Vaisala 3TIER Services Energy Results Comparison

PROJECT

Busch Ranch II : Las Animas and Huerfano Counties, Colorado

using 27 Vestas V120-2.2MW wind turbines at 80 m

FOR

Black Hills Corp.

DATE

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1 EXECUTIVE SUMMARY

3TIER Services by Vaisala has been retained by Black Hills Corp. (the "Client") to provide a due diligence analysis of the Busch Ranch II. The project consists of 27 Vestas V120-2.2MW wind turbines at a $80.0\,m$ hub height. The total project nameplate is 59.4 MW. The Client has provided Vaisala with an energy report [1], prepared by Sandbar. The Client has requested that Vaisala compare their due diligence analysis results to those results in the Sandbar energy report. Within the IE energy report, Sandbar estimates the net annual P50 of production of the Busch Ranch II to be $194.0\,GWh$, which compares to Vaisala's net annual P50 production estimate of $201.5\,GWh$.

For the observation review, two modern $60\,m$ met masts were sited at the project. Vaisala received the measurement data and was able to independently process and quality control the data. The IE only utilized one met tower (M0571) in their analysis.

For the temporal climate review, Vaisala utilized an ensemble approach using three of the major reanalysis data sets: the ECMWF ERA-I [2], NCAR/NCEP [3], and NASA's MERRA2 [4] data sets. Vaisala utilized these data sets to create a 37-year climate simulation. It is unclear what methodology (if any) was utilized by the IE for their long term correction at M0571. The IE did not report long-term wind speed estimates at the met tower location at tower. The IE does report $80\,m$ wind speeds of $7.72\,m/s$ at turbine 2 and 3 which are near the location of M0571. Vaisala has estimated wind speeds at turbine 2 and 3 of $7.47\,m/s$ and $7.52\,m/s$, respectively, which indicates significant differences in long term correction results at M0571. Differences in shear extrapolation assumptions could also play a factor in these wind speed anomalies.

For the spatial modeling review, Vaisala utilized a mesoscale Numerical Weather Prediction (NWP) modeling approach. The IE report indicates a "simplified version of a flow-field model" to generate and convert the spatial wind resource into energy production at each turbine location. Vaisala chose to incorporate two met towers (M0571 and M4666) in its resource model, while the IE only used M0571 from its spatial model. There are significant anomalies in the spatial model results. The IE's spatial model indicates the project wind resource improves from east to west, while the Vaisala spatial model indicates the project wind resource improves from west to east. This is resulting in significant differences in projected wind speeds at each turbine location, with the IE predicting a project average wind speed of $7.16\,m/s$ at hub height compared to Vaisala's prediction of $7.62\,m/s$.

Vaisala modeled wakes using its own model. The IE's wake model losses (95.9%) were slightly less conservative than Vaisala's wake model losses (95.3%).

For the technical loss review, Vaisala's total losses (81.2%) were more conservative to the IE's total losses (85.3%), although distributed differently.

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