Increasing Transmission Capacities By Dynamic Line Rating Based On CFD

- Jake Gentle, Warren Parsons, Michael West – Idaho National Laboratory; Idaho Falls, ID
- Dr. Cathérine Meißner – WindSim AS; Tønsberg, Norway
- Philip Anderson– Idaho Power; Boise, ID

Abstract

Transmission lines maximum capacity is traditionally limited by the conductor thermal capacity. The thermal capacity is normally defined by a static rating using predetermined environmental conditions assuming there's little or no wind blowing. Without accurately measuring environmental conditions and their effects, existing transmission lines can be critically underutilized. Using a dynamic line rating system to accurately monitor the wind and temperature and to transfer those conditions to every point along the electricity line leads to improved line ampacity ratings.

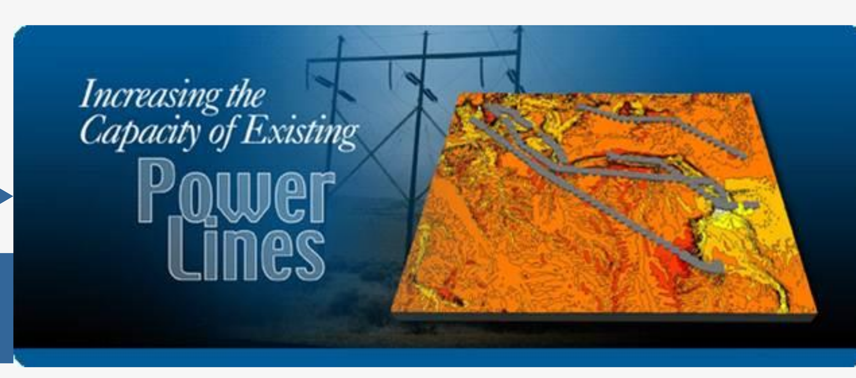
Method

Unknowns	Knowns
1. Wind Speed	1. Terrain
2. Wind Direction	2. Conductor Load Flow
3. Ambient Air Temperature	3. Conductor Temperature
4. Solar Radiation Exposure	4. Static Ampacity Ratings

Detailed wind maps, line loading, and conductor temperature information is translated to real-time estimates, providing dynamic ampacity ratings

Simulation of wind speed and wind direction along a conductor is done with the computational fluid dynamics (CFD) model known as WindSim.

WindSim CFD



3D wind flow model

WindSim's modified CFD software imports infrastructure information on transmission lines combined with weather data to calculate the cooling along every span of the line.

GLASS

INL's 'General Line Ampacity State Solver' (GLASS) uses the WindSim CFD to model wind flow affects on transmission system capacity.

Dynamic Temperature and Ampacity Ratings

With simulated wind speeds and direction at every span, the conductor thermal capacity can be calculated very precisely, and the dynamic ampacity of the line can exceed the static rating.

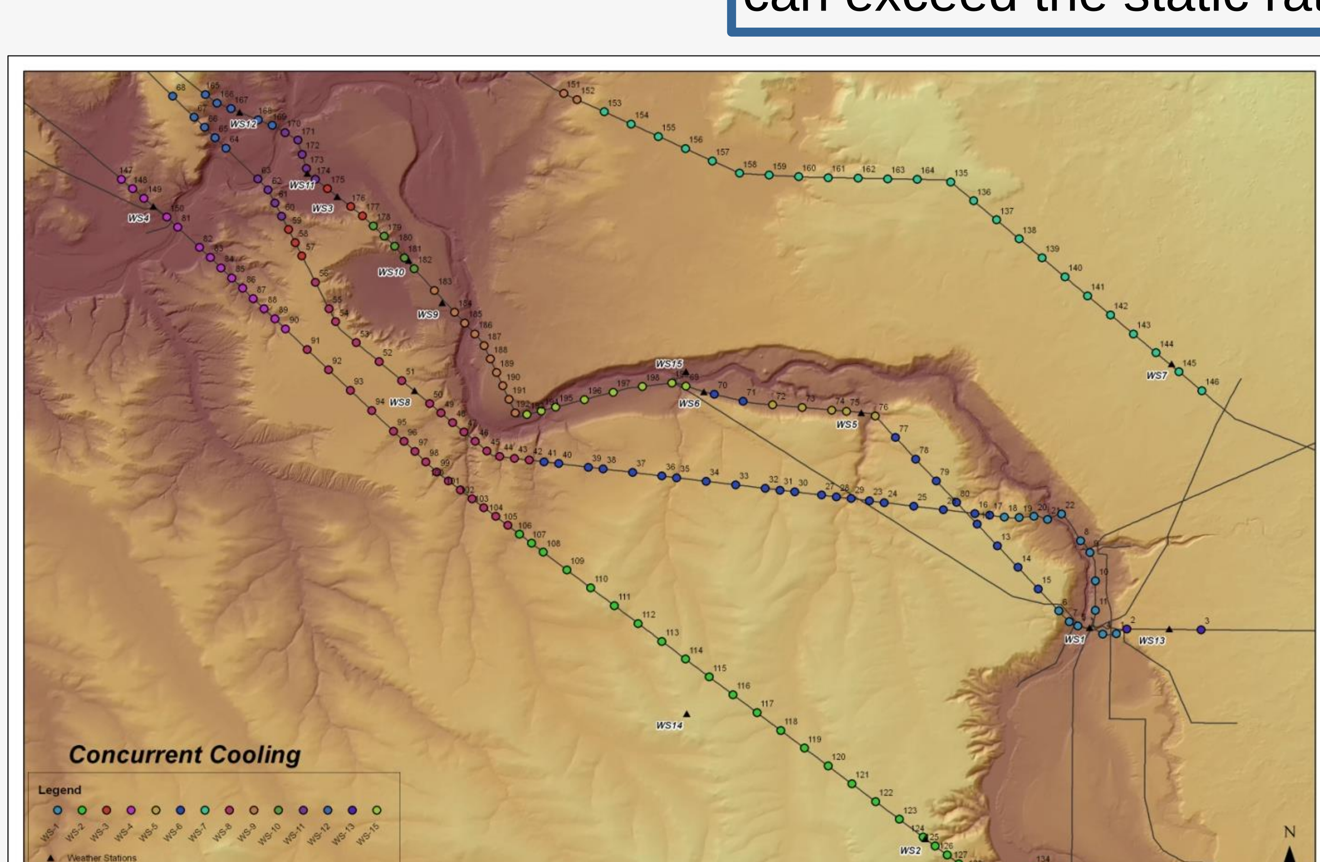


Fig. 1: CFD simulation area showing the mid points between the conductor spans

Validation

Researchers at INL have installed more than 40 weather stations along 450 miles of transmission lines in a windy part of southern Idaho within a 2,400 square mile project area. A validation of the developed system was done for the time period of one year thus the different seasons could be investigated. A CFD model with 50 million cells was run on a horizontal resolution of about 40 m for 12 wind directions to transfer the measurements from the weather stations onto the transmission line in a height of 10 m (Fig. 1).

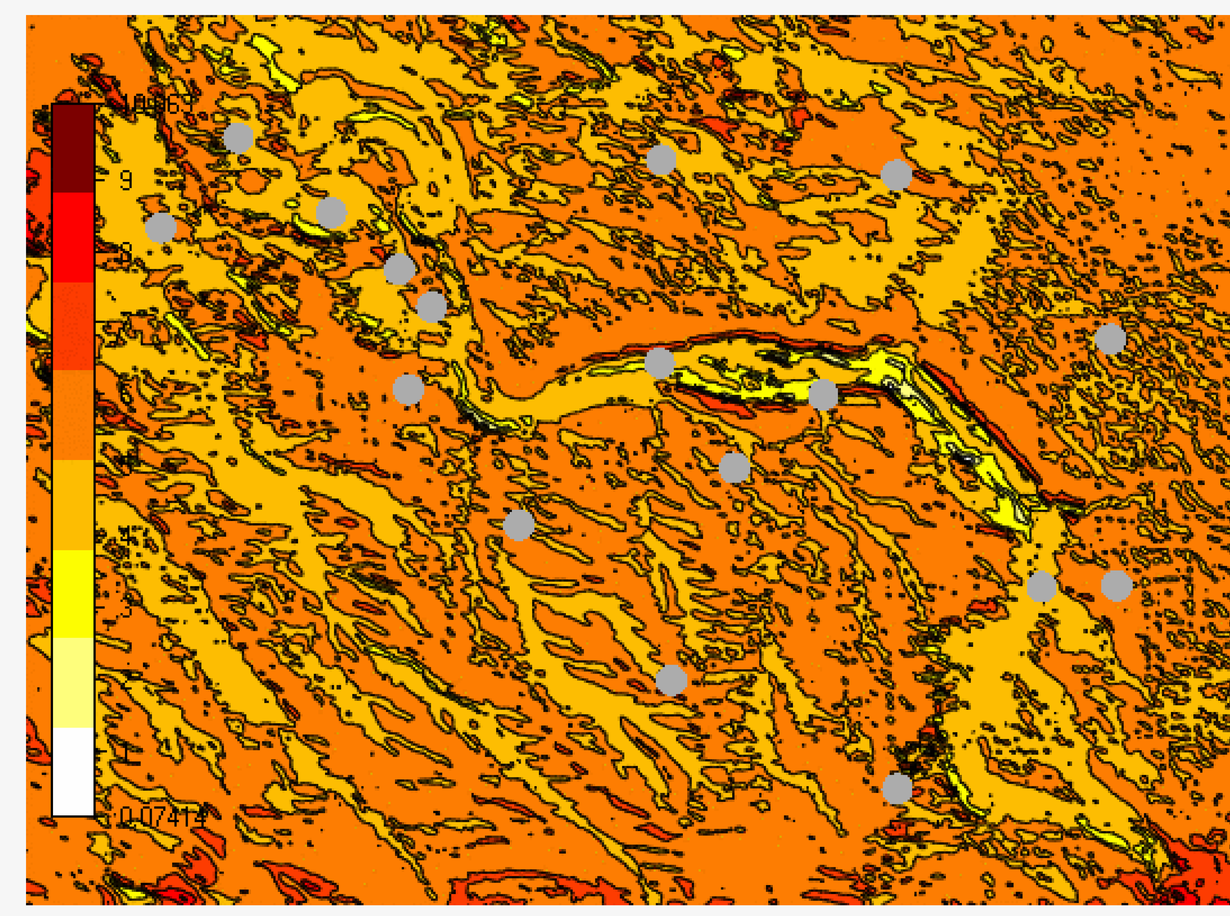


Fig. 2: 2 Pictures from the result module of Windsim showing the wind speed in m/s for 0 degree including the weather stations.

Using the project area, WindSim, and GLASS, INL is able to follow the IEEE 738.2012 Standard for static ratings, and apply them to the dynamic environmental conditions simulated. Results show potential capacity increases as high as 40%, allowing for potential to defer costly upgrades, increase the yield of Distributed Generation (DG), and support the network during outages

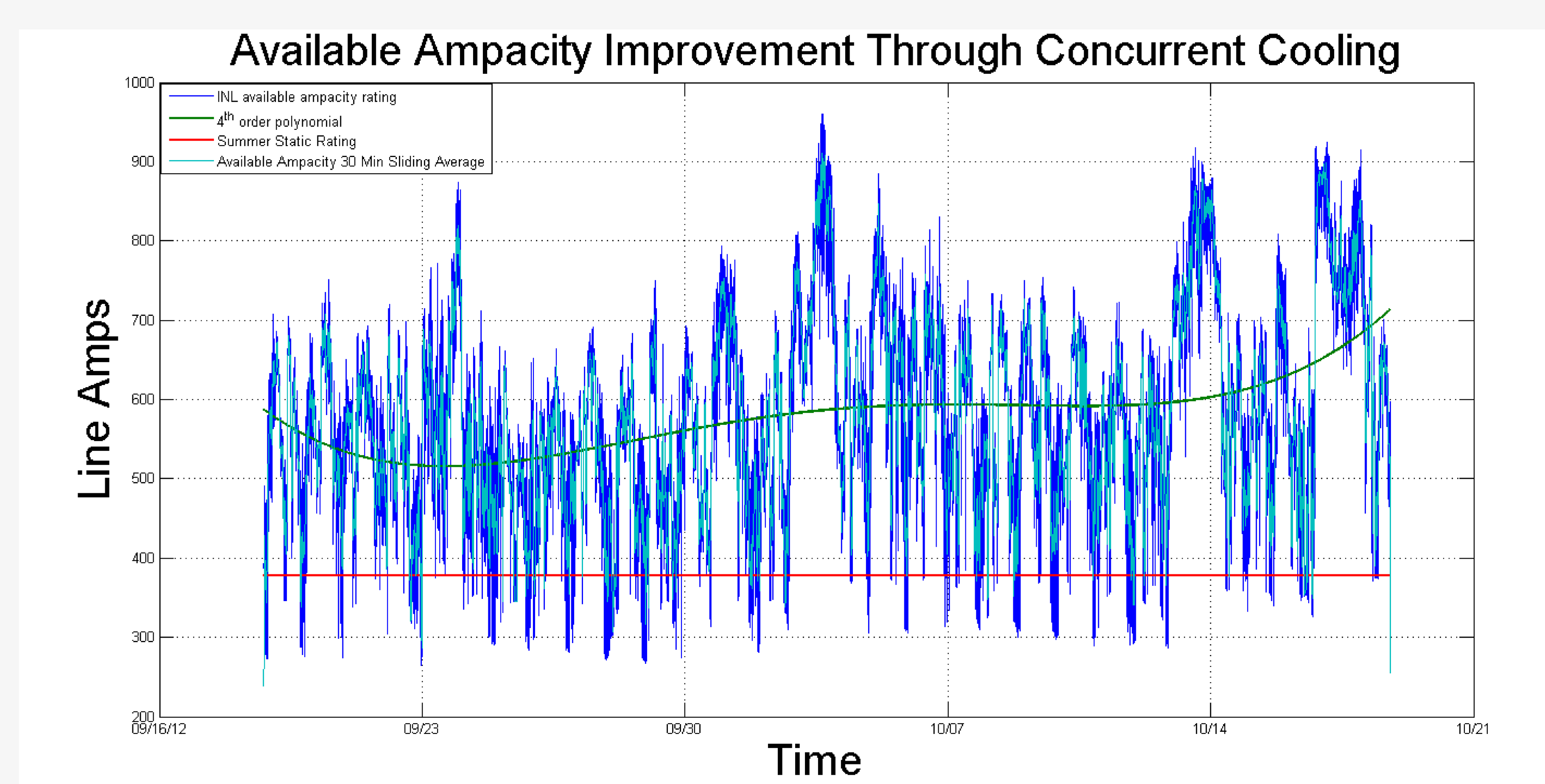


Fig. 3: Comparison of Calculated Dynamic (Blue) and. Static (Red) ampacity rating

Conclusions

Idaho National Laboratory has performed thorough validation of a CFD approach to dynamic line ratings by field testing with Idaho Power, and has shown that the transmission line capacity can be increased by up to 40%. The new method combines wind speed and wind direction as calculated by WindSim's CFD software with the cooling calculation done by the GLASS tool developed by INL.

- J. Gentle, K. Myers, J. Bush, S. Carnohan and M. West, "Dynamic Line Rating: Research and Policy Evaluation," PES General Meeting, pp. 1.5, 27-31, 2014 IEEE.
- J. Gentle, W. Parsons, M. West, and S. Jaison, "Modernizing An Aging Infrastructure Through Real-Time Transmission Monitoring," PES General Meeting, 2015 IEEE

IDAHO POWER. An IDACORP Company

windsim

Idaho National Laboratory

INL/CON-15-34747