The Benefit of Computational Fluid Dynamics Data in Dynamic Line Rating Calculations


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BACKGROUND

- Typical static line rating values for transmission lines use constant values for temperature and wind in calculations for the IEEE 738 standard. Some ratings are adjusted seasonally or with daily ambient temperature adjustments, but usually these ratings are overly conservative in static rating values.
- Using dynamic line ratings (DLR) for transmission lines provides the potential to increase ampacity without additional infrastructure cost.

OBJECTIVE

- The objective of this research is to show the increase that DLR can have over typical static rating assumptions using actual weather data.
- The weather data collected is coupled with computational fluid dynamics (CFD) results so that the wind fields are corrected from weather data to every span along a transmission line.
- The area of study is a complex region of terrain, Hell's Canyon along the Idaho-Oregon border which consists of mountain peaks up to 2300m above the height of the Snake River.

RESULTS

- The line considered as a substitute for the actual conductor. With parallel wind flow, and conservative constant wind speed and temperature assumptions reflecting IEEE 738 standards, the static rating on the line is 600A.
- Figure 1 shows the terrain of interest, and the transmission line path and Figure 2 shows the local wind fields calculated with the CFD simulation results for the north and south wind sectors for the two domains. The white color highlights low wind speeds due to the terrain. CFD captures these low wind speeds that may go unnoticed in other methodologies.
- Figure 3 shows the collected weather data for the region. The red line shows the azimuth of the weather station, and the turquoise shade shows the range of the transmission line midpoints.
- Figure 4 shows the total percentage of dynamic line rating. Figure 4 shows the total percentage of time the DLR is calculated to be over the static rating. The head room on the line is above the static line rating nearly 99% of the time.
- This plot shows for data calculated directly at the weather stations, and data that is processed through the GLASS code to utilize CFD results for differing wind speeds along a line.
- Table 1 shows the difference in average ampacity over static; without accounting for slow wind speeds from the CFD results the additional head room can be over predicted.
- Using the CFD results the locations of the limiting midpoints can be found, this is plotted in the histogram in Figure 4. These locations for limiting spans may prove useful for placement of other line rating sensors.
- Figure 5 shows close-ups of the terrain of the limiting spans, which occur here next to ridges blocking wind from the N-S or E-W direction.

METHODS

CFD
- The CFD code WindSim was used for the simulations. The area was divided into two sections of 55 million cells each with 30 meter spatial resolution.
- The CFD simulations solve the standard k-ε RANS model for turbulent kinetic energy and dissipation rate.

GLASS
- The general line ampacity state solver (GLASS) tool was developed by INL for processing the weather data together with CFD wind fields.
- GLASS parses all of the weather data and runs it through local wind direction changes and speed changes from the CFD wind field to determine the ampacity at every transmission line span with IEEE 738 standard calculations.

REFERENCES


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