Attachment F:
Commercial Wind
Wind Resource Assessment Final Report Outline

Wind Resource Assessment Grantees are required to provide the following information in the final report.

Component	Tasks
Executive Summary and Recommendations	
1. Prepare an executive summary	• Summarize the results for the period of wind monitoring • Please indicate if raw data was provided to MassCEC
Measurement Equipment & Logistics	
2. Provide information on the wind measurement site and equipment used	• Location: Provide the coordinates of the measurement location in NAD 83, NAD 84, or any other valid survey format. Describe the location including nearby buildings, vegetation, water bodies, and cleared land. • Equipment: Provide the following information on the measuring equipment used: o Anemometers – Height, type (make and model) o Wind vanes – Height, type (make and model) o Temperature sensors – Height, type (make and model) o Data logger – specs. o Other sensors • Measurement period • Measurement data recovery and quality

Component	Tasks
Data Summary	
3. Evaluate and summarize collected wind data	• Provide a table that summarizes the wind speed measured during the twelve-month period. Please show the following: o Measured Monthly Average Wind speed at all measured heights o Calculated monthly wind shear for the entire twelve-month period, providing the reference heights o Average wind speed for each measured height and the calculated wind shear (with reference heights) for the twelve-month period • Provide a graph depicting the seasonal wind speed profile for each measured height (wind speed vs. month) for the twelve-month period • Provide a Wind rose that represents the twelve-month period • Provide a table that summarizes turbulence intensity data and includes the following: o Measured turbulence intensity at all measured heights for each month • Discussion on calculated wind shear including overview of calculation methodology • Discussion and explanation of wind speeds, wind shear and turbulence intensity

Component	Tasks
4. Long-term Wind conditions	• Describe the method used to estimate the long-term wind conditions • What long-term reference data was used? Provide the location and the long-term reference period. • Provide information on the reference site data such as sensor height, elevation above sea level, coordinates, data quality, etc. • Provide a detailed analysis of the long-term historical correlation, and the prediction procedure utilized • If available, provide the average wind speed for the year coincident with the measurement period as well as the long term average • Vertical Extrapolation: Estimate average annual wind speed at hub height at project site. Summarize extrapolation methodology, including: o Utilized wind shear o Utilized lower level wind speeds (e.g. what data from what height) o The average annual wind speeds at hub heights • Horizontal Extrapolation, if necessary (e.g. how do you arrive at the project site wind speed from the measurement site wind speed?) o What methodology was used to estimate project site wind speeds at the project site (WAsP, MS-Micro, CFD, etc.)? • What roughness values generally characterize the terrain surrounding the project and measurement sites? • Compile a wind resource profile for the turbine location(s), including o Wind rose o Diurnal average wind speed profile o Seasonal average wind speed profile o Estimated turbulence intensity o Estimated wind shear • Identify any obstructions or characteristics at the turbine location(s) and detail their impact on the wind resource at that site • For multi-turbine projects, address issues of interactive resource loss or wake-added turbulence • Characterize the overall viability of the site from a wind resource perspective • Make recommendations regarding additional wind resource monitoring or validation

Component	Tasks
5. Graphs & Tables	• Time series: graph the 10-minute average wind speeds vs time. This should be for the entire year being reported. • Wind Speed Frequency Distribution: provide a histogram and a table giving the percentage of time that the wind is at a given wind speed. Both the table and the graph should cover wind speeds from 1 m/s to the maximum wind speed experienced. • Monthly average: provide a graph and a table of the monthly average wind speed since the start of the measurement period. This graph will need to show information for the entire year. • Diurnal: provide a graph and a table of the average wind speed for each hour of the day for the year being reported • Turbulence Intensity: A graph of turbulence intensity as a function of wind speed.
6. Risk and Uncertainty	For the project turbine location(s), complete a risk and uncertainty analysis for the predicted annual wind resource: • Identify sources and values of uncertainty in wind and/or energy production, which could include: o Wind measurement error o Long-term correlation error o Error in vertical extrapolation o Error in horizontal extrapolation o Fluctuation of yearly annual wind speeds o Uncertainty of shifting average wind speeds due to climate change o Power curve error o Any additional uncertainty • Based on identified sources of uncertainty, provide estimate of total uncertainty in average annual wind speed and energy production • For average annual wind speed and energy production, provide estimates at o P50 (the expected value) and o P90 (the low-side estimate based on "persistent error"[1] expected to be exceeded with 90% probability) • Characterize the "monthly/annual variability" [2] of wind speeds and the impact they have on monthly/annual energy production and economics • Identify any risks related to the site's wind resource, which could include: o Excessive site wind shear o Excessive site wind turbulence • Other potential risks (including inflow angle, extreme wind conditions, etc.)

[1] For the purposes of this analysis, MassCEC is interested in the characterization of "persistent error" in wind speed and energy production estimates. Persistent error reflects those factors in the wind data and energy production evaluation that could contribute to a mischaracterization of the projected annual average wind speed and energy production estimates. For example, a P90 analysis using persistent error would reflect the probability that a site's wind resource would consistently be lower than expected, year after year. This persistent error evaluation in part determines the representativeness of the period measured and the estimation performed. The P90 uncertainty analysis is not intended to characterize the annual variability in wind speeds, but rather the likelihood that the estimated wind resource is persistently overestimated.

Component	Tasks
7. Other	• Discuss any significant meteorological events during the year. Discuss any data collection problems or equipment maintenance that had to take place • Data recovery and validation

The P90 analysis should incorporate sources of error and uncertainty in both the wind resource and energy production analysis. The P90 value should represent the wind speed and energy production value that will be exceeded in 90% of the cases, i.e. one-tailed error representing the "low-side" case.

[2] The "annual variability" and "monthly variability" in wind conditions is important and should be evaluated separately from persistent error. This non-persistent uncertainty impacts monthly and annual revenue streams, but will have minimal impact on the ultimate project economics.