
LINEVISION
Accelerating the
Net Zero Grid
LineVision is accelerating the net zero grid by equipping our utility partners with unique monitoring and analytics that improve the capacity, resilience, and safety of the grid.

Barriers to a Net Zero Future

Grid Challenges

Grid Expansion

100% growth in grid capacity required by 2035

Intensifying Climate Risk

$90B+ in economic losses from Texas' 2021 storm

Aging Infrastructure

50% of lines are at or near the end of useful life

Interconnection Backlog

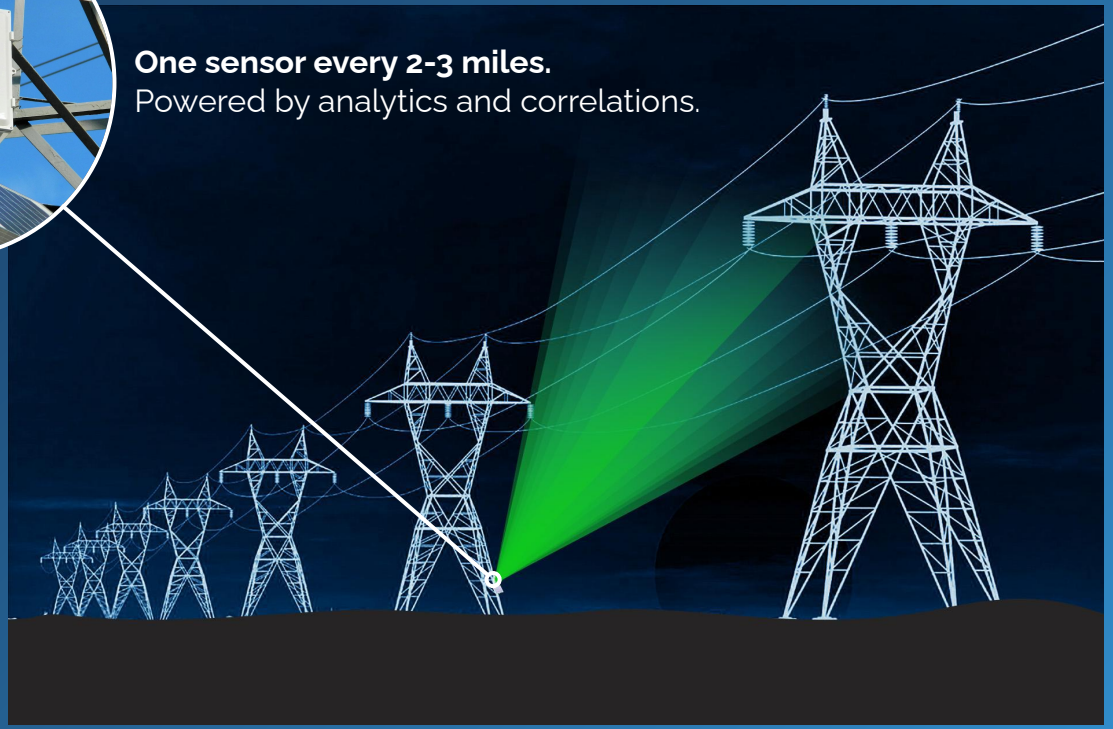
1400 GW of transmission projects stuck in the interconnection queue

Lack of Visibility

99.9% of all transmission lines have no monitoring beyond the substation

Monitoring every phase of power with

One Single Sensor



One sensor every 2-3 miles.
Powered by analytics and correlations.

Complete Visibility

> Any tower, any voltage, any conductor

> Data on all conductors

> No outages and no live-line work

400+
Sensors Installed Globally

1.14 GW
Renewable Energy Added

$55 M+
Dollars Saved for Customers

1.2 M
Metric tons of CO2 avoided

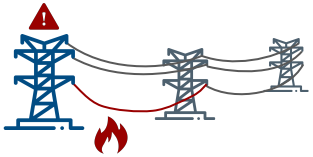
The Intelligent Solution

One Platform

LineAware

Situational Awareness

Ensure lines are within safe operating limits with real-time alerting on threats to grid reliability or public safety



Reduced Operational Risk

LineRate

Advanced Line Ratings

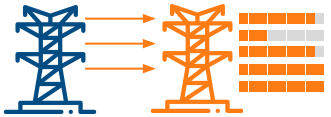
Reliably and safely increase capacity on transmission lines by up to 40% with Ambient Adjusted and Dynamic Line Ratings

FERC Compliance & Increased Capacity

LineHealth

Asset Health Insight

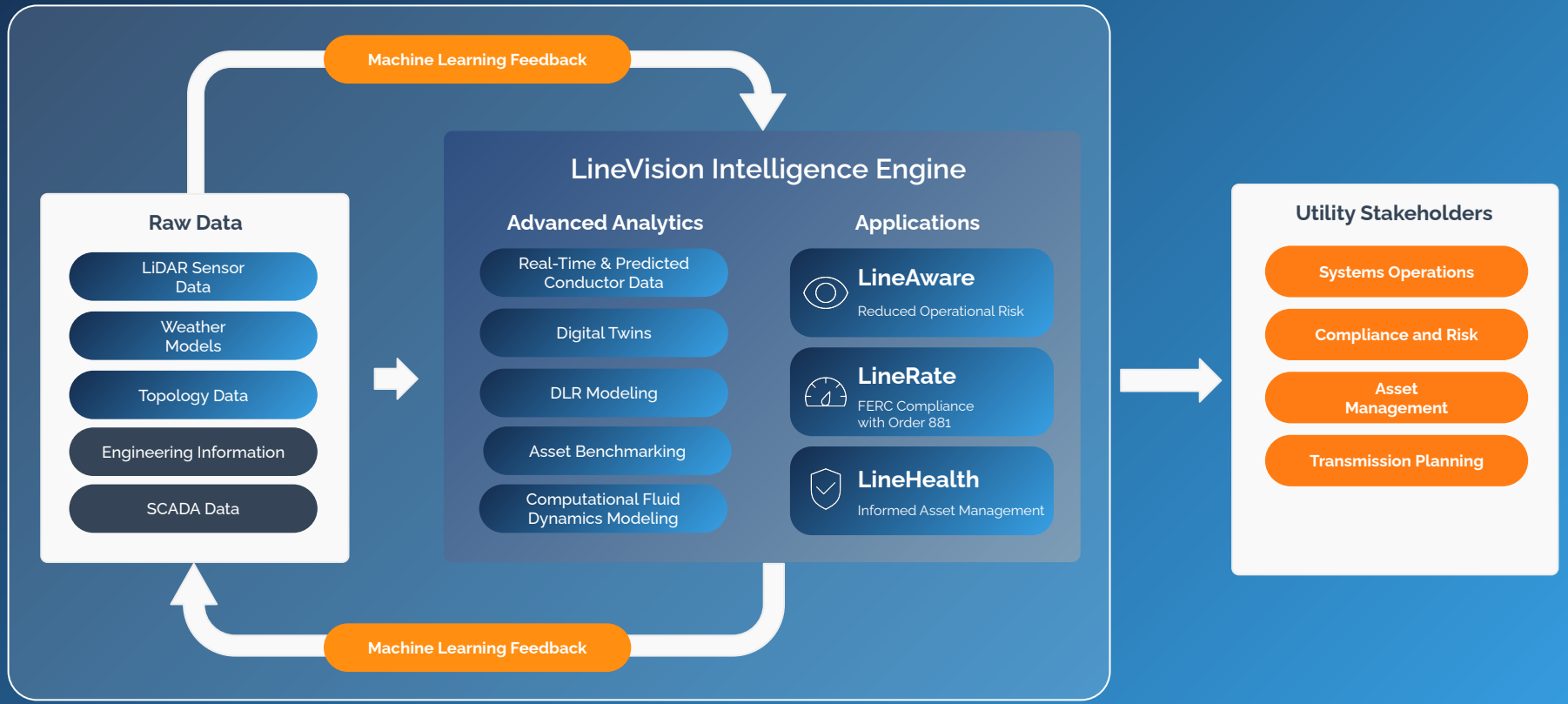
Evaluate conductor health with non-destructive techniques to prioritize maintenance where needed



Informed Asset Management

One Platform

Three Powerful Applications



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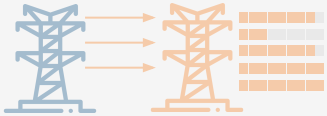
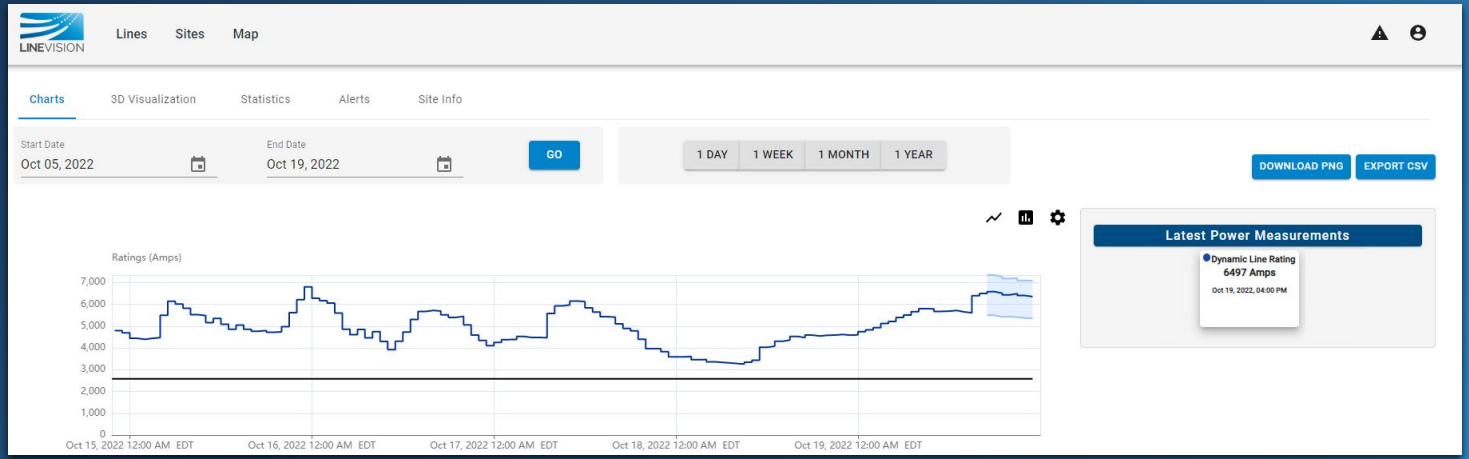


Informed Asset Management

LineRate Suite

Advanced Line Ratings



Dynamic Line Rating

Increase the ratings on existing lines with up to 40% additional capacity.

IEEE & CIGRE

Methodology based on industry standards.

Data Delivery Options

> LineVision Cloud

> Utility Cloud

> Utility On-Premise

LineRate DLR Output

> Real Time Dynamic Line Rating

> Forecasted DLR hourly up to 240 hours (10 days)

> Emergency Ratings

> Average Conductor Temperature of the Stringing Section

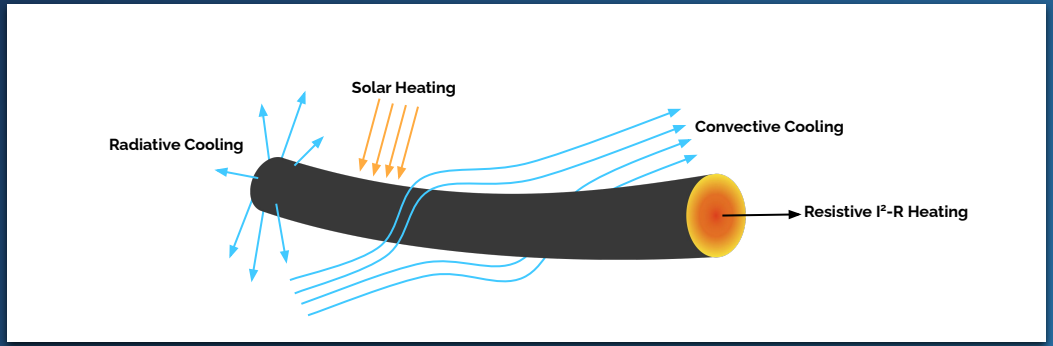
The Intelligent Solution

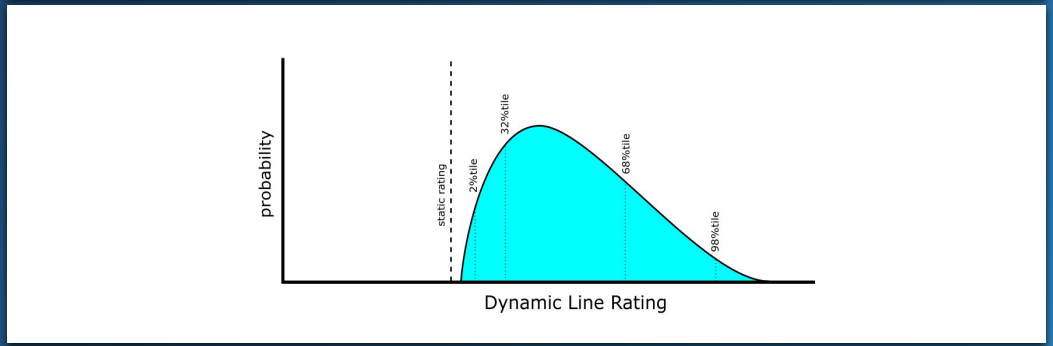
LineRate Suite Offerings

	AAR Ambient Adjusted Ratings	**AAR +** Ambient Adjusted Ratings +	**DLR** Dynamic Line Ratings
Capacity Added Compared to Static	minimal capacity increases or decreases	minimal capacity increase with basic sensor validation	up to 40% increase with full sensor validation
Reliability Concerns	very conservative assumptions reduce overestimation of ratings	conservative assumptions and basic sensor validation prevent overestimation of ratings	full sensor validation prevents overestimation of ratings
Field Sensors	none	sensors deployed at critical locations	full line equipped with sensors
Methodology - Wind	CIGRE-recommended fixed values	assumes fixed values and derates based on sensor inputs	fully modeled with computational fluid dynamics, blowout measurements, and conductor sag/temperature checks
Methodology - Ambient Temperature	localized weather data		
Methodology - Solar Heat Gain	localized time of day values		
Frequency & Forecast	hourly update with a 240 hour forecast		
Regulatory Compliance	FERC Order 881 compliant		

LineRate Suite

DLR Methodology





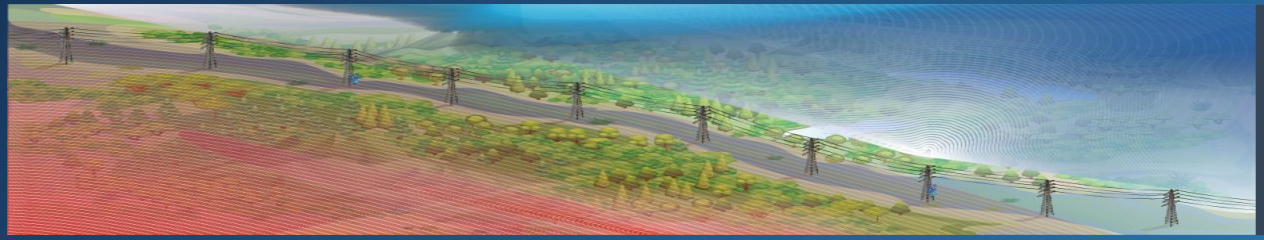
We use IEEE 738-2012 for all formulas, constants, coefficients, etc. DLR is computed using Monte Carlo methods to account for input uncertainty.

Inputs to DLR Calculation:

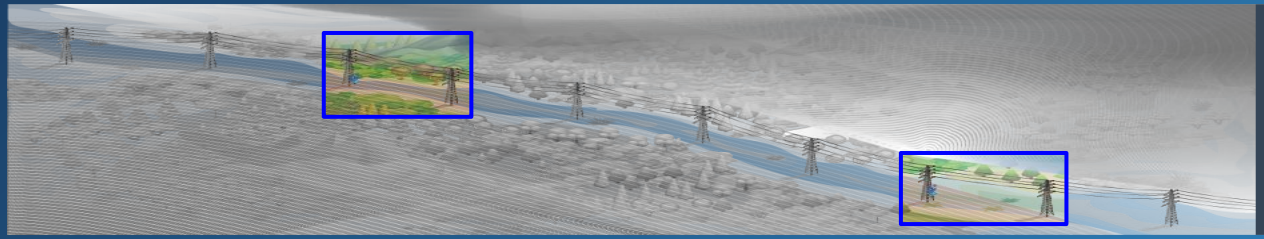
- Maximum Operating Temperature
- Solar Irradiance
- Air Temperature
- Wind Speed
- Fixed conductor properties:
  - Resistivity
  - Emissivity/absorptivity
  - Thermal mass

LineRate Suite

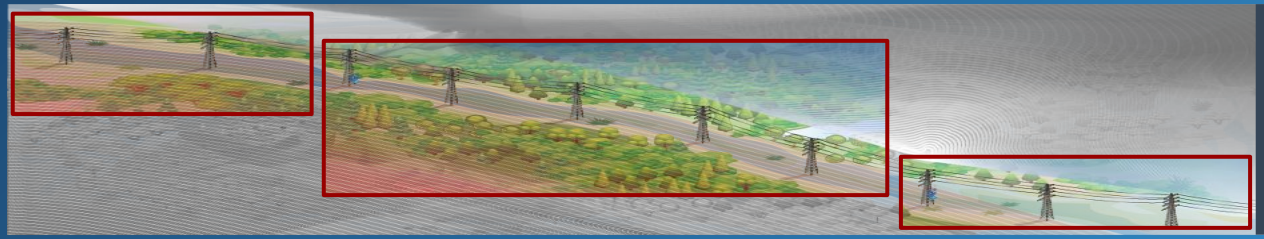
How it Works



Computational Fluid Dynamics (CFD) used to model Numerical Weather Prediction wind speeds at **each individual span**, based on local topography and vegetation.



Monitored **Blowout** is a rich data set on real-time wind conditions for each monitored span.



Conductor Temperature, derived from the sag measurements, is an independent data set to create a digital twin.

LineRate Suite

Data Integration

LineVision Cloud

> Line ratings are calculated in the LineVision cloud

> Data can be sent from this environment via SFTP or accessed directly via REST API

The fastest path to integration

Utility Corporate (non-CIP) Environment

> Line ratings are calculated in the transmission owner's corporate environment

> Cloud or server-based environment integrated with the LineVision cloud for real-time ingestion of data

Requires utility IT integration work

On-Prem (CIP Environment) Calculation

> Line rating calculations are fully on-premise in the CIP / SCADA environment

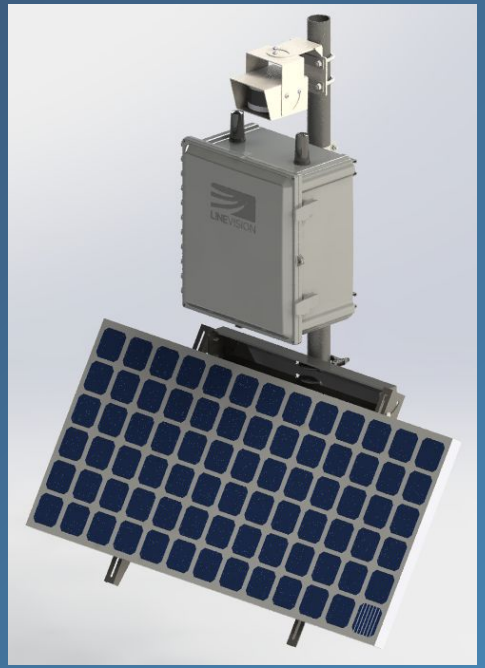
> Requires ingestion of Linevision data

Used if line ratings considered in scope for NERC CIP

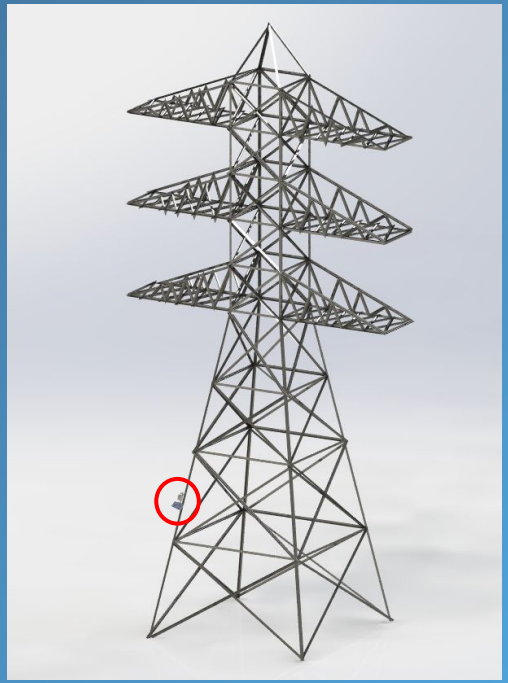
Non-Contact, No System Outages

System Installation Process

Full Sensor Assembly



LineVision Sensor Assembly



Non-Contact, No System Outages

System Installation Process

Step 1

Span & Site Selection

Select based on topography and criticality

Step 2

Monitors Installed Using Hand Tools

Installation done without specialized equipment or outages

Step 3

Site Survey & Ratings Engine Training

Span geometry digitally reconstructed and critical point of sag identified

No live-line work!

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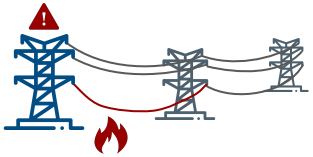

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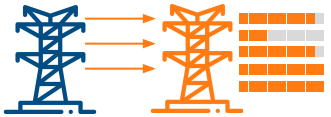


Informed Asset Management

LineVision Global Footprint

Projects

Dominion Energy	exelon	NY Power Authority	American Electric Power	MAVIR	Xcel Energy
ComEd	Duke Energy	nationalgrid	BGE	ipto Independent Power Transmission Operator	SKP
SMUD	50hertz | Elia Group	DLC Duquesne Light Co.	Northern Ireland Electricity Networks	comed An Exelon Company	HOPS

LineVision USA Footprint

Projects

nationalgrid

Featured Application:
LineRate DLR on a congested transmission line in a renewable generation rich area.

Impact:
Avoided the rebuild of 30 miles of double circuit transmission, avoiding ~$55M in construction costs. Reduced wind curtailments by 320 MW, added 190 MW in additional headroom.

DLC DUQUESNE LIGHT CO.

Featured Application:
LineRate DLR on congested transmission lines

Impact:
DLR on congested lines provided an additional 25% available capacity on existing transmission infrastructure.

Xcel Energy®

Featured Application:
Using all LineVision applications for holistic grid enhancements.

Impact:
DLR to reduce congestion in MISO territory, LineAware & LineHealth in Colorado wildfire risk zones to ensure public safety and system reliability.

SMUD®

Featured Application:
LineRate DLR and LineAware situational awareness.

Impact:
Increased capacity from DLR will prevent power imports with a payback period of days while also monitoring critical sags in high-risk wildfire zones

Analysis on Static, Ambient Adjusted, and Dynamic Line Ratings

LINEVISION

LineVision performed an analysis comparing different line rating methodologies on a 345kV transmission line in the Midwestern USA.

The data illustrating the differences in the resultant ratings is presented herein.

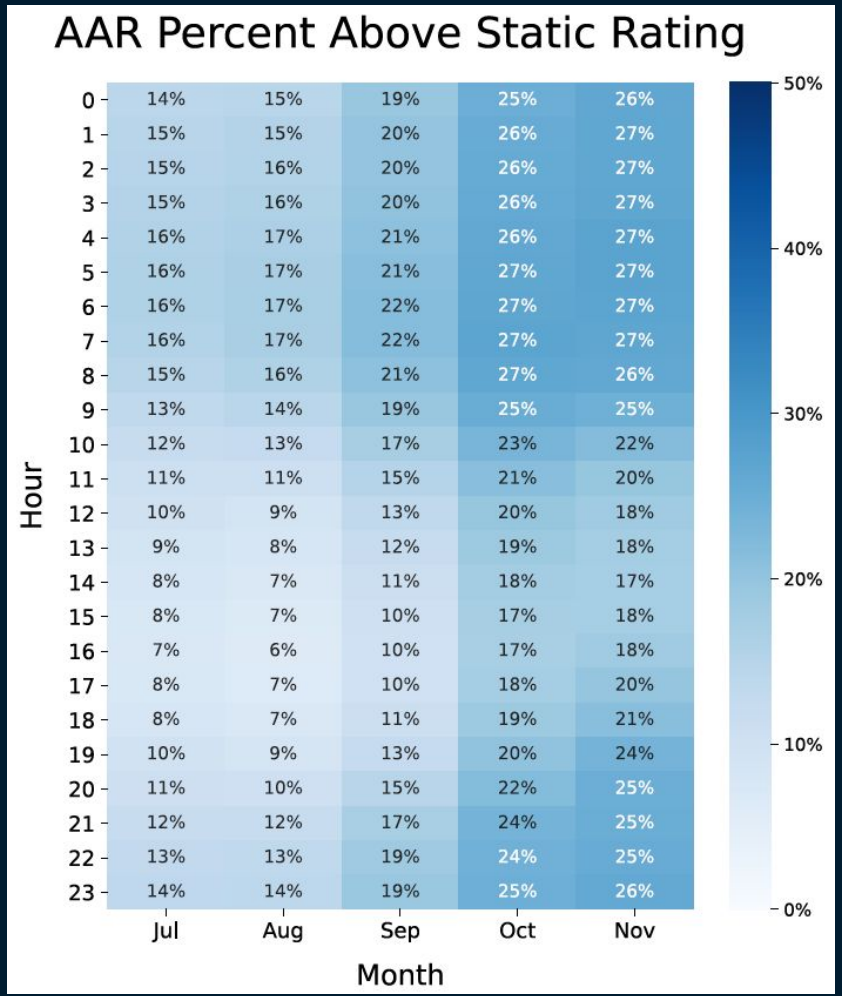
Assumptions	Notes
Study Location	Midwestern USA in SPP footprint.
Study time period	July 10, 2020 through November 17, 2020
Local Time Zone	US/Central
Static Rating GHI	1100
Static Rating Wind Speed	3 (fps) / 0.9144 (m/s) perpendicular to the conductor
Static Rating Ambient Temperature	40 C
Ambient Adjusted Rating Temperatures	From GPS Site Specific Weather Model
Ambient Adjusted Rating Wind Speed	3 (fps) / 0.9144 (m/s) perpendicular to the conductor
Dynamic Line Ratings	From LineVision V3 Monitoring System
DLR Capping Factor	DLR was capped at a maximum at +50% of Static Rating

Ambient Adjusted Ratings vs Static Ratings

This heatmap illustrates the percent increase provided by AAR over Static Ratings.

The largest increases are observed during the overnight hours when load demand is low.

Moderate increases are provided during the mid-day peak loading hours.

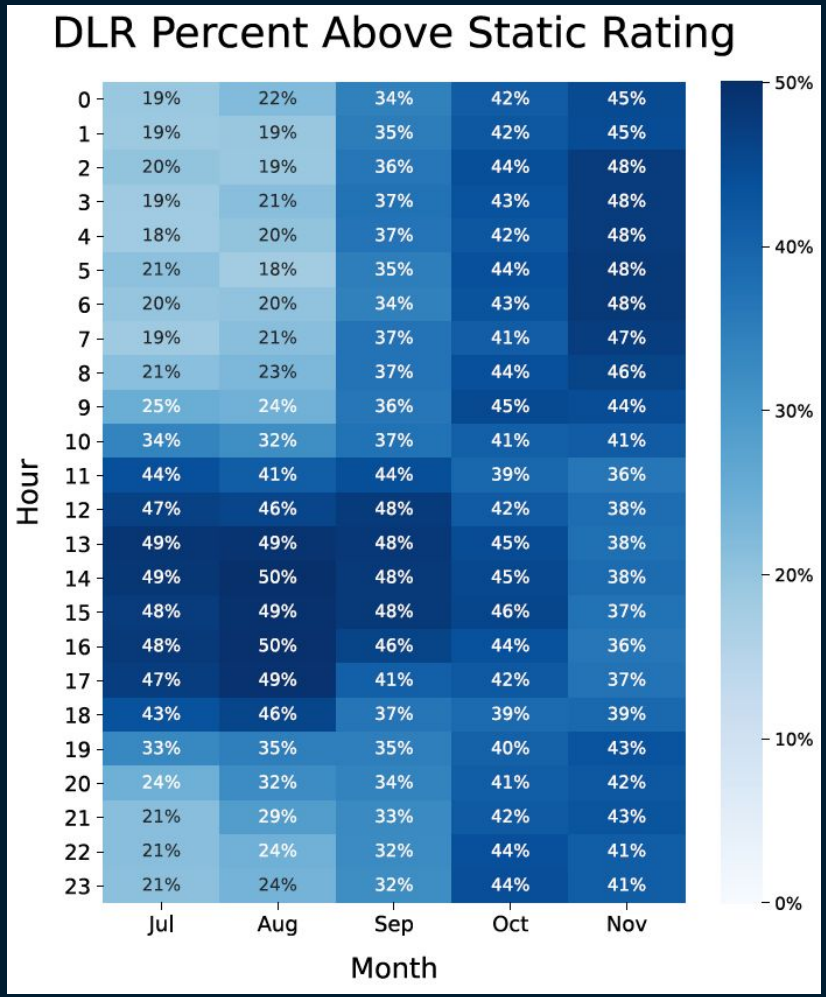


Dynamic Line Ratings Ratings vs Static Ratings

This heatmap illustrates the percent increase provided by DLR over Static Ratings.

The largest increases in ratings are observed during the mid-day hours which are concurrent with peak load demand and peak renewable generation output.

DLR provides increased ratings when they are needed most.

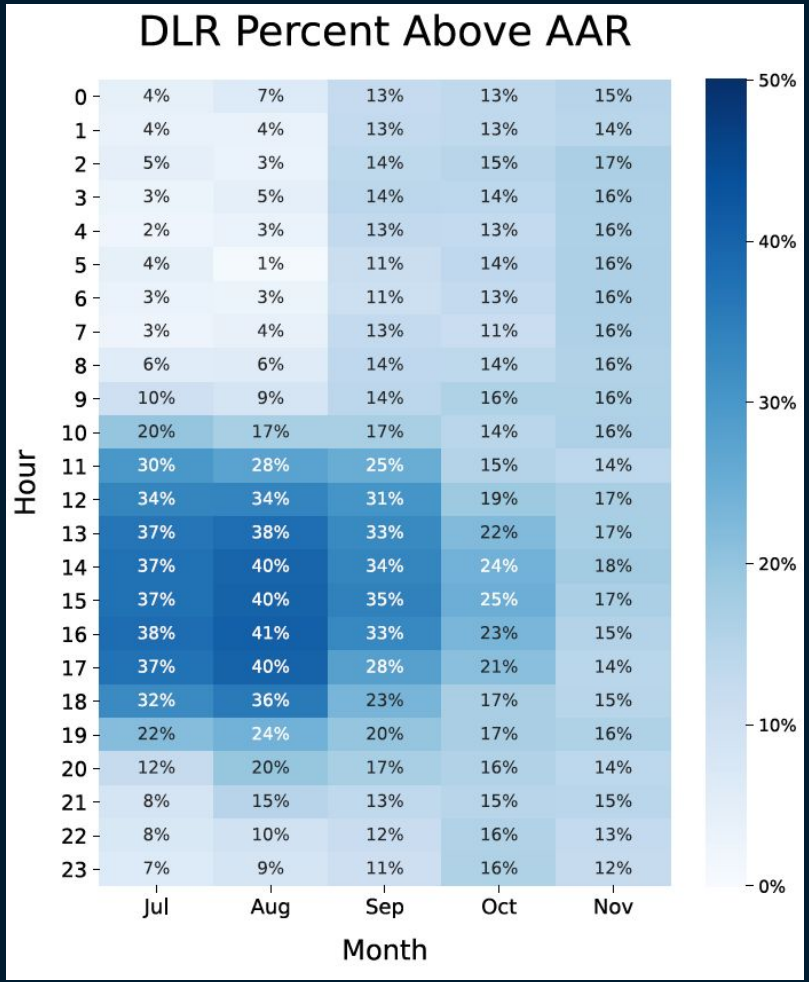


Dynamic Line Ratings Ratings vs Ambient Adjusted Ratings

This heatmap illustrates the percentage increase in the rating provided by DLR above AAR.

Dynamic Line Ratings provides increased line ratings above Ambient Adjusted during the mid-day hours as this is when wind speeds are at their highest levels.

Wind is the most significant factor when determining an increase in a line's rating and Ambient Adjusted Ratings do not take this into account.

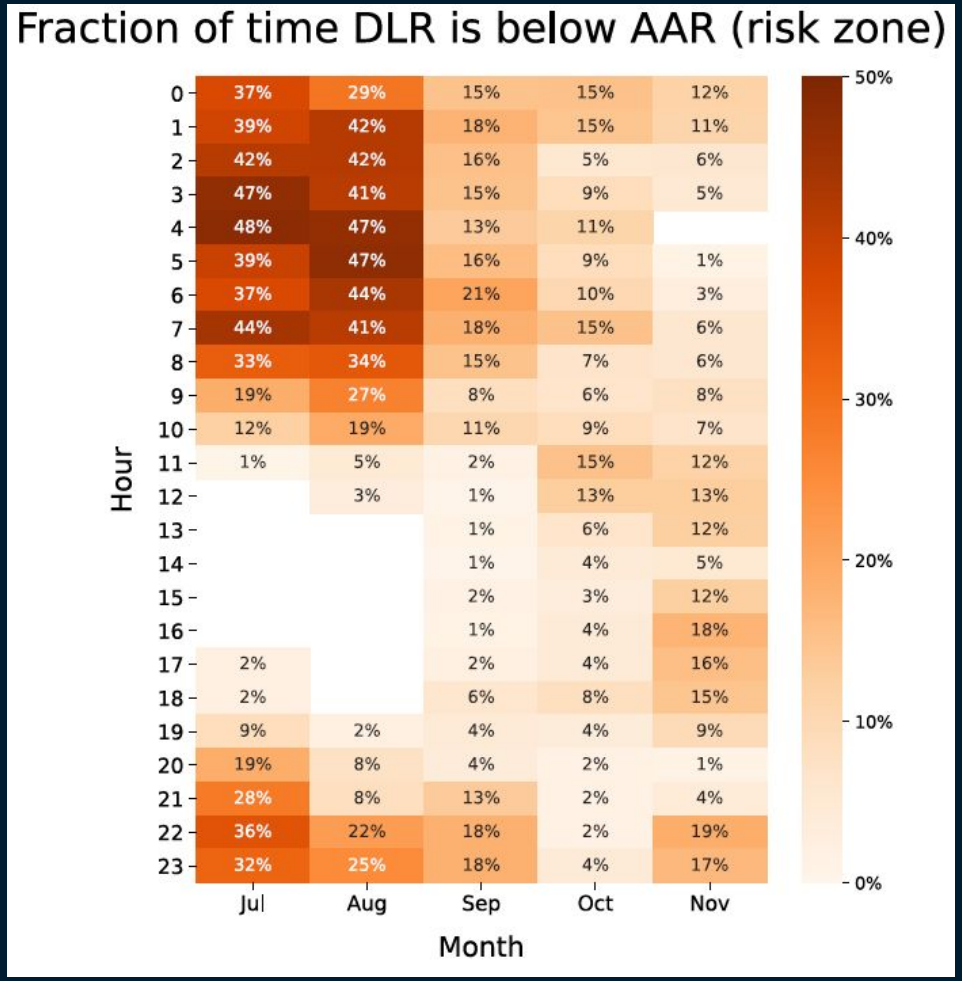


Percentage of Time When DLR is below AAR

This heatmap illustrates the % of the time when the AAR approach incorrectly and unsafely provides additional capacity above the field sensor verified DLR value.

Since AAR assumes a fixed wind speed is cooling the line even when it is not present in reality, it falsely provides extra capacity, putting reliability and safety at risk.

Using AAR ignores the single most influential variable in a line rating, wind speed.

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