136.7	46.7	2073.6	45.3	1914.3	41.8
P99	2032.1	44.4	1942.8	42.5	1752.3	38.3

APPENDIX A - ENERGY PRODUCTION LOSSES

Table A1. Sagamore Vestas V110-2.0 MW Detailed Energy Production Loss Accounting

Wake Effect	**First Year**	**Long-Term**
Internal Wake Effect of the Project	7.3%	7.3%
Wake Effect of Existing or Planned Projects	0.2%	0.2%
Wake Effect Total	**7.5%**	**7.5%**
Availability		
Contractual Turbine Availability	3.0%	3.0%
Non-Contractual Turbine Availability	1.3%	1.3%
Long-term Availability Correlation with High Wind Events	0.6%	0.6%
Availability of Collection & Substation	0.2%	0.2%
Availability of Utility Grid	0.3%	0.3%
Plant Re-start after Grid outages	0.2%	0.2%
First-Year Plant Availability	4.0%	0.0%
Availability Total	**9.3%**	**5.5%**
Electrical		
Electrical Efficiency	2.0%	2.0%
Power Consumption of Extreme Weather Package	0.0%	0.0%
Electrical Total	**2.0%**	**2.0%**
Turbine Performance		
Sub-Optimal Operation	1.0%	1.0%
Power Curve Adjustment	2.4%	2.4%
High Wind Control Hysteresis	0.2%	0.2%
Inclined Flow	0.0%	0.0%
Turbine Performance Total	**3.6%**	**3.6%**
Environmental		
Icing	0.3%	0.3%
Blade Degradation	0.7%	1.2%
Low/High Temperature Shutdown	0.2%	0.2%
Site Access	0.1%	0.1%
Lightning	0.5%	0.5%
Environmental Total	**1.8%**	**2.3%**
Curtailments		
Directional Curtailment	0.0%	0.0%
PPA Curtailment	0.0%	0.0%
Environmental Curtailment	0.0%	0.0%
Curtailment Total	**0.0%**	**0.0%**
Total Losses	**22.2%**	**19.4%**

The summarized loss categories presented in the main report are explained in detail below.

Wake Effect

Wind turbines alter the free stream wind flow which may reduce the energy production of a wind project. Losses due to this wake effect are divided into the following categories:

- **Internal Wake Effect of the Project:** This loss accounts for the wake effect from turbines within the project being analyzed.
- **Wake Effect of Existing or Planned Projects:** This loss accounts for the wake effect of existing or planned projects located adjacent to the project being analyzed for which sufficient information was available to make a precise estimate of their impact on the project being studied.

Availability

A plant or turbine is said to be available when it is capable of generating its full rated output, given sufficient wind. Availability losses occur when some turbines in a project, or an entire project, are inoperative for some reason. Data reviewed by AWS Truepower shows that a typical wind plant within North America is likely to average 95% time-based availability in long-term operation. Of the implied 5% downtime, the availability losses are divided into the categories described below, with an additional correlation loss to adjust from time-based to energy-based availability.

- **Contractual Availability of Wind Turbines:** Turbine downtime traditionally covered under availability warranties (while in effect); AWS Truepower typically assumes a baseline time-weighted turbine availability of 97%.
- **Non-Contractual Availability of Wind Turbines:** AWS Truepower attributes an additional 1.3% of turbine downtime as a result of force majeure events, scheduled maintenance, and repair delays due to high winds or lack of spare parts, which are typically not covered under traditional warranties.
- **Long-term Availability Correlation with High Wind Events (LACHWE):** This factor accounts for the likelihood that the turbines will experience shutdowns more often in high winds than at other times, resulting in energy losses not accounted for by downtime alone. Shutdowns tend to occur in high winds because that is when turbine components are most likely to exceed limits specified in the control software. AWS Truepower's estimate of this loss, which depends upon the turbine type, expected downtime, and capacity factor, is based on detailed study of losses in operating wind projects.
- **Availability of Collection and Substation:** This loss accounts for outages of the collection system and substation. It is typically assigned a value of 0.2%, which corresponds to 2 events per year of 8 hours average duration.
- **Availability of Utility Grid:** This loss accounts for outages of the utility grid. It is typically assigned a value of 0.3%, which corresponds to 4 events per year of 6 hours average duration.
- **Plant Restart after Grid Outage:** This loss is typically assigned a value of 0.2%, which assumes that 4 utility grid outages per year are accompanied by a 5-hour average standby period while the turbine components are brought within temperature, humidity, and other operating specifications.
- **First-Year Plant Availability:** This value is typically set to 4% to account for the additional turbine and plant downtime that is often observed during the first year of operation.

Electrical

- **Electrical Efficiency:** Losses are experienced in all electrical components of the wind project, including the padmount transformer, electrical collection system, and substation transformer. These losses are established in the electrical system design. The typical 2% value assumed here is intended to account for losses between the low-voltage terminals of the turbine (where the output is measured in a power curve test) and the revenue meter located on the high-voltage side of the on-site substation. If the revenue meter is to be placed at a distance from the on-site substation, a loss should be added to account for the length of high-voltage transmission line between the sub-station and the revenue meter.
- **Power Consumption of Extreme Weather Package:** This loss is intended to account for the energy consumed by the equipment included in an extreme weather package, if the turbines are so equipped. Power consumption for site lighting, O&M facilities, and other site facilities not associated with the turbines are not included as loss items and should be considered in the project's financial modeling.

Turbine Performance

- **Sub-Optimal Operation:** This factor accounts for shortfalls from ideal performance due to suboptimal turbine settings. Typical examples include yaw misalignments, control anemometer calibration, blade pitch inaccuracies or misalignments, and other control setting issues.
- **Power Curve Adjustment:** This loss accounts for expected turbine performance relative to the modeled performance using the advertised power curve.[20]
- **High Wind Control Hysteresis:** For most turbines, once the wind speed exceeds the turbine's design cut-out speed and the machine shuts down, the control software waits until the speed drops below a lower speed threshold (the reset-from-cut-out speed) before allowing the turbine to restart. This loss accounts for the energy lost in this hysteresis loop. It is calculated from wind data collected at the site and the manufacturer's specified cut-out and reset-from-cut-out speeds.
- **Inclined Flow:** This loss has been included to account for the estimated impact of inclined (non-horizontal) flow on power production.

Environmental

- **Icing:** This loss reflects decreased rotor aerodynamic efficiency caused by the accumulation of ice on the turbines during plant operation, as well as turbine shutdowns caused by excessive ice accumulation. The icing losses are estimated from site weather data, including the expected frequency and duration of freezing precipitation and rime ice formation.
- **Blade Degradation:** This loss reflects changes to the aerodynamic efficiency of the turbine blades over time and consists of long- and short-term components. Long-term impacts result from normal wear and are caused by factors such as the permanent effects of sun exposure, wind-blown sand, and the freeze/thaw cycle of moisture within micro-cracks on the blades. These factors typically affect the leading edge of the blade and result in performance degradation over time. Short-term effects generally result from the accretion of insects and dirt. This factor is estimated from the expected dust and insect accumulation in the area and the frequency of precipitation, which cleans the blades.
- **Low/High Temperature Shutdown:** This loss value is calculated based on the energy that will be lost when the turbine shuts down due to temperatures outside the operating design envelope.

- **Site Access:** Severe weather can limit access to some sites, which can reduce energy production because response times for repairs are increased. This situation often occurs in areas prone to heavy snow. However, offshore projects may also be strongly affected. This loss is estimated based on weather data and other site specific information.
- **Lightning:** Lightning can damage turbine components and cause electrical faults resulting in shutdowns. This loss is estimated from meteorological data indicating the likely frequency of lightning at the site.

Curtailments

- **Directional Curtailment:** If turbines are spaced closer than three rotor diameters from each other, a directional curtailment strategy may be imposed by the manufacturer to limit the fatigue losses on the affected turbines caused by wake-induced turbulence. For such layouts, AWS Truepower estimates a representative loss until a detailed curtailment strategy is specified by the manufacturer. At that time, a more detailed calculation of this loss can be performed.
- **PPA Curtailment:** If the wind farm is forced to curtail production, loss of revenue could result from the sale of energy and or loss of production incentives. Typically, AWS Truepower does not have sufficient information to assign a value to this loss. Consequently, it is typically set to zero unless loss data is supplied by the client.
- **Environmental Curtailment:** If the wind farm is required to comply with certain operational standards due to environmental constraints, an environmental curtailment loss may be estimated. Production may be curtailed due to habitat concerns, noise restraints, shadow flicker, and other such environmental issues. Typically, AWS Truepower does not have sufficient information to assign a value to this loss. Consequently, it is normally set to zero unless specific restrictions are supplied by the client.

APPENDIX B - ADDITIONAL ENERGY PRODUCTION ESTIMATES

Table B1. Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail with Xcel Energy Losses

Project:	Xcel Energy - Sagamore Wind Project, NM	
Date:	7-Feb-17	
Comments:	L016 Client Layout With Effects of Surrounding Farms	
Turbine Manufacturer/Model:	Vestas V110-2.0 MW	Vestas V116-2.0 MW
Turbine Rated Power (MW):	2.00	2.00
Hub Height (m):	80	80
Number of Turbines:	26	235
Total Number of Turbines:	261	
Plant Capacity (MW):	522	
Site Air Density (kg/m3):	1.052	1.052

Loss Accounting	
Wake Effect	7.5%
Availability	3.7%
Electrical	2.0%
Turbine Performance	3.6%
Environmental	2.3%
Curtailments	0.0%
Average Total Loss	**17.8%**

Overall Wind Plant Summary	
Average Free Wind Speed (m/s)	8.68
Gross Plant Production (MWh/yr)	2,962,645
Net Plant Production (MWh/yr)	2,436,711
Net Capacity Factor	53.3%

A long-term availability value of 3.7 % was specified by Xcel for this project, based on their anticipated fleet availability. AWS Truepower has not evaluated the appropriateness of this specified value for the project.

Per Turbine Summary

Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
1	M8026	669637	3764030	9.19	11,996	91.6	8.4	18.6	9,763	34	55.7	7.0	Vestas V116-2.0 MW
2	M8026	669098	3763449	9.22	12,040	93.0	7.0	17.2	9,967	18	56.9	6.7	Vestas V116-2.0 MW
3	M8026	675181	3764734	9.15	11,997	96.4	3.6	14.2	10,290	2	58.7	6.7	Vestas V116-2.0 MW
4	M8026	675607	3764829	9.18	12,032	94.5	5.5	15.9	10,113	10	57.7	6.8	Vestas V116-2.0 MW
5	M8026	673572	3764745	9.19	12,025	94.6	5.4	15.8	10,120	9	57.7	6.7	Vestas V116-2.0 MW
6	M8026	673175	3764621	9.16	11,987	96.2	3.8	14.4	10,262	3	58.5	6.6	Vestas V116-2.0 MW
7	M8026	670016	3764157	9.18	11,980	92.2	7.8	18.0	9,821	25	56.0	6.9	Vestas V116-2.0 MW
8	M8026	669411	3763618	9.19	12,017	91.6	8.4	18.5	9,799	31	55.9	6.8	Vestas V116-2.0 MW
9	M8026	670375	3764259	9.20	12,002	93.7	6.3	16.7	9,997	15	57.0	6.8	Vestas V116-2.0 MW
10	M8026	668333	3763544	9.23	12,030	95.4	4.6	15.1	10,215	6	58.3	6.5	Vestas V116-2.0 MW
11	M8026	675996	3764767	9.14	11,975	94.7	5.3	15.8	10,085	11	57.5	6.7	Vestas V116-2.0 MW
12	M8026	676131	3765184	9.07	11,897	92.7	7.3	17.5	9,815	27	56.0	7.0	Vestas V116-2.0 MW
13	M8026	670801	3762833	8.98	11,787	94.6	5.4	15.9	9,914	21	56.5	6.7	Vestas V116-2.0 MW
14	M8026	676491	3765194	9.03	11,861	94.9	5.1	15.5	10,022	13	57.2	6.9	Vestas V116-2.0 MW
15	M8026	670270	3762777	9.02	11,817	94.8	5.2	15.7	9,960	19	56.8	6.6	Vestas V116-2.0 MW
16	M8026	672185	3760822	9.00	11,816	94.8	5.2	15.6	9,969	17	56.9	6.9	Vestas V116-2.0 MW
17	M8026	668697	3763452	9.05	11,824	93.8	6.2	16.5	9,871	23	56.3	6.7	Vestas V116-2.0 MW
18	M8026	672336	3761304	8.97	11,781	93.1	6.9	17.1	9,763	35	55.7	7.2	Vestas V116-2.0 MW
19	M8026	668953	3758653	8.94	11,744	91.6	8.4	18.5	9,568	56	54.6	7.2	Vestas V116-2.0 MW
20	M8026	673968	3764664	9.00	11,792	94.4	5.6	16.0	9,908	22	56.5	6.7	Vestas V116-2.0 MW
21	M8026	668455	3758721	8.95	11,751	92.5	7.5	17.7	9,665	43	55.1	7.2	Vestas V116-2.0 MW
22	M8026	669664	3759819	8.98	11,785	91.4	8.6	18.7	9,581	54	54.6	7.3	Vestas V116-2.0 MW
23	M8026	670463	3759835	8.93	11,730	92.0	8.0	18.1	9,605	51	54.8	7.3	Vestas V116-2.0 MW
24	M8026	668085	3757204	8.94	11,741	90.1	9.9	19.9	9,410	96	53.7	7.5	Vestas V116-2.0 MW
25	M8026	674246	3760560	8.93	11,734	95.9	4.1	14.6	10,016	14	57.1	6.9	Vestas V116-2.0 MW
26	M8026	669296	3759508	8.97	11,771	89.1	10.9	20.8	9,326	123	53.2	7.6	Vestas V116-2.0 MW
27	M8026	670085	3759821	8.94	11,746	91.1	8.9	18.9	9,525	64	54.3	7.3	Vestas V116-2.0 MW
28	M8026	667696	3757195	8.93	11,729	90.2	9.8	19.8	9,409	97	53.7	7.5	Vestas V116-2.0 MW
29	M8026	673734	3760677	8.96	11,766	95.1	4.9	15.4	9,951	20	56.8	7.0	Vestas V116-2.0 MW
30	M8026	673328	3759843	8.91	11,711	95.9	4.1	14.7	9,988	16	57.0	7.2	Vestas V116-2.0 MW
31	M8026	667318	3757119	8.91	11,698	90.2	9.8	19.8	9,386	103	53.5	7.5	Vestas V116-2.0 MW
32	M8026	668449	3757136	8.91	11,714	90.4	9.6	19.6	9,420	88	53.7	7.5	Vestas V116-2.0 MW
33	M8026	671283	3758024	8.88	11,673	93.6	6.4	16.8	9,717	39	55.4	7.2	Vestas V116-2.0 MW
34	M8026	669176	3759134	8.95	11,752	90.1	9.9	19.9	9,418	89	53.7	7.4	Vestas V116-2.0 MW
35	M8026	674387	3764564	8.83	11,605	95.3	4.7	15.2	9,842	24	56.1	6.9	Vestas V116-2.0 MW
36	M8026	670776	3758129	8.86	11,645	90.1	9.9	19.9	9,328	121	53.2	7.6	Vestas V116-2.0 MW
37	M8026	665635	3756072	8.90	11,672	92.1	7.9	18.1	9,565	57	54.6	7.3	Vestas V116-2.0 MW
38	M8026	671730	3759425	8.83	11,600	94.8	5.2	15.7	9,780	33	55.8	7.2	Vestas V116-2.0 MW
39	M8026	666462	3756231	8.88	11,659	91.7	8.3	18.4	9,517	67	54.3	7.3	Vestas V116-2.0 MW
40	M8026	668869	3757206	8.87	11,665	92.0	8.0	18.2	9,544	59	54.4	7.4	Vestas V116-2.0 MW
41	M8026	666017	3756257	8.90	11,668	90.7	9.3	19.3	9,415	92	53.7	7.4	Vestas V116-2.0 MW
42	M8026	670110	3757765	8.88	11,673	92.6	7.4	17.6	9,613	49	54.8	7.2	Vestas V116-2.0 MW
43	M8026	665374	3755410	8.87	11,630	92.6	7.4	17.6	9,581	53	54.7	7.2	Vestas V116-2.0 MW
44	M8026	657276	3737735	8.57	11,256	93.7	6.3	16.6	9,385	105	53.5	7.4	Vestas V116-2.0 MW
45	M8026	675325	3757258	8.80	11,572	97.5	2.5	13.3	10,033	12	57.2	6.9	Vestas V116-2.0 MW
46	M8026	663750	3754025	8.92	11,684	94.3	5.7	16.1	9,804	30	55.9	7.0	Vestas V116-2.0 MW
47	M8026	664419	3753880	8.88	11,638	93.3	6.7	17.0	9,663	44	55.1	7.2	Vestas V116-2.0 MW
48	M8026	667644	3755434	8.84	11,605	88.2	11.8	21.6	9,102	204	51.9	7.5	Vestas V116-2.0 MW
49	M8026	668621	3755595	8.82	11,574	90.2	9.8	19.7	9,292	140	53.0	7.4	Vestas V116-2.0 MW
50	M8026	666995	3754840	8.81	11,564	91.8	8.2	18.3	9,451	83	53.9	7.2	Vestas V116-2.0 MW

Table B1 (Cont'd). Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail with Xcel Energy Losses

Per Turbine Summary													
Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
51	M8026	667373	3755028	8.79	11,542	89.9	10.1	20.1	9,226	167	52.6	7.4	Vestas V116-2.0 MW
52	M8026	668192	3755701	8.81	11,565	89.3	10.7	20.5	9,191	176	52.4	7.5	Vestas V116-2.0 MW
53	M8026	670925	3755618	8.77	11,540	92.0	8.0	18.2	9,445	85	53.9	7.2	Vestas V116-2.0 MW
54	M8026	664722	3754839	8.85	11,592	93.3	6.7	17.0	9,618	48	54.9	7.1	Vestas V116-2.0 MW
55	M8026	655324	3750337	8.81	11,566	90.5	9.5	19.5	9,312	130	53.1	7.4	Vestas V116-2.0 MW
56	M8026	655976	3741344	8.44	10,660	90.3	9.7	19.7	8,564	253	48.8	8.3	Vestas V110-2.0 MW
57	M8026	666965	3757174	8.81	11,573	92.0	8.0	18.2	9,465	79	54.0	7.4	Vestas V116-2.0 MW
58	M8026	669007	3755542	8.79	11,545	90.3	9.7	19.7	9,276	152	52.9	7.4	Vestas V116-2.0 MW
59	M8026	673663	3756240	8.78	11,550	95.2	4.8	15.3	9,784	32	55.8	7.0	Vestas V116-2.0 MW
60	M8026	654868	3749649	8.79	11,545	88.8	11.2	21.0	9,117	200	52.0	7.4	Vestas V116-2.0 MW
61	M8026	666126	3754049	8.77	11,506	92.0	8.0	18.2	9,417	90	53.7	7.3	Vestas V116-2.0 MW
62	M8026	671321	3755638	8.70	11,454	91.6	8.4	18.5	9,335	116	53.2	7.3	Vestas V116-2.0 MW
63	M8026	673766	3756612	8.76	11,530	91.8	8.2	18.3	9,417	91	53.7	7.3	Vestas V116-2.0 MW
64	M8026	665614	3754005	8.84	11,583	92.5	7.5	17.7	9,535	62	54.4	7.2	Vestas V116-2.0 MW
65	M8026	648549	3740112	8.64	11,370	94.9	5.1	15.5	9,603	52	54.8	7.2	Vestas V116-2.0 MW
66	M8026	649357	3738542	8.61	11,336	93.9	6.1	16.5	9,466	78	54.0	7.3	Vestas V116-2.0 MW
67	M8026	648468	3738537	8.59	11,316	96.2	3.8	14.5	9,680	42	55.2	7.2	Vestas V116-2.0 MW
68	M8026	658452	3749933	8.73	11,452	90.1	9.9	19.9	9,174	183	52.3	7.3	Vestas V116-2.0 MW
69	M8026	655200	3749916	8.79	11,540	90.1	9.9	19.9	9,249	161	52.8	7.2	Vestas V116-2.0 MW
70	M8026	649030	3740033	8.64	11,371	93.0	7.0	17.2	9,411	95	53.7	7.3	Vestas V116-2.0 MW
71	M8026	647966	3738637	8.61	11,345	97.2	2.8	13.5	9,812	29	56.0	7.1	Vestas V116-2.0 MW
72	M8026	655049	3735589	8.65	11,383	94.1	5.9	16.3	9,528	63	54.3	7.3	Vestas V116-2.0 MW
73	M8026	657845	3749567	8.72	11,443	92.0	8.0	18.2	9,365	108	53.4	7.2	Vestas V116-2.0 MW
74	M8026	649339	3740596	8.56	11,273	93.0	7.0	17.2	9,331	118	53.2	7.5	Vestas V116-2.0 MW
75	M8026	669397	3755443	8.74	11,494	90.9	9.1	19.1	9,300	134	53.0	7.3	Vestas V116-2.0 MW
76	M8026	657609	3742952	8.49	10,733	89.1	10.9	20.8	8,503	259	48.5	8.3	Vestas V110-2.0 MW
77	M8026	672185	3754476	8.72	11,466	91.0	9.0	19.1	9,281	148	52.9	7.3	Vestas V116-2.0 MW
78	M8026	654538	3748997	8.73	11,475	89.3	10.7	20.6	9,115	202	52.0	7.3	Vestas V116-2.0 MW
79	M8026	656615	3737375	8.64	11,348	92.6	7.4	17.6	9,348	114	53.3	7.4	Vestas V116-2.0 MW
80	M8026	649707	3738720	8.60	11,316	92.1	7.9	18.1	9,273	154	52.9	7.4	Vestas V116-2.0 MW
81	M8026	657425	3749544	8.75	11,485	92.5	7.5	17.7	9,452	82	53.9	7.1	Vestas V116-2.0 MW
82	M8026	661262	3750418	8.75	11,470	91.0	9.0	19.1	9,282	147	52.9	7.4	Vestas V116-2.0 MW
83	M8026	670580	3754052	8.68	11,403	91.0	9.0	19.1	9,230	165	52.6	7.7	Vestas V116-2.0 MW
84	M8026	665435	3751775	8.74	11,438	90.2	9.8	19.8	9,177	182	52.3	7.7	Vestas V116-2.0 MW
85	M8026	670215	3754143	8.70	11,433	89.8	10.2	20.1	9,138	192	52.1	7.7	Vestas V116-2.0 MW
86	M8026	668123	3752879	8.70	11,399	91.1	8.9	18.9	9,241	164	52.7	7.7	Vestas V116-2.0 MW
87	M8026	654634	3735552	8.65	11,388	93.7	6.3	16.6	9,492	72	54.1	7.2	Vestas V116-2.0 MW
88	M8026	669860	3754120	8.71	11,437	89.4	10.6	20.5	9,094	206	51.9	7.8	Vestas V116-2.0 MW
89	M8026	663057	3751636	8.77	11,483	93.4	6.6	16.9	9,542	60	54.4	7.5	Vestas V116-2.0 MW
90	M8026	657876	3736065	8.71	11,446	95.2	4.8	15.3	9,690	40	55.3	7.2	Vestas V116-2.0 MW
91	M8026	663519	3738774	8.40	11,017	94.8	5.2	15.7	9,290	144	53.0	8.1	Vestas V116-2.0 MW
92	M8026	672818	3754685	8.66	11,390	94.5	5.5	16.0	9,573	55	54.6	7.3	Vestas V116-2.0 MW
93	M8026	649003	3738580	8.59	11,309	94.8	5.2	15.7	9,537	61	54.4	7.3	Vestas V116-2.0 MW
94	M8026	650075	3738757	8.64	11,380	93.8	6.2	16.5	9,500	70	54.2	7.3	Vestas V116-2.0 MW
95	M8026	668607	3754203	8.71	11,427	88.4	11.6	21.3	8,990	224	51.3	7.9	Vestas V116-2.0 MW
96	M8026	658368	3740114	8.47	10,709	90.9	9.1	19.1	8,661	250	49.4	8.2	Vestas V110-2.0 MW
97	M8026	656853	3749575	8.73	11,454	91.4	8.6	18.7	9,312	131	53.1	7.4	Vestas V116-2.0 MW
98	M8026	670933	3754022	8.67	11,387	91.1	8.9	18.9	9,230	166	52.6	7.7	Vestas V116-2.0 MW
99	M8026	661770	3750867	8.72	11,421	89.0	11.0	20.9	9,038	219	51.6	7.8	Vestas V116-2.0 MW
100	M8026	654216	3735370	8.63	11,377	97.0	3.0	13.7	9,817	26	56.0	7.1	Vestas V116-2.0 MW
101	M8026	655507	3735925	8.67	11,412	92.1	7.9	18.1	9,352	111	53.3	7.3	Vestas V116-2.0 MW
102	M8026	659159	3741850	8.44	10,657	90.1	9.9	19.9	8,541	256	48.7	8.3	Vestas V110-2.0 MW
103	M8026	671833	3754270	8.67	11,401	92.3	7.7	17.9	9,361	110	53.4	7.6	Vestas V116-2.0 MW
104	M8026	665982	3752209	8.69	11,384	89.4	10.6	20.5	9,052	216	51.6	7.8	Vestas V116-2.0 MW
105	M8026	659321	3740440	8.44	10,664	90.5	9.5	19.5	8,580	252	48.9	8.2	Vestas V110-2.0 MW
106	M8026	650264	3739377	8.62	11,347	92.4	7.6	17.8	9,329	120	53.2	7.3	Vestas V116-2.0 MW
107	M8026	658326	3749532	8.70	11,411	92.5	7.5	17.7	9,391	102	53.6	7.3	Vestas V116-2.0 MW
108	M8026	669674	3753703	8.71	11,432	88.3	11.7	21.5	8,979	227	51.2	7.8	Vestas V116-2.0 MW
109	M8026	664623	3751668	8.72	11,420	89.3	10.7	20.5	9,074	211	51.8	7.8	Vestas V116-2.0 MW
110	M8026	672281	3754815	8.64	11,369	87.7	12.3	22.0	8,868	239	50.6	7.7	Vestas V116-2.0 MW
111	M8026	665596	3752185	8.73	11,438	87.9	12.1	21.8	8,950	233	51.0	7.8	Vestas V116-2.0 MW
112	M8026	660423	3738940	8.50	10,750	91.8	8.2	18.4	8,776	243	50.1	7.9	Vestas V110-2.0 MW
113	M8026	666229	3752500	8.71	11,415	88.0	12.0	21.7	8,938	235	51.0	8.0	Vestas V116-2.0 MW
114	M8026	668278	3753386	8.70	11,406	90.0	10.0	20.0	9,130	193	52.1	7.7	Vestas V116-2.0 MW
115	M8026	661617	3750477	8.75	11,466	89.4	10.6	20.5	9,118	198	52.0	7.3	Vestas V116-2.0 MW
116	M8026	656262	3735878	8.64	11,364	93.7	6.3	16.6	9,475	75	54.0	7.3	Vestas V116-2.0 MW
117	M8026	664133	3750903	8.72	11,421	91.7	8.3	18.4	9,318	128	53.1	7.6	Vestas V116-2.0 MW
118	M8026	668456	3753853	8.70	11,416	89.3	10.7	20.5	9,072	212	51.7	7.8	Vestas V116-2.0 MW
119	M8026	666577	3752507	8.72	11,422	90.7	9.3	19.3	9,217	169	52.6	7.7	Vestas V116-2.0 MW
120	M8026	654095	3736886	8.67	11,412	94.9	5.1	15.6	9,631	47	54.9	7.2	Vestas V116-2.0 MW

Table B1 (Cont'd). Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail with Xcel Energy Losses

Per Turbine Summary													
Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
121	M8026	655907	3735864	8.66	11,388	93.6	6.4	16.7	9,486	73	54.1	7.3	Vestas V116-2.0 MW
122	M8026	657500	3736025	8.69	11,420	96.0	4.0	14.6	9,748	37	55.6	7.1	Vestas V116-2.0 MW
123	M8026	667749	3752682	8.66	11,350	92.4	7.6	17.8	9,329	119	53.2	7.6	Vestas V116-2.0 MW
124	M8026	654635	3749349	8.73	11,472	88.2	11.8	21.5	9,003	223	51.3	7.5	Vestas V116-2.0 MW
125	M8026	655163	3736009	8.65	11,388	90.0	10.0	20.0	9,116	201	52.0	7.4	Vestas V116-2.0 MW
126	M8026	671292	3754113	8.67	11,390	92.0	8.0	18.2	9,322	127	53.2	7.6	Vestas V116-2.0 MW
127	M8026	656510	3749226	8.69	11,406	92.3	7.7	17.9	9,367	106	53.4	7.5	Vestas V116-2.0 MW
128	M8026	660839	3749940	8.66	11,351	89.7	10.3	20.2	9,061	214	51.7	7.8	Vestas V116-2.0 MW
129	M8026	665043	3751614	8.73	11,435	90.7	9.3	19.3	9,225	168	52.6	7.7	Vestas V116-2.0 MW
130	M8026	650849	3739512	8.63	11,350	93.7	6.3	16.7	9,459	81	54.0	7.2	Vestas V116-2.0 MW
131	M8026	669560	3753288	8.67	11,381	88.6	11.4	21.2	8,968	230	51.2	7.8	Vestas V116-2.0 MW
132	M8026	656649	3736017	8.65	11,378	94.4	5.6	16.0	9,558	58	54.5	7.3	Vestas V116-2.0 MW
133	M8026	655114	3737308	8.64	11,355	93.2	6.8	17.1	9,413	94	53.7	7.3	Vestas V116-2.0 MW
134	M8026	651077	3738132	8.59	11,313	97.0	3.0	13.7	9,761	36	55.7	7.4	Vestas V116-2.0 MW
135	M8026	670597	3752336	8.61	11,287	91.1	8.9	19.0	9,147	189	52.2	7.7	Vestas V116-2.0 MW
136	M8026	654302	3748655	8.71	11,437	92.9	7.1	17.4	9,448	84	53.9	7.3	Vestas V116-2.0 MW
137	M8026	650952	3741763	8.59	11,299	93.9	6.1	16.5	9,434	87	53.8	7.5	Vestas V116-2.0 MW
138	M8026	670529	3757776	8.80	11,572	91.2	8.8	18.9	9,386	104	53.5	7.4	Vestas V116-2.0 MW
139	M8026	663038	3749997	8.67	11,351	91.6	8.4	18.5	9,254	160	52.8	7.6	Vestas V116-2.0 MW
140	M8026	678614	3765973	9.04	11,899	96.5	3.5	14.1	10,218	5	58.3	6.7	Vestas V116-2.0 MW
141	M8026	651420	3739364	8.65	11,375	93.6	6.4	16.7	9,472	76	54.0	7.3	Vestas V116-2.0 MW
142	M8026	651302	3741882	8.59	11,297	90.6	9.4	19.5	9,099	205	51.9	7.6	Vestas V116-2.0 MW
143	M8026	662514	3749585	8.66	11,343	91.0	9.0	19.1	9,181	181	52.4	7.7	Vestas V116-2.0 MW
144	M8026	654433	3737251	8.65	11,377	92.4	7.6	17.8	9,347	115	53.3	7.3	Vestas V116-2.0 MW
145	M8026	659946	3737098	8.65	11,359	97.1	2.9	13.6	9,815	28	56.0	7.2	Vestas V116-2.0 MW
146	M8026	660618	3749568	8.64	11,327	92.2	7.8	17.9	9,296	139	53.0	7.6	Vestas V116-2.0 MW
147	M8026	664464	3751149	8.63	11,315	90.0	10.0	19.9	9,060	215	51.7	7.8	Vestas V116-2.0 MW
148	M8026	667075	3750475	8.62	11,277	92.7	7.3	17.5	9,300	136	53.0	7.6	Vestas V116-2.0 MW
149	M8026	658984	3738130	8.68	11,391	90.7	9.3	19.4	9,184	180	52.4	7.5	Vestas V116-2.0 MW
150	M8026	678097	3765906	9.03	11,880	96.9	3.1	13.8	10,240	4	58.4	6.7	Vestas V116-2.0 MW
151	M8026	677630	3765219	9.00	11,866	96.6	3.4	14.1	10,195	7	58.2	6.7	Vestas V116-2.0 MW
152	M8026	663453	3749990	8.65	11,329	91.3	8.7	18.7	9,207	171	52.5	7.7	Vestas V116-2.0 MW
153	M8026	655339	3747855	8.65	10,975	92.1	7.9	18.1	8,990	225	51.3	7.5	Vestas V110-2.0 MW
154	M8026	657775	3746500	8.50	11,140	90.5	9.5	19.5	8,967	231	51.1	8.1	Vestas V116-2.0 MW
155	M8026	664771	3749659	8.63	11,292	90.8	9.2	19.2	9,122	196	52.0	7.7	Vestas V116-2.0 MW
156	M8026	662174	3749178	8.63	11,307	89.7	10.3	20.3	9,017	222	51.4	7.8	Vestas V116-2.0 MW
157	M8026	655706	3747860	8.60	11,300	90.7	9.3	19.3	9,118	199	52.0	7.9	Vestas V116-2.0 MW
158	M8026	652897	3746609	8.60	11,297	90.7	9.3	19.3	9,119	197	52.0	7.9	Vestas V116-2.0 MW
159	M8026	651607	3742100	8.57	10,868	90.2	9.8	19.7	8,723	247	49.8	7.7	Vestas V110-2.0 MW
160	M8026	670327	3752072	8.56	11,226	93.3	6.7	17.1	9,311	132	53.1	7.7	Vestas V116-2.0 MW
161	M8026	656107	3737305	8.61	11,307	91.2	8.8	18.9	9,173	185	52.3	7.5	Vestas V116-2.0 MW
162	M8026	672858	3753245	8.55	11,236	95.3	4.7	15.2	9,524	65	54.3	7.4	Vestas V116-2.0 MW
163	M8026	651248	3746383	8.60	10,902	94.4	5.6	16.1	9,151	188	52.2	7.8	Vestas V110-2.0 MW
164	M8026	653589	3747177	8.61	11,309	90.7	9.3	19.3	9,127	194	52.1	8.0	Vestas V116-2.0 MW
165	M8026	651790	3739378	8.61	11,323	92.0	8.0	18.2	9,264	157	52.8	7.5	Vestas V116-2.0 MW
166	M8026	656162	3748019	8.62	11,316	91.2	8.8	18.9	9,174	184	52.3	8.0	Vestas V116-2.0 MW
167	M8026	652138	3742011	8.56	11,259	92.5	7.5	17.8	9,260	158	52.8	7.6	Vestas V116-2.0 MW
168	M8026	655807	3746276	8.57	11,242	92.9	7.1	17.4	9,286	146	53.0	7.9	Vestas V116-2.0 MW
169	M8026	679128	3766082	9.06	11,910	97.5	2.5	13.2	10,333	1	58.9	6.7	Vestas V116-2.0 MW
170	M8026	666529	3750559	8.62	11,285	92.6	7.4	17.6	9,300	137	53.0	7.6	Vestas V116-2.0 MW
171	M8026	660652	3747981	8.61	11,286	94.0	6.0	16.4	9,437	86	53.8	7.5	Vestas V116-2.0 MW
172	M8026	652315	3742619	8.52	11,198	92.2	7.8	17.9	9,189	177	52.4	7.9	Vestas V116-2.0 MW
173	M8026	652565	3746375	8.55	11,237	91.1	8.9	18.9	9,109	203	52.0	8.0	Vestas V116-2.0 MW
174	M8026	667325	3751325	8.63	11,311	92.4	7.6	17.8	9,297	138	53.0	7.6	Vestas V116-2.0 MW
175	M8026	661625	3748025	8.54	11,188	92.4	7.6	17.8	9,201	172	52.5	8.0	Vestas V116-2.0 MW
176	M8026	667925	3751225	8.58	11,240	93.3	6.7	17.0	9,326	125	53.2	7.5	Vestas V116-2.0 MW
177	M8026	652168	3739345	8.60	11,306	92.3	7.7	17.9	9,280	149	52.9	7.4	Vestas V116-2.0 MW
178	M8026	672329	3752965	8.53	11,192	95.1	4.9	15.4	9,471	77	54.0	7.6	Vestas V116-2.0 MW
179	M8026	652172	3746237	8.56	11,246	93.5	6.5	16.8	9,351	112	53.3	7.9	Vestas V116-2.0 MW
180	M8026	655725	3737320	8.63	11,339	92.1	7.9	18.1	9,288	145	53.0	7.4	Vestas V116-2.0 MW
181	M8026	663592	3737060	8.54	11,217	96.8	3.2	13.9	9,659	45	55.1	7.2	Vestas V116-2.0 MW
182	M8026	658211	3737024	8.60	11,296	94.7	5.3	15.7	9,518	66	54.3	7.3	Vestas V116-2.0 MW
183	M8026	661226	3737068	8.56	11,237	96.9	3.1	13.8	9,683	41	55.2	7.3	Vestas V116-2.0 MW
184	M8026	658333	3737475	8.58	11,274	91.7	8.3	18.4	9,195	175	52.4	7.5	Vestas V116-2.0 MW
185	M8026	657467	3746271	8.53	11,179	92.4	7.6	17.8	9,186	178	52.4	8.0	Vestas V116-2.0 MW
186	M8026	665480	3749628	8.56	11,203	93.3	6.7	17.0	9,300	135	53.0	7.8	Vestas V116-2.0 MW
187	M8026	653272	3738483	8.60	11,303	96.1	3.9	14.5	9,659	46	55.1	7.1	Vestas V116-2.0 MW
188	M8026	664483	3749331	8.60	11,260	91.3	8.7	18.8	9,146	191	52.2	7.6	Vestas V116-2.0 MW
189	M8026	661199	3747947	8.59	11,250	93.2	6.8	17.1	9,326	124	53.2	7.7	Vestas V116-2.0 MW
190	M8026	656251	3739390	8.45	11,087	94.0	6.0	16.4	9,269	155	52.9	8.1	Vestas V116-2.0 MW

Table B1 (Cont'd). Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Detail with Xcel Energy Losses

Per Turbine Summary														
Turbine ID	Mast Association	Coordinates (WGS84 UTM13) Easting (m)	Northing (m)	Free Speed (m/s)	Gross MWh/yr	Array Eff. (%)	Array Loss (%)	Total Loss (%)	Net MWh/yr	Turbine Rank	Net Capacity Factor (%)	Total TI at 15m/s (%)	Turbine Model
191	M8026	654313	3738641	8.57	11,269	94.7	5.3	15.7	9,494	71	54.2	7.4	Vestas V116-2.0 MW
192	M8026	659845	3742277	8.44	11,069	90.0	10.0	19.9	8,861	240	50.5	8.3	Vestas V116-2.0 MW
193	M8026	665916	3750079	8.58	11,231	92.1	7.9	18.1	9,199	173	52.5	7.8	Vestas V116-2.0 MW
194	M8026	657983	3739707	8.55	11,219	90.8	9.2	19.2	9,062	213	51.7	8.2	Vestas V116-2.0 MW
195	M8026	663948	3738967	8.37	10,971	93.1	6.9	17.2	9,087	208	51.8	8.2	Vestas V116-2.0 MW
196	M8026	663941	3737377	8.52	11,196	95.0	5.0	15.5	9,460	80	54.0	7.5	Vestas V116-2.0 MW
197	M8026	656246	3746277	8.55	11,215	91.1	8.9	19.0	9,089	207	51.8	8.1	Vestas V116-2.0 MW
198	M8026	652737	3742991	8.46	11,107	91.5	8.5	18.6	9,043	218	51.6	8.2	Vestas V116-2.0 MW
199	M8026	657251	3739142	8.54	11,218	93.2	6.8	17.1	9,303	133	53.1	7.6	Vestas V116-2.0 MW
200	M8026	654341	3745729	8.54	11,212	93.2	6.8	17.1	9,292	142	53.0	8.0	Vestas V116-2.0 MW
201	M8026	659982	3747926	8.60	11,270	94.8	5.2	15.7	9,502	69	54.2	7.8	Vestas V116-2.0 MW
202	M8026	663319	3748293	8.57	11,219	91.7	8.3	18.5	9,147	190	52.2	7.7	Vestas V116-2.0 MW
203	M8026	659650	3741900	8.43	11,057	91.1	8.9	19.0	8,958	232	51.1	8.3	Vestas V116-2.0 MW
204	M8026	660185	3743120	8.45	11,072	94.1	5.9	16.2	9,273	153	52.9	8.1	Vestas V116-2.0 MW
205	M8026	658768	3737842	8.59	11,286	92.4	7.6	17.8	9,278	150	52.9	7.3	Vestas V116-2.0 MW
206	M8026	655820	3743587	8.51	11,167	93.4	6.6	16.9	9,277	151	52.9	8.1	Vestas V116-2.0 MW
207	M8026	653271	3743527	8.52	11,192	91.3	8.7	18.8	9,087	209	51.8	8.2	Vestas V116-2.0 MW
208	M8026	651599	3746336	8.59	10,885	92.1	7.9	18.0	8,921	237	50.9	7.9	Vestas V110-2.0 MW
209	M8026	662374	3737863	8.52	11,175	93.9	6.1	16.5	9,334	117	53.2	7.5	Vestas V116-2.0 MW
210	M8026	661451	3737795	8.53	11,194	94.5	5.5	15.9	9,414	93	53.7	7.4	Vestas V116-2.0 MW
211	M8026	653270	3747029	8.60	10,893	90.4	9.6	19.6	8,761	244	50.0	8.0	Vestas V110-2.0 MW
212	M8026	667175	3748225	8.46	11,074	95.1	4.9	15.4	9,363	109	53.4	7.7	Vestas V116-2.0 MW
213	M8026	659617	3738606	8.50	10,756	93.4	6.6	17.0	8,932	236	50.9	7.8	Vestas V110-2.0 MW
214	M8026	668950	3750675	8.52	11,159	95.5	4.5	15.1	9,478	74	54.1	7.7	Vestas V116-2.0 MW
215	M8026	661904	3748841	8.55	10,800	88.2	11.8	21.6	8,467	260	48.3	8.0	Vestas V110-2.0 MW
216	M8026	667825	3755775	8.80	11,557	87.3	12.7	22.3	8,979	228	51.2	7.7	Vestas V116-2.0 MW
217	M8026	668250	3749675	8.50	11,120	93.1	6.9	17.1	9,214	170	52.6	7.8	Vestas V116-2.0 MW
218	M8026	657675	3744875	8.46	11,094	92.5	7.5	17.7	9,125	195	52.0	8.0	Vestas V116-2.0 MW
219	M8026	661920	3737854	8.51	10,761	93.1	6.9	17.2	8,913	238	50.8	7.5	Vestas V110-2.0 MW
220	M8026	655692	3740968	8.45	10,672	90.6	9.4	19.4	8,601	251	49.1	8.3	Vestas V110-2.0 MW
221	M8026	652883	3743402	8.50	10,754	89.2	10.8	20.7	8,530	257	48.7	8.3	Vestas V110-2.0 MW
222	M8026	664250	3748700	8.57	11,216	92.2	7.8	18.0	9,198	174	52.5	7.6	Vestas V116-2.0 MW
223	M8026	652627	3740195	8.55	10,829	91.2	8.8	18.8	8,789	242	50.1	7.9	Vestas V110-2.0 MW
224	M8026	661774	3748419	8.50	10,739	88.1	11.9	21.6	8,419	261	48.0	8.2	Vestas V110-2.0 MW
225	M8026	652424	3739618	8.59	11,292	90.0	10.0	20.0	9,037	220	51.5	7.7	Vestas V116-2.0 MW
226	M8026	655375	3740475	8.46	11,103	93.8	6.2	16.6	9,264	156	52.8	8.1	Vestas V116-2.0 MW
227	M8026	657625	3739454	8.45	10,677	90.1	9.9	19.8	8,558	254	48.8	8.3	Vestas V110-2.0 MW
228	M8026	654225	3740808	8.56	11,231	94.1	5.9	16.3	9,401	100	53.6	7.7	Vestas V116-2.0 MW
229	M8026	659993	3738676	8.52	11,181	92.1	7.9	18.1	9,161	187	52.3	7.9	Vestas V116-2.0 MW
230	M8026	662999	3748045	8.54	11,175	94.2	5.8	16.2	9,365	107	53.4	7.8	Vestas V116-2.0 MW
231	M8026	656478	3743784	8.50	11,149	93.2	6.8	17.1	9,246	162	52.7	8.1	Vestas V116-2.0 MW
232	M8026	656588	3746486	8.49	11,146	90.3	9.7	19.7	8,949	234	51.0	8.1	Vestas V116-2.0 MW
233	M8026	660758	3739265	8.48	10,722	91.5	8.5	18.6	8,725	246	49.8	7.9	Vestas V110-2.0 MW
234	M8026	666625	3748225	8.38	10,960	92.7	7.3	17.5	9,044	217	51.6	8.0	Vestas V116-2.0 MW
235	M8026	658050	3744975	8.47	11,109	91.4	8.6	18.7	9,031	221	51.5	8.1	Vestas V116-2.0 MW
236	M8026	658650	3741850	8.47	10,699	89.4	10.6	20.5	8,504	258	48.5	8.3	Vestas V110-2.0 MW
237	M8026	669369	3752967	8.64	11,339	92.5	7.5	17.7	9,328	122	53.2	7.5	Vestas V116-2.0 MW
238	M8026	671103	3750558	8.45	11,072	94.9	5.1	15.6	9,350	113	53.3	7.8	Vestas V116-2.0 MW
239	M8026	657900	3743350	8.45	11,088	91.1	8.9	18.9	8,989	226	51.3	8.2	Vestas V116-2.0 MW
240	M8026	667925	3749325	8.48	11,103	93.0	7.0	17.3	9,184	179	52.4	7.8	Vestas V116-2.0 MW
241	M8026	654634	3743522	8.47	11,121	92.7	7.3	17.6	9,167	186	52.3	8.1	Vestas V116-2.0 MW
242	M8026	654470	3746080	8.51	10,761	89.3	10.7	20.5	8,554	255	48.8	8.2	Vestas V110-2.0 MW
243	M8026	663882	3748487	8.55	11,194	93.0	7.0	17.3	9,259	159	52.8	7.8	Vestas V116-2.0 MW
244	M8026	665427	3738000	8.50	11,165	98.0	2.0	12.8	9,734	38	55.5	7.4	Vestas V116-2.0 MW
245	M8026	662710	3738149	8.50	11,152	93.2	6.8	17.1	9,242	163	52.7	7.8	Vestas V116-2.0 MW
246	M8026	654896	3743815	8.50	11,157	90.4	9.6	19.6	8,969	229	51.2	8.2	Vestas V116-2.0 MW
247	M8026	664359	3739133	8.46	11,101	94.4	5.6	16.1	9,314	129	53.1	8.0	Vestas V116-2.0 MW
248	M8026	672689	3751231	8.47	11,108	97.2	2.8	13.5	9,608	50	54.8	7.6	Vestas V116-2.0 MW
249	M8026	669050	3746625	8.35	10,937	97.7	2.3	13.1	9,505	68	54.2	7.7	Vestas V116-2.0 MW
250	M8026	671434	3751071	8.48	11,127	94.2	5.8	16.2	9,326	126	53.2	7.7	Vestas V116-2.0 MW
251	M8026	653307	3740109	8.56	11,250	93.9	6.1	16.4	9,400	101	53.6	7.7	Vestas V116-2.0 MW
252	M8026	670622	3750536	8.46	11,090	95.3	4.7	15.2	9,404	99	53.6	7.7	Vestas V116-2.0 MW
253	M8026	667475	3749025	8.49	11,106	94.1	5.9	16.3	9,292	141	53.0	7.7	Vestas V116-2.0 MW
254	M8026	677143	3765188	9.00	11,845	96.3	3.7	14.3	10,152	8	57.9	6.7	Vestas V116-2.0 MW
255	M8026	658275	3741825	8.47	10,702	91.9	8.1	18.3	8,744	245	49.9	8.2	Vestas V110-2.0 MW
256	M8026	661426	3739448	8.45	11,083	94.2	5.8	16.2	9,291	143	53.0	8.1	Vestas V116-2.0 MW
257	M8026	659794	3740406	8.43	11,058	92.3	7.7	17.9	9,074	210	51.8	8.2	Vestas V116-2.0 MW
258	M8026	666225	3748050	8.49	11,113	95.1	4.9	15.4	9,405	98	53.6	7.8	Vestas V116-2.0 MW
259	M8026	654384	3741331	8.48	10,722	91.2	8.8	18.9	8,695	249	49.6	8.1	Vestas V110-2.0 MW
260	M8026	657350	3742611	8.48	10,712	92.4	7.6	17.9	8,798	241	50.2	8.1	Vestas V110-2.0 MW
261	M8026	658878	3740452	8.44	10,661	91.8	8.2	18.3	8,707	248	49.7	8.2	Vestas V110-2.0 MW

Table B2. Vestas V110-2.0 MW and Vestas V116-2.0 MW Wind Speed and Energy Production Uncertainty Summary (Evaluation Period [Years 2-10])

Uncertainty Source	Wind Speed		Energy Equivalent	
	%	m/s	%	GWh/Yr
Wind Resource				
Site Documentation and Verification	0.3	0.03	0.3	7.5
Wind Speed Measurements	1.0	0.08	1.0	24.0
Long-Term Average Speed	1.5	0.13	1.5	36.8
Evaluation Period Wind Resource	1.3	0.12	1.4	33.2
Wind Shear	1.1	0.10	1.1	27.5
Wind Flow Modeling	4.5	0.39	4.6	112.4
Total Wind Resource Uncertainty	**5.1**	**0.45**	**5.3**	**128.4**
Performance				
Wind Speed Frequency Distribution			1.1	26.4
Total Plant Losses			3.5	85.7
Total Energy Uncertainty			**6.4**	**156.6**

Table B3. Vestas V110-2.0 MW and Vestas V116-2.0 MW Estimated Energy Production and Net Capacity Factor at Five Confidence Levels (Evaluation Period [Years 2-10], Annual, and First Year)

Probability of Exceedance	Evaluation Period Average Energy Production (GWh)	Evaluation Period Average Capacity Factor (%)	Annual Energy Production (GWh)	Annual Capacity Factor (%)	First Year Energy Production (GWh)	First Year Capacity Factor (%)
P50	2436.7	53.3	2436.7	53.3	2351.1	51.4
P75	2331.1	50.9	2304.7	50.4	2187.5	47.8
P90	2236.0	48.9	2185.8	47.8	2040.3	44.6
P95	2179.1	47.6	2114.7	46.2	1952.3	42.7
P99	2072.3	45.3	1981.3	43.3	1787.0	39.1

Table B4. Sagamore Vestas V110-2.0 MW and Vestas V116-2.0 MS Detailed Energy Production Loss Accounting (Xcel Provided Availability Losses)

Wake Effect	**First Year**	**Long-Term**
Internal Wake Effect of the Project	7.3%	7.3%
Wake Effect of Existing or Planned Projects	0.2%	0.2%
Wake Effect Total	**7.5%**	**7.5%**
Availability		
Contractual Turbine Availability	2.0%	2.0%
Non-Contractual Turbine Availability	0.5%	0.5%
Long-term Availability Correlation with High Wind Events	0.8%	0.8%
Availability of Collection & Substation	0.2%	0.2%
Availability of Utility Grid	0.2%	0.2%
Plant Re-start after Grid outages	0.0%	0.0%
First-Year Plant Availability	4.0%	0.0%
Availability Total	**7.5%**	**3.7%**
Electrical		
Electrical Efficiency	2.0%	2.0%
Power Consumption of Extreme Weather Package	0.0%	0.0%
Electrical Total	**2.0%**	**2.0%**
Turbine Performance		
Sub-Optimal Operation	1.0%	1.0%
Power Curve Adjustment	2.4%	2.4%
High Wind Control Hysteresis	0.2%	0.2%
Inclined Flow	0.0%	0.0%
Turbine Performance Total	**3.6%**	**3.6%**
Environmental		
Icing	0.3%	0.3%
Blade Degradation	0.7%	1.2%
Low/High Temperature Shutdown	0.2%	0.2%
Site Access	0.1%	0.1%
Lightning	0.5%	0.5%
Environmental Total	**1.8%**	**2.3%**
Curtailments		
Directional Curtailment	0.0%	0.0%
PPA Curtailment	0.0%	0.0%
Environmental Curtailment	0.0%	0.0%
Curtailment Total	**0.0%**	**0.0%**
Total Losses	**20.6%**	**17.8%**

AWS TRUEPOWER

PREPARED FOR
XCEL ENERGY

PRELIMINARY ENERGY ASSESSMENT

MARCH 10, 2017

Modeled Assessment of the Wind Resource and Energy Production

FOR THE HALE WIND PROJECT

HALE COUNTY, TEXAS

CLASSIFICATION
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DOCUMENT HISTORY

ISSUE	DATE	SUMMARY
A	06 March 2017	Initial Report

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EXECUTIVE SUMMARY

AWS Truepower, LLC, a UL Company, was retained by Xcel Energy to conduct a basic site assessment to provide preliminary estimates of the long-term wind resource and energy production potential based on modeled wind data of the proposed Hale Wind Project in Hale County, Texas. The preliminary turbine layout consists of 216 Vestas V116-2.0 MW (IEC class IIIA, 2.0 MW) turbines with a rotor diameter of 116 m and a hub height of 80 m and 23 Vestas V110-2.0 MW turbines (IEC class IIIA/IIIC, 2.0 MW) with a rotor diameter of 110 m. In total, 239 turbines were used for this analysis. This report presents the results and discusses the methodology to design the proposed preliminary wind plant. The preliminary energy production estimates assume typical loss factors (e.g., electrical, high wind hysteresis, maintenance downtime, and icing and blade degradation) experienced by wind projects in similar climates. Lastly, recommendations for future development are provided.

The results of the preliminary analysis indicate that the Hale Wind Project has the potential for the installation of 478 MW of wind capacity. Using modeled wind resource data at a turbine hub height of 80 m and loss factors that are typical of wind projects in similar climates, the project is estimated to produce approximately 2,076,886 megawatt-hours (MWh) per year. This energy value corresponds to a net capacity factor of 49.6%. Appendix A contains the energy production and uncertainty estimates for the same project scenario, but assuming turbine availability losses provided by Xcel Energy.

1. INTRODUCTION

AWS Truepower, LLC, a UL Company (AWST), was retained by Xcel Energy to conduct a preliminary wind project analysis to support the development planning efforts for the proposed Hale Wind Project. The project is located in a rural open landscape primarily used for agriculture in Texas, about 40 km to the northeast of Lubbock. The objective of this study is to estimate the energy production capability of a 478 MW preliminary wind energy project that uses large-scale commercial wind turbines. The following sections explain the methodology used to derive these estimates and illustrate a typical preliminary wind turbine layout design process. Standard industry practices were applied throughout this analysis.

2. OVERVIEW OF WIND RESOURCE

Using AWST's widely used and validated MesoMap® system, which uses numerical weather prediction models to simulate wind and weather conditions in any region, the long-term annual wind conditions at 80 meters above ground were estimated at a resolution of 200 m. This analysis concluded that the predicted average free wind speed of the Hale Wind Project at 80 m is expected to range between 8.48 m/s to 8.70 m/s, with an overall estimated site average of 8.62 m/s. The project area consists of rolling hills and the wind resource if fairly consistent across the project area. However, the wind resource has slightly more potential on the hilltops throughout the project area.

The directional distribution of the wind resource is an important factor to consider when designing the wind project to minimize the wake interference between turbines. The estimated frequency and energy distribution by direction plot (wind rose) is shown in Figure 1. The model indicates that the prevailing winds are from the south-southwest and the southwest with a secondary component in the south.

3. MESOMAP SYSTEM CONFIGURATION

The standard MesoMap system configuration was used to produce the wind resource maps. The mesoscale model, Mesoscale Atmospheric Simulations System (MASS) simulated regional weather patterns with a grid spacing of 2.5 km. The microscale model (WindMap) simulated the localized effects of topography and surface roughness on a grid spacing of 200 m. The source of topographic data was the National Elevation Dataset (NED) a digital terrain model produced on a 10 m grid by the US Geological Survey (USGS). The source of land cover data was the 30 m resolution National Land Cover Dataset, which is produced by the USGS and derived from Landsat imagery. Both data sets are of very high quality.

In converting from land cover to surface roughness, the roughness length values that were applied are believed to be typical of conditions in Texas. However, the roughness could vary a good deal within each class.

4. PRELIMINARY LAYOUT

Xcel Energy provided AWST with a turbine layout in the state of Texas. This layout sites 216 Vestas V116-2.0 MW turbines and 23 Vestas V100-2.0 MW turbines for a total of 239 turbines. The preliminary wind turbine layout is shown in Figure 2.

5. PRELIMINARY PLANT PRODUCTION ESTIMATES

For this preliminary layout, AWST calculated estimates of both the gross and net energy production for the Hale Wind Project site. Wind speed frequency distribution data from the previously mentioned MesoMap system for each turbine site were applied to the appropriate turbine power curve. It should be further noted that the preliminary energy production estimate was determined using data from a wind resource model, which should not be considered a substitute for on-site measurements. The turbine power curves were interpolated to the site air density at each turbine location, which is estimated to average 1.078 kg/m3 at 80 m across the entire layout. Summing the results from each individual turbine yields an annual gross energy production of 2,592,571 MWh, as shown in Table 1.

The gross energy production represents the project's maximum ideal output. However, various loss factors must be applied to represent typical operating conditions. These include wake effects from nearby turbines, downtime due to maintenance issues, electrical line losses, and blade soiling/icing, among others. In total, the losses, which are listed in Table 1, are estimated to be 19.9%. Deducting the total losses from the gross energy production yields the net annual energy production of 2,076,886 MWh. The net production value is the amount of energy predicted to be delivered to the transmission grid.

Energy production values are also expressed as capacity factors. The capacity factor is the ratio of the actual annual output of a turbine (or array) to the maximum possible output, which assumes the turbines are operating at full capacity at all times. For this project, the gross capacity factor is 61.9% while the net capacity factor is 49.6%.

6. WIND RESOURCE ESTIMATE UNCERTAINTY

The accuracy of the data, which is derived from the MesoMap system, has been verified by comparing map predictions with independent observations for over 2000 stations around the world. The National Renewable Energy Laboratory has been closely involved in the validation to ensure its objectivity. In simple wind regimes (such as open plains or well offshore), the root-mean-square (rms) error has typically been found to be 5% or less. In complex wind regimes such as Wyoming and coastal Brazil, the rms error (after accounting for uncertainty in the measurements) is typically 0.3-0.5 m/s, or 5-7% of the mean speed. This is comparable to the error margin associated with one year of measurement from a 50 m mast. It should be stressed that the mean wind speed at any particular location may depart substantially from the predicted values, especially where the elevation, exposure, or surface roughness differs from that assumed by the model, or where the model scale is inadequate to resolve significant features of the terrain. The resulting uncertainty is assumed to be 10% on wind speed and 20% on energy. The project uncertainty numbers can be found in Table 1.

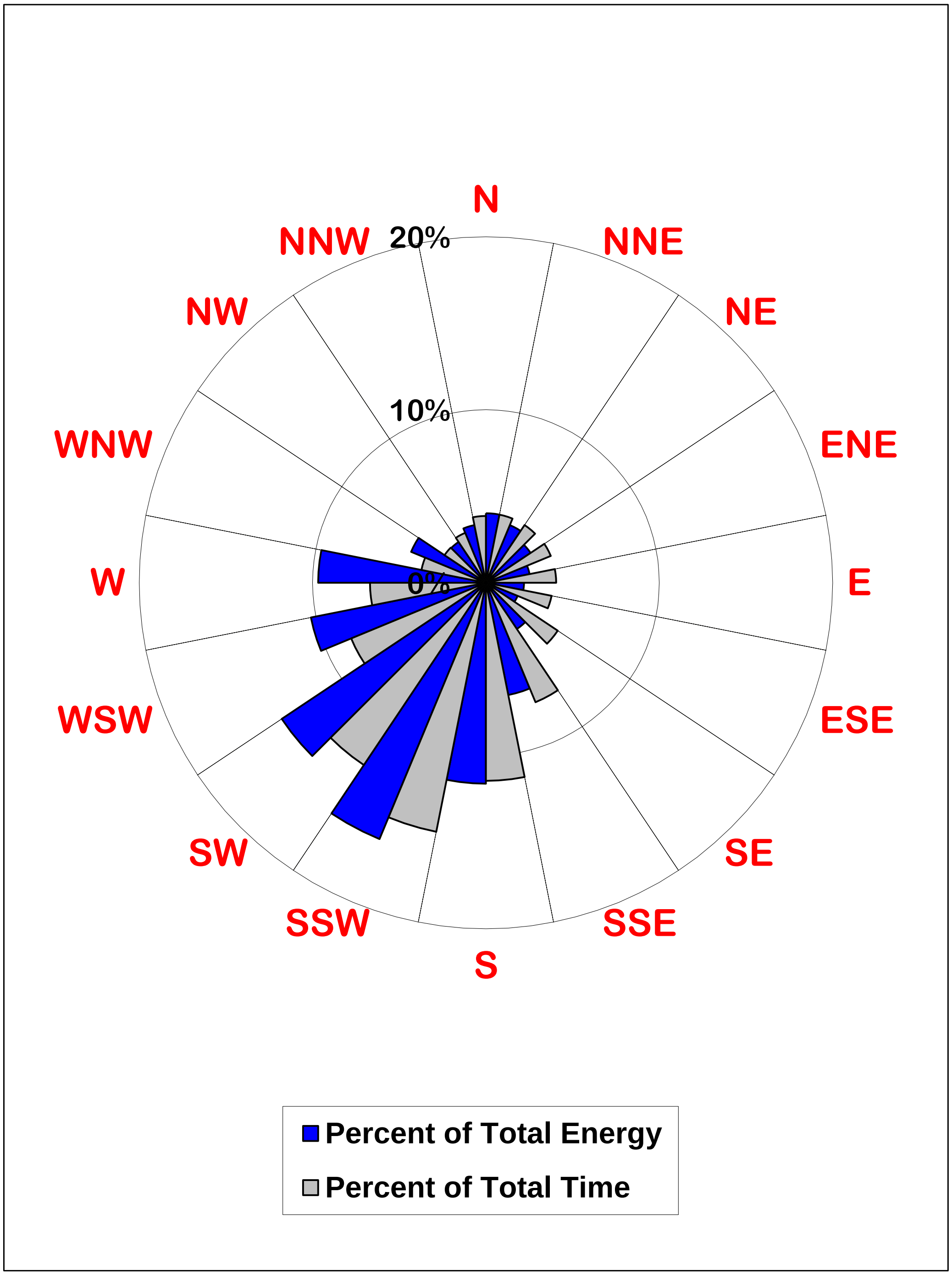

Figure 1. Representative Wind Rose for the Hale Wind Project

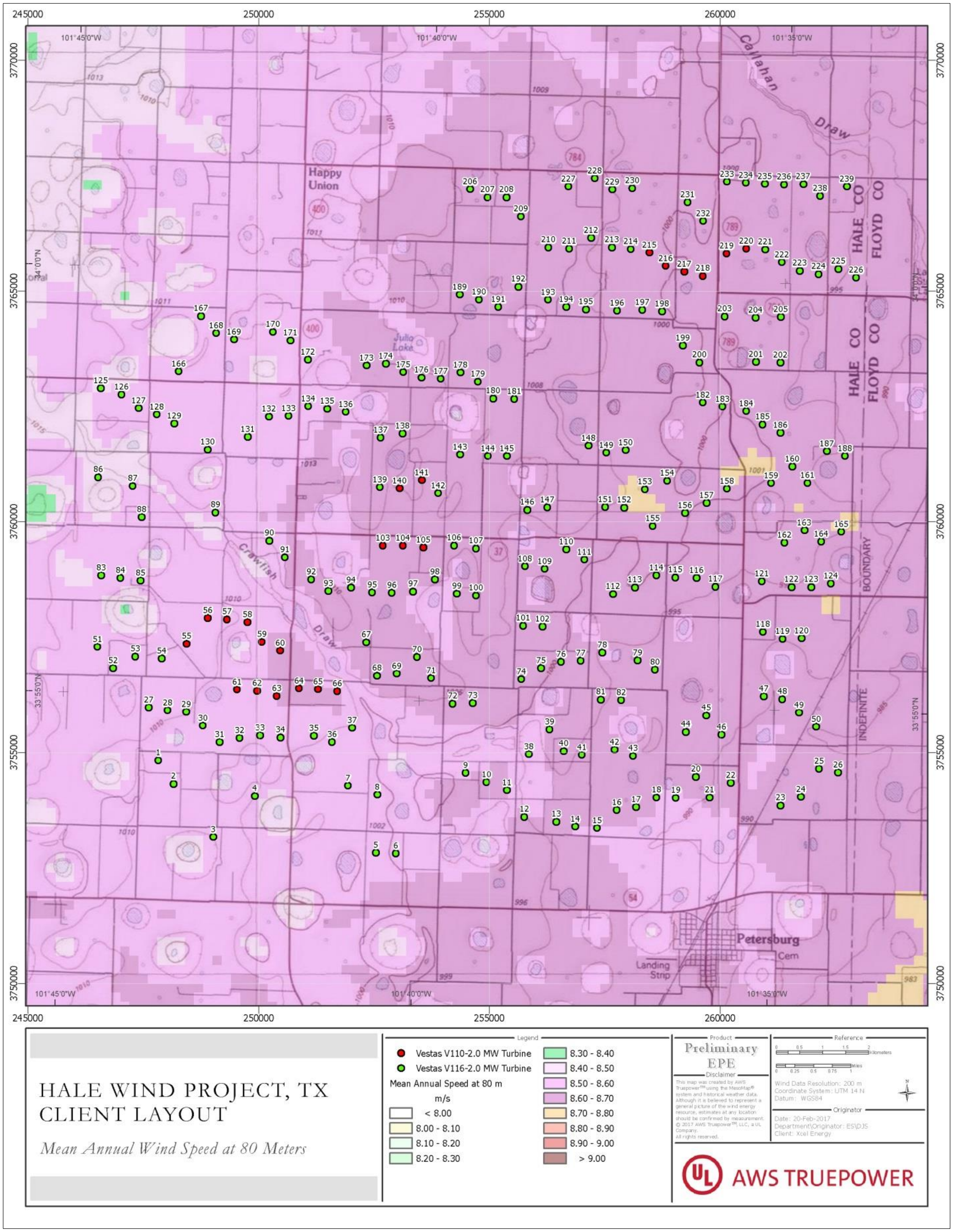

Figure 2. Hale Wind Project Preliminary Layout

Table 1. Hale Wind Project Wind Speed and Preliminary Energy Production Detail

Project Information		
Project:	Xcel Energy - Hale Wind Project, TX	
Date:	20-Feb-17	
Comments:	Client Layout	
Turbine Manufacturer/Model:	Vestas V110-2.0 MW	Vestas V116-2.0 MW
Turbine Rated Power (MW):	2.00	2.00
Hub Height (m):	80	80
Number of Turbines:	23	216
Total Number of Turbines:	239	
Plant Capacity (MW):	478	
Site Air Density (kg/m^3):	1.078	1.078

The estimates presented herein are based on AWS Truepower's modeled wind map; no on-site measurements were considered for this analysis. AWS Truepower considers these estimates preliminary for the specified project area and recommends confirming with on-site measurements.

Overall Wind Plant Summary			
Average Free Wind Speed (m/s):	8.62		
P50 Gross Energy (MWh/yr):	2,592,571	Capacity Factor:	61.9%
P50 Net Energy (MWh/yr):	2,076,886	Capacity Factor:	49.6%
Net Energy and Capacity Factor Probability Table			
P75 Net Energy (GWh/yr):	1796.7	Capacity Factor:	42.9%
P90 Net Energy (GWh/yr):	1544.6	Capacity Factor:	36.9%
P95 Net Energy (GWh/yr):	1393.7	Capacity Factor:	33.3%
P99 Net Energy (GWh/yr):	1110.6	Capacity Factor:	26.5%
Loss Accounting			
Wake Effect:			8.1%
Availability:			5.6%
Electrical:			2.0%
Turbine Performance:			3.6%
Environmental:			2.3%
Curtailments:			0.0%
Average Total Loss:			19.9%

Table 2. Hale Wind Project Wind Speed and Preliminary Energy Production Detail (Cont'd)

Per Turbine Summary						
Turbine ID	Coordinates (WGS84 UTM14) Easting (m)	Northing (m)	Free Speed (m/s)	Gross Energy (MWh/yr)	Net Energy (MWh/yr)	Turbine Type
1	247821	3754833	8.54	10,707	8,819	Vestas V116-2.0 MW
2	248154	3754326	8.56	10,727	8,955	Vestas V116-2.0 MW
3	249017	3753171	8.54	10,702	9,061	Vestas V116-2.0 MW
4	249912	3754061	8.54	10,716	8,940	Vestas V116-2.0 MW
5	252540	3752833	8.57	10,768	8,994	Vestas V116-2.0 MW
6	252968	3752818	8.57	10,774	8,931	Vestas V116-2.0 MW
7	251934	3754281	8.58	10,794	8,916	Vestas V116-2.0 MW
8	252573	3754086	8.58	10,787	8,924	Vestas V116-2.0 MW
9	254486	3754564	8.58	10,787	8,858	Vestas V116-2.0 MW
10	254935	3754360	8.61	10,827	8,777	Vestas V116-2.0 MW
11	255378	3754187	8.60	10,819	8,764	Vestas V116-2.0 MW
12	255753	3753611	8.60	10,822	9,019	Vestas V116-2.0 MW
13	256445	3753506	8.61	10,830	8,867	Vestas V116-2.0 MW
14	256853	3753397	8.60	10,823	8,821	Vestas V116-2.0 MW
15	257328	3753365	8.60	10,822	8,841	Vestas V116-2.0 MW
16	257756	3753761	8.62	10,847	8,762	Vestas V116-2.0 MW
17	258179	3753823	8.62	10,848	8,717	Vestas V116-2.0 MW
18	258615	3754029	8.60	10,834	8,735	Vestas V116-2.0 MW
19	259034	3754022	8.59	10,821	8,742	Vestas V116-2.0 MW
20	259468	3754478	8.63	10,867	8,684	Vestas V116-2.0 MW
21	259768	3754028	8.62	10,854	8,921	Vestas V116-2.0 MW
22	260225	3754345	8.62	10,858	8,890	Vestas V116-2.0 MW
23	261308	3753859	8.63	10,882	9,028	Vestas V116-2.0 MW
24	261746	3754042	8.65	10,898	8,935	Vestas V116-2.0 MW
25	262144	3754654	8.66	10,920	8,985	Vestas V116-2.0 MW
26	262550	3754570	8.67	10,933	9,160	Vestas V116-2.0 MW
27	247618	3755977	8.54	10,705	8,767	Vestas V116-2.0 MW
28	248021	3755917	8.55	10,727	8,508	Vestas V116-2.0 MW
29	248431	3755880	8.56	10,745	8,480	Vestas V116-2.0 MW
30	248785	3755587	8.56	10,754	8,568	Vestas V116-2.0 MW
31	249150	3755230	8.57	10,771	8,711	Vestas V116-2.0 MW
32	249589	3755319	8.56	10,766	8,549	Vestas V116-2.0 MW
33	250030	3755378	8.57	10,774	8,529	Vestas V116-2.0 MW
34	250468	3755332	8.58	10,792	8,676	Vestas V116-2.0 MW
35	251193	3755368	8.58	10,806	8,693	Vestas V116-2.0 MW
36	251588	3755230	8.57	10,801	8,642	Vestas V116-2.0 MW
37	252019	3755539	8.58	10,812	8,688	Vestas V116-2.0 MW
38	255850	3754964	8.57	10,791	8,656	Vestas V116-2.0 MW
39	256303	3755507	8.61	10,847	8,601	Vestas V116-2.0 MW
40	256605	3755033	8.63	10,865	8,637	Vestas V116-2.0 MW
41	257003	3754951	8.62	10,860	8,600	Vestas V116-2.0 MW
42	257707	3755061	8.62	10,864	8,621	Vestas V116-2.0 MW
43	258113	3754929	8.63	10,867	8,648	Vestas V116-2.0 MW
44	259251	3755452	8.65	10,901	8,703	Vestas V116-2.0 MW
45	259699	3755805	8.64	10,887	8,629	Vestas V116-2.0 MW
46	260026	3755394	8.64	10,893	8,787	Vestas V116-2.0 MW
47	260945	3756218	8.66	10,919	8,855	Vestas V116-2.0 MW
48	261348	3756159	8.64	10,897	8,729	Vestas V116-2.0 MW
49	261705	3755865	8.61	10,860	8,808	Vestas V116-2.0 MW
50	262073	3755562	8.61	10,858	8,944	Vestas V116-2.0 MW

51	246503	3757291	8.54	10,697	8,857	Vestas V116-2.0 MW
52	246841	3756830	8.55	10,712	8,831	Vestas V116-2.0 MW
53	247329	3757086	8.56	10,736	8,663	Vestas V116-2.0 MW
54	247900	3757042	8.56	10,736	8,623	Vestas V116-2.0 MW
55	248436	3757359	8.57	10,411	8,285	Vestas V110-2.0 MW
56	248893	3757917	8.57	10,411	8,337	Vestas V110-2.0 MW
57	249308	3757888	8.58	10,419	8,237	Vestas V110-2.0 MW
58	249758	3757831	8.58	10,433	8,197	Vestas V110-2.0 MW
59	250070	3757399	8.59	10,450	8,250	Vestas V110-2.0 MW
60	250459	3757209	8.62	10,490	8,303	Vestas V110-2.0 MW
61	249529	3756364	8.59	10,449	8,261	Vestas V110-2.0 MW
62	249967	3756341	8.59	10,456	8,115	Vestas V110-2.0 MW
63	250393	3756227	8.60	10,470	8,144	Vestas V110-2.0 MW
64	250872	3756389	8.61	10,490	8,242	Vestas V110-2.0 MW
65	251286	3756373	8.61	10,493	8,165	Vestas V110-2.0 MW
66	251702	3756331	8.60	10,478	8,237	Vestas V110-2.0 MW
67	252329	3757392	8.63	10,845	8,682	Vestas V116-2.0 MW
68	252560	3756667	8.62	10,840	8,696	Vestas V116-2.0 MW
69	252986	3756709	8.62	10,841	8,594	Vestas V116-2.0 MW
70	253432	3757073	8.62	10,834	8,601	Vestas V116-2.0 MW
71	253739	3756612	8.63	10,847	8,759	Vestas V116-2.0 MW
72	254205	3756062	8.63	10,830	8,757	Vestas V116-2.0 MW
73	254638	3756078	8.64	10,845	8,685	Vestas V116-2.0 MW
74	255688	3756588	8.64	10,860	8,688	Vestas V116-2.0 MW
75	256120	3756832	8.63	10,862	8,523	Vestas V116-2.0 MW
76	256555	3756970	8.63	10,862	8,518	Vestas V116-2.0 MW
77	256977	3756991	8.63	10,862	8,485	Vestas V116-2.0 MW
78	257444	3757171	8.60	10,836	8,590	Vestas V116-2.0 MW
79	258204	3756999	8.62	10,867	8,626	Vestas V116-2.0 MW
80	258582	3756799	8.63	10,883	8,760	Vestas V116-2.0 MW
81	257412	3756151	8.63	10,873	8,635	Vestas V116-2.0 MW
82	257856	3756142	8.63	10,870	8,573	Vestas V116-2.0 MW
83	246588	3758842	8.52	10,684	8,815	Vestas V116-2.0 MW
84	247005	3758786	8.54	10,712	8,619	Vestas V116-2.0 MW
85	247441	3758731	8.53	10,710	8,678	Vestas V116-2.0 MW
86	246522	3760970	8.48	10,663	8,893	Vestas V116-2.0 MW
87	247271	3760776	8.51	10,707	8,758	Vestas V116-2.0 MW
88	247459	3760104	8.54	10,735	8,834	Vestas V116-2.0 MW
89	249064	3760206	8.54	10,718	8,824	Vestas V116-2.0 MW
90	250225	3759595	8.58	10,783	8,722	Vestas V116-2.0 MW
91	250567	3759232	8.59	10,796	8,768	Vestas V116-2.0 MW
92	251134	3758754	8.62	10,825	8,712	Vestas V116-2.0 MW
93	251505	3758504	8.61	10,822	8,667	Vestas V116-2.0 MW
94	251997	3758575	8.60	10,812	8,522	Vestas V116-2.0 MW
95	252459	3758474	8.61	10,826	8,520	Vestas V116-2.0 MW
96	252886	3758463	8.62	10,830	8,487	Vestas V116-2.0 MW
97	253344	3758494	8.61	10,819	8,497	Vestas V116-2.0 MW
98	253813	3758752	8.61	10,829	8,522	Vestas V116-2.0 MW
99	254293	3758445	8.61	10,822	8,596	Vestas V116-2.0 MW
100	254712	3758405	8.64	10,859	8,659	Vestas V116-2.0 MW
101	255733	3757753	8.64	10,865	8,653	Vestas V116-2.0 MW
102	256152	3757734	8.64	10,866	8,554	Vestas V116-2.0 MW
103	252689	3759486	8.61	10,489	8,290	Vestas V110-2.0 MW
104	253126	3759485	8.62	10,501	8,151	Vestas V110-2.0 MW
105	253564	3759448	8.62	10,504	8,143	Vestas V110-2.0 MW
106	254238	3759490	8.61	10,837	8,563	Vestas V116-2.0 MW
107	254705	3759425	8.63	10,857	8,626	Vestas V116-2.0 MW
108	255770	3759035	8.61	10,845	8,608	Vestas V116-2.0 MW
109	256195	3758977	8.61	10,844	8,518	Vestas V116-2.0 MW
110	256667	3759407	8.66	10,905	8,618	Vestas V116-2.0 MW
111	257054	3759182	8.65	10,890	8,686	Vestas V116-2.0 MW
112	257676	3758436	8.64	10,889	8,721	Vestas V116-2.0 MW
113	258153	3758582	8.66	10,923	8,612	Vestas V116-2.0 MW
114	258618	3758843	8.67	10,938	8,659	Vestas V116-2.0 MW
115	259029	3758798	8.68	10,954	8,650	Vestas V116-2.0 MW

116	259490	3758786	8.68	10,962	8,715	Vestas V116-2.0 MW
117	259896	3758596	8.66	10,951	8,885	Vestas V116-2.0 MW
118	260925	3757616	8.65	10,917	8,794	Vestas V116-2.0 MW
119	261352	3757463	8.65	10,912	8,718	Vestas V116-2.0 MW
120	261767	3757473	8.67	10,939	8,852	Vestas V116-2.0 MW
121	260904	3758714	8.66	10,945	8,847	Vestas V116-2.0 MW
122	261547	3758590	8.69	10,964	8,763	Vestas V116-2.0 MW
123	261972	3758590	8.69	10,968	8,740	Vestas V116-2.0 MW
124	262402	3758663	8.67	10,951	8,974	Vestas V116-2.0 MW
125	246575	3762894	8.50	10,678	8,943	Vestas V116-2.0 MW
126	247024	3762757	8.51	10,706	8,756	Vestas V116-2.0 MW
127	247400	3762461	8.54	10,740	8,754	Vestas V116-2.0 MW
128	247793	3762324	8.53	10,740	8,645	Vestas V116-2.0 MW
129	248172	3762134	8.54	10,747	8,737	Vestas V116-2.0 MW
130	248896	3761566	8.57	10,768	8,869	Vestas V116-2.0 MW
131	249763	3761841	8.57	10,787	8,760	Vestas V116-2.0 MW
132	250222	3762282	8.59	10,822	8,656	Vestas V116-2.0 MW
133	250644	3762291	8.59	10,818	8,523	Vestas V116-2.0 MW
134	251077	3762502	8.59	10,832	8,568	Vestas V116-2.0 MW
135	251487	3762449	8.60	10,843	8,577	Vestas V116-2.0 MW
136	251889	3762381	8.59	10,831	8,641	Vestas V116-2.0 MW
137	252639	3761824	8.62	10,863	8,662	Vestas V116-2.0 MW
138	253114	3761913	8.62	10,869	8,611	Vestas V116-2.0 MW
139	252623	3760749	8.61	10,836	8,683	Vestas V116-2.0 MW
140	253052	3760723	8.62	10,501	8,172	Vestas V110-2.0 MW
141	253537	3760901	8.63	10,517	8,180	Vestas V110-2.0 MW
142	253892	3760619	8.65	10,874	8,653	Vestas V116-2.0 MW
143	254364	3761457	8.65	10,893	8,738	Vestas V116-2.0 MW
144	254963	3761423	8.65	10,895	8,618	Vestas V116-2.0 MW
145	255381	3761426	8.64	10,898	8,673	Vestas V116-2.0 MW
146	255818	3760263	8.65	10,894	8,730	Vestas V116-2.0 MW
147	256256	3760312	8.67	10,917	8,667	Vestas V116-2.0 MW
148	257146	3761650	8.67	10,946	8,750	Vestas V116-2.0 MW
149	257530	3761496	8.69	10,961	8,629	Vestas V116-2.0 MW
150	257955	3761553	8.69	10,968	8,668	Vestas V116-2.0 MW
151	257508	3760323	8.69	10,952	8,689	Vestas V116-2.0 MW
152	257922	3760311	8.70	10,967	8,575	Vestas V116-2.0 MW
153	258366	3760705	8.70	10,975	8,609	Vestas V116-2.0 MW
154	258851	3760889	8.67	10,938	8,658	Vestas V116-2.0 MW
155	258534	3759909	8.68	10,952	8,732	Vestas V116-2.0 MW
156	259236	3760191	8.68	10,946	8,690	Vestas V116-2.0 MW
157	259708	3760411	8.67	10,939	8,640	Vestas V116-2.0 MW
158	260148	3760715	8.70	10,983	8,832	Vestas V116-2.0 MW
159	261106	3760839	8.68	10,973	8,789	Vestas V116-2.0 MW
160	261562	3761200	8.69	10,989	8,711	Vestas V116-2.0 MW
161	261892	3760840	8.67	10,962	8,826	Vestas V116-2.0 MW
162	261393	3759548	8.68	10,969	8,695	Vestas V116-2.0 MW
163	261826	3759814	8.70	10,987	8,654	Vestas V116-2.0 MW
164	262190	3759575	8.68	10,972	8,741	Vestas V116-2.0 MW
165	262623	3759783	8.70	11,001	8,978	Vestas V116-2.0 MW
166	248267	3763261	8.55	10,781	8,787	Vestas V116-2.0 MW
167	248752	3764461	8.54	10,780	8,869	Vestas V116-2.0 MW
168	249079	3764086	8.55	10,791	8,786	Vestas V116-2.0 MW
169	249468	3763949	8.53	10,774	8,745	Vestas V116-2.0 MW
170	250313	3764114	8.56	10,815	8,763	Vestas V116-2.0 MW
171	250691	3763929	8.57	10,826	8,702	Vestas V116-2.0 MW
172	251068	3763517	8.58	10,826	8,779	Vestas V116-2.0 MW
173	252333	3763386	8.63	10,889	8,774	Vestas V116-2.0 MW
174	252752	3763429	8.62	10,889	8,616	Vestas V116-2.0 MW
175	253133	3763243	8.62	10,881	8,602	Vestas V116-2.0 MW
176	253529	3763125	8.63	10,890	8,589	Vestas V116-2.0 MW
177	253944	3763097	8.64	10,902	8,522	Vestas V116-2.0 MW
178	254373	3763232	8.65	10,914	8,561	Vestas V116-2.0 MW
179	254750	3763037	8.64	10,908	8,599	Vestas V116-2.0 MW
180	255083	3762674	8.66	10,930	8,698	Vestas V116-2.0 MW

181	255541	3762665	8.66	10,937	8,734	Vestas V116-2.0 MW
182	259625	3762580	8.66	10,967	8,795	Vestas V116-2.0 MW
183	260049	3762492	8.68	10,992	8,728	Vestas V116-2.0 MW
184	260561	3762396	8.68	10,992	8,777	Vestas V116-2.0 MW
185	260921	3762112	8.68	10,988	8,798	Vestas V116-2.0 MW
186	261306	3761932	8.67	10,984	8,866	Vestas V116-2.0 MW
187	262307	3761528	8.67	10,985	8,908	Vestas V116-2.0 MW
188	262705	3761425	8.67	10,990	9,041	Vestas V116-2.0 MW
189	254359	3764925	8.63	10,936	8,818	Vestas V116-2.0 MW
190	254774	3764814	8.63	10,933	8,616	Vestas V116-2.0 MW
191	255189	3764657	8.64	10,939	8,694	Vestas V116-2.0 MW
192	255627	3765096	8.65	10,969	8,773	Vestas V116-2.0 MW
193	256269	3764809	8.67	10,989	8,766	Vestas V116-2.0 MW
194	256663	3764656	8.68	11,008	8,715	Vestas V116-2.0 MW
195	257090	3764605	8.67	10,997	8,756	Vestas V116-2.0 MW
196	257763	3764580	8.67	10,994	8,823	Vestas V116-2.0 MW
197	258315	3764591	8.66	10,985	8,687	Vestas V116-2.0 MW
198	258739	3764559	8.65	10,976	8,702	Vestas V116-2.0 MW
199	259186	3763819	8.67	10,991	8,810	Vestas V116-2.0 MW
200	259547	3763455	8.66	10,984	8,839	Vestas V116-2.0 MW
201	260774	3763466	8.65	10,974	8,780	Vestas V116-2.0 MW
202	261307	3763450	8.66	10,990	8,852	Vestas V116-2.0 MW
203	260101	3764453	8.65	10,989	8,801	Vestas V116-2.0 MW
204	260769	3764423	8.64	10,974	8,708	Vestas V116-2.0 MW
205	261315	3764443	8.65	10,990	8,791	Vestas V116-2.0 MW
206	254576	3767210	8.63	10,961	9,056	Vestas V116-2.0 MW
207	254959	3767035	8.65	10,981	8,873	Vestas V116-2.0 MW
208	255371	3767036	8.66	10,995	8,782	Vestas V116-2.0 MW
209	255679	3766617	8.66	10,997	8,968	Vestas V116-2.0 MW
210	256279	3765949	8.66	10,996	8,816	Vestas V116-2.0 MW
211	256731	3765919	8.67	11,008	8,604	Vestas V116-2.0 MW
212	257199	3766154	8.67	11,010	8,667	Vestas V116-2.0 MW
213	257656	3765949	8.66	11,000	8,672	Vestas V116-2.0 MW
214	258064	3765908	8.65	10,995	8,628	Vestas V116-2.0 MW
215	258469	3765832	8.64	10,629	8,279	Vestas V110-2.0 MW
216	258822	3765545	8.64	10,633	8,330	Vestas V110-2.0 MW
217	259221	3765422	8.63	10,617	8,241	Vestas V110-2.0 MW
218	259622	3765328	8.63	10,613	8,275	Vestas V110-2.0 MW
219	260135	3765812	8.64	10,636	8,369	Vestas V110-2.0 MW
220	260563	3765922	8.63	10,633	8,280	Vestas V110-2.0 MW
221	260976	3765901	8.65	11,006	8,653	Vestas V116-2.0 MW
222	261333	3765621	8.65	11,014	8,741	Vestas V116-2.0 MW
223	261720	3765441	8.65	11,013	8,796	Vestas V116-2.0 MW
224	262130	3765369	8.65	11,012	8,773	Vestas V116-2.0 MW
225	262562	3765481	8.66	11,026	8,868	Vestas V116-2.0 MW
226	262948	3765294	8.66	11,025	9,144	Vestas V116-2.0 MW
227	256715	3767266	8.66	11,012	8,952	Vestas V116-2.0 MW
228	257285	3767439	8.66	11,012	8,852	Vestas V116-2.0 MW
229	257662	3767202	8.66	11,004	8,758	Vestas V116-2.0 MW
230	258095	3767228	8.63	10,974	8,781	Vestas V116-2.0 MW
231	259292	3766925	8.65	10,992	8,831	Vestas V116-2.0 MW
232	259630	3766515	8.65	11,001	8,772	Vestas V116-2.0 MW
233	260143	3767367	8.66	11,018	8,907	Vestas V116-2.0 MW
234	260553	3767346	8.66	11,025	8,730	Vestas V116-2.0 MW
235	260963	3767319	8.65	11,027	8,730	Vestas V116-2.0 MW
236	261384	3767309	8.66	11,040	8,736	Vestas V116-2.0 MW
237	261801	3767317	8.66	11,048	8,779	Vestas V116-2.0 MW
238	262166	3767062	8.67	11,064	8,962	Vestas V116-2.0 MW
239	262748	3767265	8.67	11,075	9,198	Vestas V116-2.0 MW

APPENDIX – XCEL ENERGY PROVIDED LOSSES

Table A1. Hale Wind Project Wind Speed and Preliminary Energy Production Detail with Xcel Energy Losses

Project Information		
Project:	Xcel Energy - Hale Wind Project, TX	
Date:	20-Feb-17	
Comments:	Client Layout	
Turbine Manufacturer/Model:	Vestas V110-2.0 MW	Vestas V116-2.0 MW
Turbine Rated Power (MW):	2.00	2.00
Hub Height (m):	80	80
Number of Turbines:	23	216
Total Number of Turbines:	239	
Plant Capacity (MW):	478	
Site Air Density (kg/m^3):	1.078	1.078

The estimates presented herein are based on AWS Truepower's modeled wind map; no on-site measurements were considered for this analysis. AWS Truepower considers these estimates preliminary for the specified project area and recommends confirming with on-site measurements.

A long-term availability value of 3.7 % was specified by Xcel for this project, based on their anticipated fleet availability. AWS Truepower has not evaluated the appropriateness of this specified value for the project.

Overall Wind Plant Summary			
Average Free Wind Speed (m/s):	8.62		
P50 Gross Energy (MWh/yr):	2,592,571	Capacity Factor:	61.9%
P50 Net Energy (MWh/yr):	2,120,179	Capacity Factor:	50.6%

Net Energy and Capacity Factor Probability Table			
P75 Net Energy (GWh/yr):	1834.2	Capacity Factor:	43.8%
P90 Net Energy (GWh/yr):	1576.8	Capacity Factor:	37.6%
P95 Net Energy (GWh/yr):	1422.7	Capacity Factor:	34.0%
P99 Net Energy (GWh/yr):	1133.7	Capacity Factor:	27.1%

Loss Accounting	
Wake Effect:	8.1%
Availability:	3.7%
Electrical:	2.0%
Turbine Performance:	3.6%
Environmental:	2.3%
Curtailments:	0.0%
Average Total Loss:	18.2%

Table A1. Hale Wind Project Wind Speed and Preliminary Energy Production Detail with Xcel Energy Losses (Cont'd)

Per Turbine Summary						
Turbine ID	Coordinates (WGS84 UTM14) Easting (m)	Northing (m)	Free Speed (m/s)	Gross Energy (MWh/yr)	Net Energy (MWh/yr)	Turbine Type
1	247821	3754833	8.54	10,707	9,003	Vestas V116-2.0 MW
2	248154	3754326	8.56	10,727	9,142	Vestas V116-2.0 MW
3	249017	3753171	8.54	10,702	9,249	Vestas V116-2.0 MW
4	249912	3754061	8.54	10,716	9,127	Vestas V116-2.0 MW
5	252540	3752833	8.57	10,768	9,182	Vestas V116-2.0 MW
6	252968	3752818	8.57	10,774	9,117	Vestas V116-2.0 MW
7	251934	3754281	8.58	10,794	9,102	Vestas V116-2.0 MW
8	252573	3754086	8.58	10,787	9,110	Vestas V116-2.0 MW
9	254486	3754564	8.58	10,787	9,042	Vestas V116-2.0 MW
10	254935	3754360	8.61	10,827	8,960	Vestas V116-2.0 MW
11	255378	3754187	8.60	10,819	8,947	Vestas V116-2.0 MW
12	255753	3753611	8.60	10,822	9,207	Vestas V116-2.0 MW
13	256445	3753506	8.61	10,830	9,051	Vestas V116-2.0 MW
14	256853	3753397	8.60	10,823	9,005	Vestas V116-2.0 MW
15	257328	3753365	8.60	10,822	9,025	Vestas V116-2.0 MW
16	257756	3753761	8.62	10,847	8,944	Vestas V116-2.0 MW
17	258179	3753823	8.62	10,848	8,899	Vestas V116-2.0 MW
18	258615	3754029	8.60	10,834	8,917	Vestas V116-2.0 MW
19	259034	3754022	8.59	10,821	8,924	Vestas V116-2.0 MW
20	259468	3754478	8.63	10,867	8,865	Vestas V116-2.0 MW
21	259768	3754028	8.62	10,854	9,107	Vestas V116-2.0 MW
22	260225	3754345	8.62	10,858	9,075	Vestas V116-2.0 MW
23	261308	3753859	8.63	10,882	9,216	Vestas V116-2.0 MW
24	261746	3754042	8.65	10,898	9,121	Vestas V116-2.0 MW
25	262144	3754654	8.66	10,920	9,172	Vestas V116-2.0 MW
26	262550	3754570	8.67	10,933	9,351	Vestas V116-2.0 MW
27	247618	3755977	8.54	10,705	8,950	Vestas V116-2.0 MW
28	248021	3755917	8.55	10,727	8,685	Vestas V116-2.0 MW
29	248431	3755880	8.56	10,745	8,657	Vestas V116-2.0 MW
30	248785	3755587	8.56	10,754	8,747	Vestas V116-2.0 MW
31	249150	3755230	8.57	10,771	8,892	Vestas V116-2.0 MW
32	249589	3755319	8.56	10,766	8,728	Vestas V116-2.0 MW
33	250030	3755378	8.57	10,774	8,706	Vestas V116-2.0 MW
34	250468	3755332	8.58	10,792	8,857	Vestas V116-2.0 MW
35	251193	3755368	8.58	10,806	8,874	Vestas V116-2.0 MW
36	251588	3755230	8.57	10,801	8,822	Vestas V116-2.0 MW
37	252019	3755539	8.58	10,812	8,869	Vestas V116-2.0 MW
38	255850	3754964	8.57	10,791	8,836	Vestas V116-2.0 MW
39	256303	3755507	8.61	10,847	8,780	Vestas V116-2.0 MW
40	256605	3755033	8.63	10,865	8,817	Vestas V116-2.0 MW
41	257003	3754951	8.62	10,860	8,779	Vestas V116-2.0 MW
42	257707	3755061	8.62	10,864	8,801	Vestas V116-2.0 MW
43	258113	3754929	8.63	10,867	8,829	Vestas V116-2.0 MW
44	259251	3755452	8.65	10,901	8,885	Vestas V116-2.0 MW
45	259699	3755805	8.64	10,887	8,808	Vestas V116-2.0 MW
46	260026	3755394	8.64	10,893	8,970	Vestas V116-2.0 MW
47	260945	3756218	8.66	10,919	9,040	Vestas V116-2.0 MW
48	261348	3756159	8.64	10,897	8,911	Vestas V116-2.0 MW
49	261705	3755865	8.61	10,860	8,992	Vestas V116-2.0 MW
50	262073	3755562	8.61	10,858	9,131	Vestas V116-2.0 MW

51	246503	3757291	8.54	10,697	9,042	Vestas V116-2.0 MW
52	246841	3756830	8.55	10,712	9,015	Vestas V116-2.0 MW
53	247329	3757086	8.56	10,736	8,843	Vestas V116-2.0 MW
54	247900	3757042	8.56	10,736	8,803	Vestas V116-2.0 MW
55	248436	3757359	8.57	10,411	8,458	Vestas V110-2.0 MW
56	248893	3757917	8.57	10,411	8,511	Vestas V110-2.0 MW
57	249308	3757888	8.58	10,419	8,409	Vestas V110-2.0 MW
58	249758	3757831	8.58	10,433	8,368	Vestas V110-2.0 MW
59	250070	3757399	8.59	10,450	8,422	Vestas V110-2.0 MW
60	250459	3757209	8.62	10,490	8,477	Vestas V110-2.0 MW
61	249529	3756364	8.59	10,449	8,433	Vestas V110-2.0 MW
62	249967	3756341	8.59	10,456	8,285	Vestas V110-2.0 MW
63	250393	3756227	8.60	10,470	8,314	Vestas V110-2.0 MW
64	250872	3756389	8.61	10,490	8,414	Vestas V110-2.0 MW
65	251286	3756373	8.61	10,493	8,335	Vestas V110-2.0 MW
66	251702	3756331	8.60	10,478	8,409	Vestas V110-2.0 MW
67	252329	3757392	8.63	10,845	8,863	Vestas V116-2.0 MW
68	252560	3756667	8.62	10,840	8,877	Vestas V116-2.0 MW
69	252986	3756709	8.62	10,841	8,773	Vestas V116-2.0 MW
70	253432	3757073	8.62	10,834	8,781	Vestas V116-2.0 MW
71	253739	3756612	8.63	10,847	8,941	Vestas V116-2.0 MW
72	254205	3756062	8.63	10,830	8,939	Vestas V116-2.0 MW
73	254638	3756078	8.64	10,845	8,866	Vestas V116-2.0 MW
74	255688	3756588	8.64	10,860	8,869	Vestas V116-2.0 MW
75	256120	3756832	8.63	10,862	8,700	Vestas V116-2.0 MW
76	256555	3756970	8.63	10,862	8,696	Vestas V116-2.0 MW
77	256977	3756991	8.63	10,862	8,662	Vestas V116-2.0 MW
78	257444	3757171	8.60	10,836	8,769	Vestas V116-2.0 MW
79	258204	3756999	8.62	10,867	8,806	Vestas V116-2.0 MW
80	258582	3756799	8.63	10,883	8,943	Vestas V116-2.0 MW
81	257412	3756151	8.63	10,873	8,815	Vestas V116-2.0 MW
82	257856	3756142	8.63	10,870	8,751	Vestas V116-2.0 MW
83	246588	3758842	8.52	10,684	8,999	Vestas V116-2.0 MW
84	247005	3758786	8.54	10,712	8,798	Vestas V116-2.0 MW
85	247441	3758731	8.53	10,710	8,859	Vestas V116-2.0 MW
86	246522	3760970	8.48	10,663	9,079	Vestas V116-2.0 MW
87	247271	3760776	8.51	10,707	8,941	Vestas V116-2.0 MW
88	247459	3760104	8.54	10,735	9,018	Vestas V116-2.0 MW
89	249064	3760206	8.54	10,718	9,007	Vestas V116-2.0 MW
90	250225	3759595	8.58	10,783	8,904	Vestas V116-2.0 MW
91	250567	3759232	8.59	10,796	8,951	Vestas V116-2.0 MW
92	251134	3758754	8.62	10,825	8,893	Vestas V116-2.0 MW
93	251505	3758504	8.61	10,822	8,848	Vestas V116-2.0 MW
94	251997	3758575	8.60	10,812	8,699	Vestas V116-2.0 MW
95	252459	3758474	8.61	10,826	8,697	Vestas V116-2.0 MW
96	252886	3758463	8.62	10,830	8,664	Vestas V116-2.0 MW
97	253344	3758494	8.61	10,819	8,675	Vestas V116-2.0 MW
98	253813	3758752	8.61	10,829	8,700	Vestas V116-2.0 MW
99	254293	3758445	8.61	10,822	8,776	Vestas V116-2.0 MW
100	254712	3758405	8.64	10,859	8,839	Vestas V116-2.0 MW
101	255733	3757753	8.64	10,865	8,834	Vestas V116-2.0 MW
102	256152	3757734	8.64	10,866	8,733	Vestas V116-2.0 MW
103	252689	3759486	8.61	10,489	8,463	Vestas V110-2.0 MW
104	253126	3759485	8.62	10,501	8,321	Vestas V110-2.0 MW
105	253564	3759448	8.62	10,504	8,313	Vestas V110-2.0 MW
106	254238	3759490	8.61	10,837	8,741	Vestas V116-2.0 MW
107	254705	3759425	8.63	10,857	8,806	Vestas V116-2.0 MW
108	255770	3759035	8.61	10,845	8,787	Vestas V116-2.0 MW
109	256195	3758977	8.61	10,844	8,696	Vestas V116-2.0 MW
110	256667	3759407	8.66	10,905	8,797	Vestas V116-2.0 MW
111	257054	3759182	8.65	10,890	8,867	Vestas V116-2.0 MW
112	257676	3758436	8.64	10,889	8,903	Vestas V116-2.0 MW
113	258153	3758582	8.66	10,923	8,791	Vestas V116-2.0 MW
114	258618	3758843	8.67	10,938	8,839	Vestas V116-2.0 MW
115	259029	3758798	8.68	10,954	8,830	Vestas V116-2.0 MW

116	259490	3758786	8.68	10,962	8,897	Vestas V116-2.0 MW
117	259896	3758596	8.66	10,951	9,071	Vestas V116-2.0 MW
118	260925	3757616	8.65	10,917	8,977	Vestas V116-2.0 MW
119	261352	3757463	8.65	10,912	8,900	Vestas V116-2.0 MW
120	261767	3757473	8.67	10,939	9,037	Vestas V116-2.0 MW
121	260904	3758714	8.66	10,945	9,032	Vestas V116-2.0 MW
122	261547	3758590	8.69	10,964	8,946	Vestas V116-2.0 MW
123	261972	3758590	8.69	10,968	8,923	Vestas V116-2.0 MW
124	262402	3758663	8.67	10,951	9,161	Vestas V116-2.0 MW
125	246575	3762894	8.50	10,678	9,130	Vestas V116-2.0 MW
126	247024	3762757	8.51	10,706	8,938	Vestas V116-2.0 MW
127	247400	3762461	8.54	10,740	8,937	Vestas V116-2.0 MW
128	247793	3762324	8.53	10,740	8,825	Vestas V116-2.0 MW
129	248172	3762134	8.54	10,747	8,919	Vestas V116-2.0 MW
130	248896	3761566	8.57	10,768	9,053	Vestas V116-2.0 MW
131	249763	3761841	8.57	10,787	8,943	Vestas V116-2.0 MW
132	250222	3762282	8.59	10,822	8,837	Vestas V116-2.0 MW
133	250644	3762291	8.59	10,818	8,700	Vestas V116-2.0 MW
134	251077	3762502	8.59	10,832	8,747	Vestas V116-2.0 MW
135	251487	3762449	8.60	10,843	8,756	Vestas V116-2.0 MW
136	251889	3762381	8.59	10,831	8,821	Vestas V116-2.0 MW
137	252639	3761824	8.62	10,863	8,842	Vestas V116-2.0 MW
138	253114	3761913	8.62	10,869	8,790	Vestas V116-2.0 MW
139	252623	3760749	8.61	10,836	8,864	Vestas V116-2.0 MW
140	253052	3760723	8.62	10,501	8,343	Vestas V110-2.0 MW
141	253537	3760901	8.63	10,517	8,350	Vestas V110-2.0 MW
142	253892	3760619	8.65	10,874	8,833	Vestas V116-2.0 MW
143	254364	3761457	8.65	10,893	8,920	Vestas V116-2.0 MW
144	254963	3761423	8.65	10,895	8,798	Vestas V116-2.0 MW
145	255381	3761426	8.64	10,898	8,854	Vestas V116-2.0 MW
146	255818	3760263	8.65	10,894	8,912	Vestas V116-2.0 MW
147	256256	3760312	8.67	10,917	8,847	Vestas V116-2.0 MW
148	257146	3761650	8.67	10,946	8,932	Vestas V116-2.0 MW
149	257530	3761496	8.69	10,961	8,809	Vestas V116-2.0 MW
150	257955	3761553	8.69	10,968	8,848	Vestas V116-2.0 MW
151	257508	3760323	8.69	10,952	8,870	Vestas V116-2.0 MW
152	257922	3760311	8.70	10,967	8,754	Vestas V116-2.0 MW
153	258366	3760705	8.70	10,975	8,789	Vestas V116-2.0 MW
154	258851	3760889	8.67	10,938	8,839	Vestas V116-2.0 MW
155	258534	3759909	8.68	10,952	8,914	Vestas V116-2.0 MW
156	259236	3760191	8.68	10,946	8,871	Vestas V116-2.0 MW
157	259708	3760411	8.67	10,939	8,820	Vestas V116-2.0 MW
158	260148	3760715	8.70	10,983	9,016	Vestas V116-2.0 MW
159	261106	3760839	8.68	10,973	8,972	Vestas V116-2.0 MW
160	261562	3761200	8.69	10,989	8,892	Vestas V116-2.0 MW
161	261892	3760840	8.67	10,962	9,010	Vestas V116-2.0 MW
162	261393	3759548	8.68	10,969	8,876	Vestas V116-2.0 MW
163	261826	3759814	8.70	10,987	8,834	Vestas V116-2.0 MW
164	262190	3759575	8.68	10,972	8,924	Vestas V116-2.0 MW
165	262623	3759783	8.70	11,001	9,165	Vestas V116-2.0 MW
166	248267	3763261	8.55	10,781	8,971	Vestas V116-2.0 MW
167	248752	3764461	8.54	10,780	9,054	Vestas V116-2.0 MW
168	249079	3764086	8.55	10,791	8,969	Vestas V116-2.0 MW
169	249468	3763949	8.53	10,774	8,927	Vestas V116-2.0 MW
170	250313	3764114	8.56	10,815	8,946	Vestas V116-2.0 MW
171	250691	3763929	8.57	10,826	8,884	Vestas V116-2.0 MW
172	251068	3763517	8.58	10,826	8,962	Vestas V116-2.0 MW
173	252333	3763386	8.63	10,889	8,957	Vestas V116-2.0 MW
174	252752	3763429	8.62	10,889	8,796	Vestas V116-2.0 MW
175	253133	3763243	8.62	10,881	8,782	Vestas V116-2.0 MW
176	253529	3763125	8.63	10,890	8,768	Vestas V116-2.0 MW
177	253944	3763097	8.64	10,902	8,700	Vestas V116-2.0 MW
178	254373	3763232	8.65	10,914	8,739	Vestas V116-2.0 MW
179	254750	3763037	8.64	10,908	8,778	Vestas V116-2.0 MW
180	255083	3762674	8.66	10,930	8,879	Vestas V116-2.0 MW

181	255541	3762665	8.66	10,937	8,916	Vestas V116-2.0 MW
182	259625	3762580	8.66	10,967	8,979	Vestas V116-2.0 MW
183	260049	3762492	8.68	10,992	8,910	Vestas V116-2.0 MW
184	260561	3762396	8.68	10,992	8,960	Vestas V116-2.0 MW
185	260921	3762112	8.68	10,988	8,981	Vestas V116-2.0 MW
186	261306	3761932	8.67	10,984	9,051	Vestas V116-2.0 MW
187	262307	3761528	8.67	10,985	9,094	Vestas V116-2.0 MW
188	262705	3761425	8.67	10,990	9,229	Vestas V116-2.0 MW
189	254359	3764925	8.63	10,936	9,002	Vestas V116-2.0 MW
190	254774	3764814	8.63	10,933	8,796	Vestas V116-2.0 MW
191	255189	3764657	8.64	10,939	8,875	Vestas V116-2.0 MW
192	255627	3765096	8.65	10,969	8,956	Vestas V116-2.0 MW
193	256269	3764809	8.67	10,989	8,949	Vestas V116-2.0 MW
194	256663	3764656	8.68	11,008	8,897	Vestas V116-2.0 MW
195	257090	3764605	8.67	10,997	8,939	Vestas V116-2.0 MW
196	257763	3764580	8.67	10,994	9,007	Vestas V116-2.0 MW
197	258315	3764591	8.66	10,985	8,868	Vestas V116-2.0 MW
198	258739	3764559	8.65	10,976	8,884	Vestas V116-2.0 MW
199	259186	3763819	8.67	10,991	8,994	Vestas V116-2.0 MW
200	259547	3763455	8.66	10,984	9,023	Vestas V116-2.0 MW
201	260774	3763466	8.65	10,974	8,963	Vestas V116-2.0 MW
202	261307	3763450	8.66	10,990	9,037	Vestas V116-2.0 MW
203	260101	3764453	8.65	10,989	8,984	Vestas V116-2.0 MW
204	260769	3764423	8.64	10,974	8,890	Vestas V116-2.0 MW
205	261315	3764443	8.65	10,990	8,974	Vestas V116-2.0 MW
206	254576	3767210	8.63	10,961	9,245	Vestas V116-2.0 MW
207	254959	3767035	8.65	10,981	9,058	Vestas V116-2.0 MW
208	255371	3767036	8.66	10,995	8,965	Vestas V116-2.0 MW
209	255679	3766617	8.66	10,997	9,155	Vestas V116-2.0 MW
210	256279	3765949	8.66	10,996	9,000	Vestas V116-2.0 MW
211	256731	3765919	8.67	11,008	8,783	Vestas V116-2.0 MW
212	257199	3766154	8.67	11,010	8,848	Vestas V116-2.0 MW
213	257656	3765949	8.66	11,000	8,853	Vestas V116-2.0 MW
214	258064	3765908	8.65	10,995	8,808	Vestas V116-2.0 MW
215	258469	3765832	8.64	10,629	8,451	Vestas V110-2.0 MW
216	258822	3765545	8.64	10,633	8,504	Vestas V110-2.0 MW
217	259221	3765422	8.63	10,617	8,413	Vestas V110-2.0 MW
218	259622	3765328	8.63	10,613	8,447	Vestas V110-2.0 MW
219	260135	3765812	8.64	10,636	8,543	Vestas V110-2.0 MW
220	260563	3765922	8.63	10,633	8,453	Vestas V110-2.0 MW
221	260976	3765901	8.65	11,006	8,833	Vestas V116-2.0 MW
222	261333	3765621	8.65	11,014	8,923	Vestas V116-2.0 MW
223	261720	3765441	8.65	11,013	8,980	Vestas V116-2.0 MW
224	262130	3765369	8.65	11,012	8,956	Vestas V116-2.0 MW
225	262562	3765481	8.66	11,026	9,053	Vestas V116-2.0 MW
226	262948	3765294	8.66	11,025	9,334	Vestas V116-2.0 MW
227	256715	3767266	8.66	11,012	9,139	Vestas V116-2.0 MW
228	257285	3767439	8.66	11,012	9,037	Vestas V116-2.0 MW
229	257662	3767202	8.66	11,004	8,941	Vestas V116-2.0 MW
230	258095	3767228	8.63	10,974	8,964	Vestas V116-2.0 MW
231	259292	3766925	8.65	10,992	9,015	Vestas V116-2.0 MW
232	259630	3766515	8.65	11,001	8,955	Vestas V116-2.0 MW
233	260143	3767367	8.66	11,018	9,093	Vestas V116-2.0 MW
234	260553	3767346	8.66	11,025	8,912	Vestas V116-2.0 MW
235	260963	3767319	8.65	11,027	8,912	Vestas V116-2.0 MW
236	261384	3767309	8.66	11,040	8,918	Vestas V116-2.0 MW
237	261801	3767317	8.66	11,048	8,962	Vestas V116-2.0 MW
238	262166	3767062	8.67	11,064	9,149	Vestas V116-2.0 MW
239	262748	3767265	8.67	11,075	9,390	Vestas V116-2.0 MW