

Operational Efficiencies and Risks Associated with Static, Ambient Adjusted, and Dynamic Line Rating Methodologies

Kristine Engel, Jonathan Marmillo
LineVision Inc.

Mahraz Amini, Hamid Elyas, Babak Enayati
National Grid USA

Motivation

- Advanced transmission line ratings provide operational efficiencies and enhance grid reliability.
- Understating capacity in transmission-constrained areas can cause market binding events, curtailment, and roadblocks for renewable energy projects.
- Overstating capacity during periods with low or no wind present can put National Electrical Safety Code (NESC) mandated line clearances and conductor health in jeopardy.

Method/Approach

- SLR utilizes a fixed set of assumptions that do not change, or change once per year for a Winter and Summer Rating.
- AAR calculations are based upon a varying ambient temperature and can offer limited extra capacity over SLR. At times AAR will overestimate capacity because the assumed wind speeds are not available.
- DLR takes into account real-time field measurements of weather and conductor position to determine the conductor ampacity.



- To study the operational efficiencies and risks associated with the different types of line ratings, National Grid and LineVision evaluated each rating methodology for the same transmission line.

Objects of investigation

- The study was conducted on a 115 kV transmission line in Massachusetts owned and operated by National Grid.

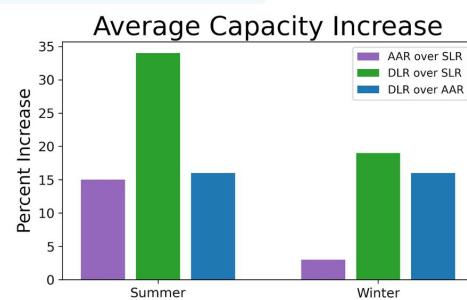
Conductor Type	Emissivity / Absorptivity	Conductor MOT
477 (18/1) ACSR Pelican	0.8 / 0.8	100 C (212 F)

Experimental setup & test results

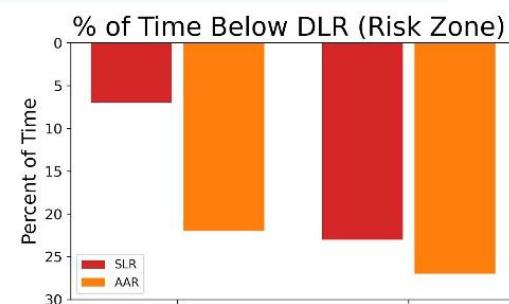
- Ratings are calculated using the IEEE 738 heat balance equation.
- The line was equipped with LineVision V3 non-contact line monitors in July of 2019.
- Static assumptions are outlined below:

Input	Ambient Temp.	Solar Irradiance	Perp. Wind Speed
Static Line Ratings (SLR)	100 F summer 50 F winter	1097 W/m ² summer 644 W/m ² winter	3.0 ft/sec
Ambient Adjusted Ratings (AAR)	dynamic	1097 W/m ² summer 644 W/m ² winter	3.0 ft/sec
Dynamic Line Ratings (DLR)	dynamic	dynamic	dynamic

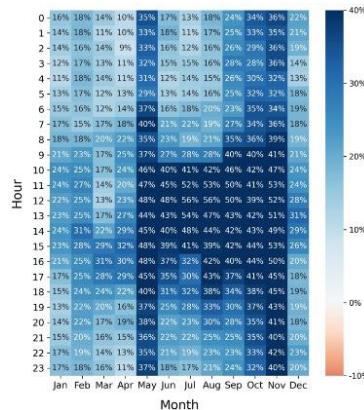
- Advanced line ratings increase capacity by up to 34% over static line ratings



- Static ratings and ambient adjusted ratings may overstate capacity when wind speeds are low.



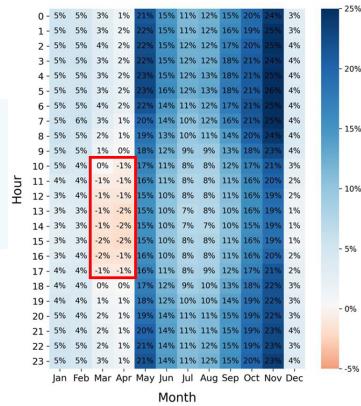
Comparison of DLR and SLR



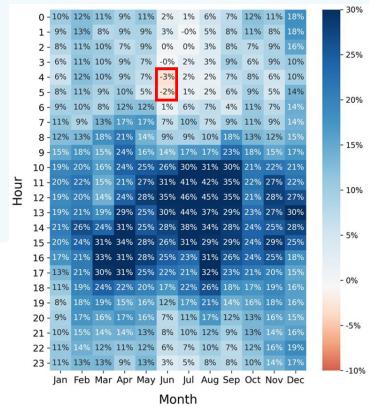
- On average, DLR is 34% higher than SLR in summer, and 19% higher than SLR in winter.
- DLR drops below SLR 7% of the time in the summer months and 23% of the time in the winter months.

Comparison of AAR and SLR

- On average, AAR is 15% higher than SLR in summer, and 3% higher than SLR in winter.
- AAR always exceeds SLR in the summer months and drops below SLR 22% of the time in the winter months.



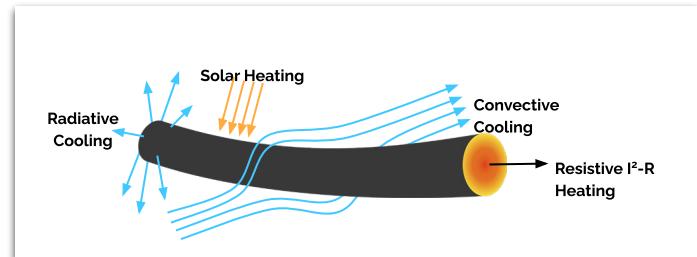
Comparison of DLR and AAR



- DLR often exceeds AAR during midday hours due to the cooling effect of wind.
- The few instances of negative percentages indicate that AAR incorrectly indicated additional capacity was available.

Line Ratings

- Several line rating methodologies exist in practice across the US grid operators, each utilizing a different approach based on fixed assumptions or variable inputs for the properties that make up the IEEE 738 steady state heat balance equation for line ratings.



Discussion

- SLR relies on fixed assumptions of both wind speed and ambient temperature.
- AAR frequently indicates additional capacity is available during periods of cooler ambient temperatures in the winter months and overnight hours but often overstates available capacity due to a fixed assumption of wind speed.
- DLR provides extra capacity during cooler weather in addition to midday peak demand hours when wind speeds are strong. DLR, as a field sensor-based technology, mitigates the risk of exceeding the conductor maximum operating temperature by utilizing real time measurements of all input parameters.

Summary of Key Findings	Summer	Winter
% of Time AAR is above SLR	100%	78%
% of Time DLR is above SLR	93%	77%
% of Time DLR is above AAR	78%	73%
Avg % Capacity Increase, AAR over SLR	15.1%	2.7%
Avg % Capacity Increase, DLR over SLR	33.8%	19.3%
Avg % Capacity Increase, DLR over AAR	16.3%	16.2%

Conclusion

- Advanced line ratings increase capacity by up to 34% over static line ratings.
- Static ratings and ambient adjusted ratings may overstate capacity when wind speeds are low.