Vaisala 3TIER Services Energy Results Comparison

PROJECT

La Cumbre : Las Animas and Huerfano Counties, Colorado

using 22 GE 2.5-127 wind turbines at 88.6 m
and 2 GE 2.3-116 wind turbines at 80 m

FOR

Black Hills Corp.

DATE

5 December, 2017

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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 La Cumbre. The project consists of 22 GE 2.5-127 wind turbines at a $88.6\,m$ hub height and 2 GE 2.3-116 wind turbines at a $80.0\,m$ hub height. The total project nameplate is 59.6 MW. The Client has provided Vaisala with an energy estimate [1], prepared by Invenergy. The Client has requested that Vaisala compare their due diligence analysis results to those results in the Invenergy energy estimate. Within the IE energy estimate, Invenergy estimates the net annual P50 of production of the La Cumbre to be $227.3\,GWh$, which compares to Vaisala's net annual P50 production estimate of $212.9\,GWh$.

For the observation review, six 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.

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. Alternatively, the IE used an unknown number of years from MERRA as the basis for the long term correction. Both the IE and Vaisala had similar long-term results at each met tower location.

Because Vaisala had access to the raw met tower observational data, it was possible to compare Vaisala's shear estimation approach. Vaisala derived similar values as the IE.

Because Vaisala had access to observational data and was able to generate a full NWP data set at this site, energy content was assessed using Vaisala's time series analysis approach. For the La Cumbre, analyzing energy content in the time series approach instead of utilizing the IE's approach based on wind speed distributions yields significant differences in gross energy estimates, and is believed to be the major factor in overall differences between the IE's gross results ($270.1\,GWh$) and Vaisala's gross results ($254.8\,GWh$).

Vaisala modeled wakes using its own model. The IE's wake model losses (95.4%) were slightly more conservative than Vaisala's wake model losses (97.1%).

For the technical loss review, Vaisala's total losses (83.6%) were slightly more conservative to the IE's total losses (84.2%), although distributed differently.

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