DYNAMIC LINE RATING DEPLOYMENT FEASIBILITY STUDY

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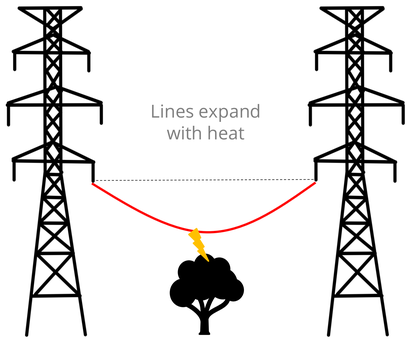
TACOMA PUBLIC UTILITIES

Intro to Line Ratings

- **Line rating:** maximum power that can flow through a conductor
- Proper ratings mean safe and reliable operation
  - Unsafe ratings → conductor expansion and sag
- **Static ratings** are traditional, using weather assumptions
  - **Conservative** for safety so power grid is underutilized



- Two methods to address this:
  1. **Ambient Adjusted Ratings (AARs):** removes ambient temperature assumptions by using hourly or daily air temperatures
  2. **Dynamic Line Ratings (DLRs):** removes all weather assumptions by measuring environmental conditions every 5-30 minutes
- When placed well, DLR can increase line capacity cost-effectively

Design Goals and Deliverables

- **The DLR product must:**
  - Continuously monitor weather
  - Comply with CIP data storage security
  - Communicate with the existing Energy Management System
  - Not require reconductoring (replacing the lines themselves)
- **Project deliverables:**
  - Recommend a DLR vendor for Tacoma Power
  - Identify ideal locations for deployment
  - Develop tools to validate and rank chosen locations

Deployment Locations

- Ratings are **limited** by the **lowest-rated span**
- **Wind** is the **largest influence**
  - A change of 2-degrees Fahrenheit will result in a 1% change in capacity
  - A mere **3 ft/s increase** in wind speed results in a **44% capacity increase**

Maximizing Wind Exposure	
Factor	**Justification**
Minimal direction changes	Change in line direction → different speeds and wind angles of attack → spans experience uneven cooling
Minimal wind sheltering	Sheltered spans experience less wind cooling
Minimal variations in elevation	Different elevations experience different wind speeds or ambient temperatures

Vendor Research

- **Fourteen vendors** researched and compared by:
  - Technology available, utilities implemented, product deployment process, FERC 881 compliant, etc.
- Narrowed down to top three vendors for Tacoma Power to select from

Lindsey Systems' SmartLine

Pros: Direct wind speed measurement, advanced UI options

Cons: Back-calculated some parameters, no backup battery

Laki Power's LKX-MULTI Sensor

Pros: Direct wind speed measurement, camera with on-board AI for wild-fire detection

Cons: No solar irradiance measurement, very heavy (66 lbs)

Heimdall Power's Neuron

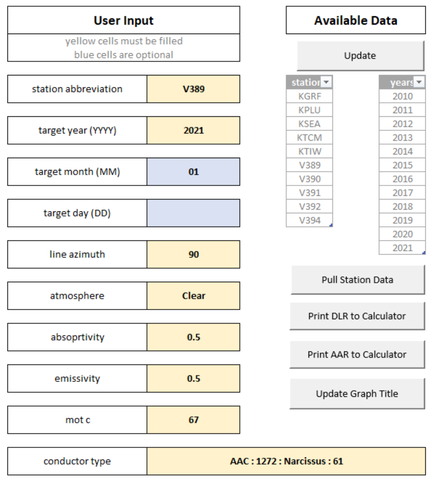
Pros: Piloted by PSE, used widely in US, drone installation

Cons: No direct wind speed measurement

Validation Tool

The validation tool helps determine if an area would benefit from DLR enough to be worth considering as a possible place of deployment.

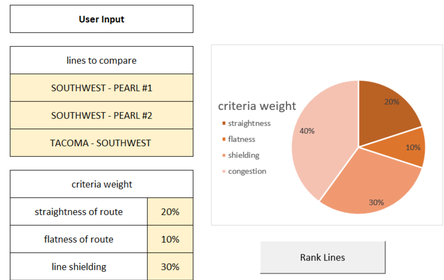
- Excel macro-based program, parses ten years of hourly data from **eleven weather stations**
- Calculates DLR values following **IEEE 738 specifications**
- User input to select the weather station and timespan (one day, one month, one year)
- Used to examine the **potential benefits of DLR** in various areas of the grid
- Generates a **graph** of **potential DLR values against AARs**
- Root data of the tool is dynamic for future use



Prioritization Tool

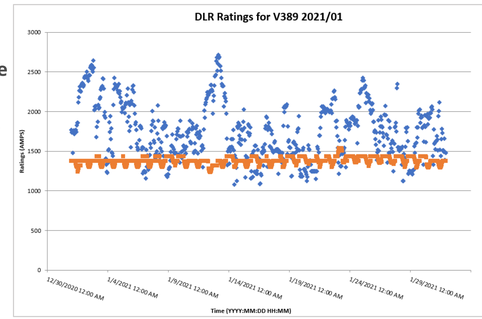
The prioritization tool ranks the potential deployment locations to determine which transmission route would benefit most from a DLR deployment.

- Excel macro-based program reads line data and grades each category
- User-input for which **lines to rank** and what **weight to assign** to each category
- Each category of data was collected or calculated by the team



Results

- Graph output from the validation tool proves **DLRs (blue)** to be **consistently above** Tacoma's **AARs (orange)**
- At Tacoma Power's request, the prioritization tool mainly considers **untapped transmission routes**:
  1. Tacoma – Southwest
  2. Southwest – Pearl 1
  3. Southwest – Pearl 2



- **Contingency analysis** conducted in Power World showed line congestion
- **Assumptions made in analysis**: conductor limited ratings, ambient temp: 110°C, wind speed: 4.58ft/s
- **Seven lines** potentially **overloaded** (max. 138%)
- Assumptions for DLR included nearby weather station wind speeds (as opposed to static wind speeds currently used)
- **Overall, ratings were increased with DLR**, avoiding line overload

Future Work and References

- **Final vendor selection** at Tacoma Power's discretion and **pilot installation** on high priority transmission lines
- Additions to the tools of more weather data or more lines available for ranking
- **Main References:** FERC Order 881 (2021), IEEE 738 (2023), IEEE 1283 (2013)

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