Orbs that Enable Dynamic Line Rating (DLR)

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1. Introduction

There are many factors driving chaos in electric utilities now. These include:

- Rapid growth of data centers in size and numbers, each demanding a large amount of additional power to be supplied.
- Electrification of thermal-energy formerly provided by natural gas in most cases.
- Electrification of the transportation sector, including traffic and pollution abatement by urging commuters to move from using autos to using mass transit. Also auto owners are switching from internal combustion powered cars to battery-electric vehicles.
- Rapid growth in renewable power projects. Although some of these can be dispatched on an "as needed basis," many are intermittent (wind, photovoltaic, and many small-hydro projects) and require large energy storage additions to be flexibly dispatched, driving up their capital cost.
- Residential customers (like your author) and commercial customers switching from utility-provided electric generation to roof-top solar, potentially with small-to-medium battery energy storage systems.

Although the above factors, collectively impact whole electric utilities, when they change utility-wide demand profiles, they particularly impact the electric transmission systems. The good news is that the title technology may be able to give the utilities that manage transmission assets a bit of wiggle-room.

Line rating has traditionally been implemented in a conservative manner, such that each given transmission line has a static rating that reflects the worst-case scenario for ambient conditions. This is instead of the line-location- and weather-specific ratings for the current and/or a future time for each segment.

This post will review instances where the capability described in the last sentence in the prior paragraph is being implemented.

2. 5 Proven Facts Behind Dynamic Line Rating

The following text is from a specific vendor, Ampacimon. Reference 1 includes Ampacimon's contact information. They might be a good partner for DLR project.

As the world races toward net zero, our grids face a simple truth: demand is rising faster than infrastructure can be built. But hidden in plain sight is untapped capacity already strung across thousands of kilometers of overhead lines. Dynamic Line Rating (DLR) is the key to unlocking it.[1]

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[1] Ampacimon, "It's Not Magic, It's Measured: 5 Proven Facts Behind Dynamic Line Rating," October 21, 2025, https://www.ampacimon.com/news/its-not-magic-its-measured-5-proven-facts-behind-dynamic-line-rating? (678) 522-1317, 110 Allen Street, Cumming, Georgia 30040

Powered by sensors, physics, and AI, DLR transforms how we understand and use our grid. It uses real-time monitoring and advanced forecasting to measure, predict, and safely increase the usable capacity of overhead lines. The science behind DLR is transparent, and it only depends on measurement and physics.

2.1. Physics

At its core, DLR is grounded in physics. Every conductor behaves according to measurable principles: current, tension, sag, vibration, wind cooling and solar heating. By attaching sensors to or near the line, and/or accessing publicly available high-resolution weather data, DLR continuously captures these variables and translates them into an accurate ampacity value which is the true current-carrying capacity of the line at any moment.

This replaces decades-old reliance on conservative estimates, which were designed to assume the worst-case scenario and leave unnecessary large safety margins. Instead, DLR empowers operators with data rooted in real physical measurements. The result is a system that is both safer and more efficient, because line-data is captured at the source, and capacity is no longer left unused.

2.2. Wind and Sag are Major Drivers

Among all the environmental influences on an overhead line, wind plays the most decisive role. Even modest differences in wind speed or direction can change the thermal balance of a conductor, either cooling it significantly or allowing heat to build.

Wind is the dominant cooling mechanism and therefore the single greatest driver of line current-carrying capacity. Unlike ambient temperature or solar radiation, which are relatively well predicted by weather models, wind is a highly localized phenomenon (local topology, turbulence, boundary layer effect, thermal effects…). That is why accurate, sensor-based wind measurement is critical. Without it, operators risk either overestimating capacity (a safety hazard) or underestimating it (wasting available transmission headroom).

By focusing on wind as the primary factor and measuring it directly near the conductor, DLR ensures that capacity estimates are accurate.

It is also good to note that while wind direction and speed are the most important thermal parameters to be known, sag is also of prime interest as it is related to clearance and safety of the grid. Algorithms that compare local wind-speed/direction with actual line-sag should result in the most accurate estimates of real-time capacity.

2.3. Forecasting Is Reliable

Beyond measuring the present, DLR also provides forecasts and predictions from up to a few hours (management grid congestion) to up a few days (energy market analysis). Forecasting line ratings is critical for system operators, who must balance supply and demand, schedule generation, and manage grid constraints hours in advance.

Recent studies show that machine learning and artificial intelligence greatly improve the reliability of these forecasts when based on sensor-driven data (historical data from sensors). By training algorithms to adjust weather-provider wind data against local sensor measurements, forecasts of Dynamic Line Ratings have achieved 97–98% confidence levels for horizons of up to four hours ahead. Alternatively, transmission system operators may also decide to select another level of confidence depending on their risk policies.

In practical terms, this means that operators can rely on DLR not only to validate capacity in real time, but also to plan operations with confidence, balancing gain and risk of overestimation. The ability to forecast ampacity safely and accurately transforms DLR from a reactive tool into a proactive one; essential for grids that must integrate fluctuating renewable generation.

2.4. AI Can Scale the Solution

As adoption grows, scalability is key. Advances in artificial intelligence and machine learning now make it possible to extend the reach of DLR more efficiently.

Ampacimon's research has demonstrated that wind and rating data from one section of line, the set of mechanically coupled spans between two anchoring chains, can be extrapolated to nearby sections, provided certain conditions are met such as similar orientation, low obstruction, and manageable distances. AI models trained on local sensor data can then predict ratings for adjacent spans with high accuracy.

This hybrid approach tries to optimize the number of sensors and their locations over the grid while still preserving the reliability of the science. It ensures that DLR can scale from pilot projects to entire networks in a cost-effective way, accelerating adoption without compromising accuracy.

2.5. Measurable Results

DLR's impact is most clearly demonstrated in how it supports renewable energy integration. Curtailment means forcing renewable plants to cut back output even when they could generate more, essentially wasting clean energy. DLR's advantages are proven in practice, with measurable results rather than abstract promises.

A case study in Japan illustrates this clearly. On an overhead line connected to large-scale photovoltaic (PV) plants, researchers compared outcomes using traditional Static Line Ratings (SLR) with those achieved through DLR. With an additional 20 MW of PV generation, simulations showed that relying on the static line rating would result in 576 hours of curtailment over the year. Using dynamic line rating reduced this to just 40 hours, a 93% decrease, highlighting the significant potential to limit PV curtailment through real-time monitoring.

3. Approaches that Inform DLR

3.1. The Orbs

It's a cloudy day in mid-July near Hamburg. A crew of technicians carries a shiny metal orb, about the size and weight of a kid's bowling ball, under a 110-kilovolt transmission line. One crew member attaches the orb to a quadcopter drone and pilots it skyward. As it nears the wire, one side of the orb slides open, like a real-life Pac-Man about to chomp a power pellet, and then clamps down over the line. The process takes about 10 seconds and requires no transmission downtime.[2]

The orb's mission? To maximize the capacity of the transmission line.

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[2] Amos Zeeberg, IEEE Spectrum, "Grid Operators Squeeze More Capacity From Their Lines, Dynamic line rating can soothe power-grid congestion," October, 2025, https://spectrum.ieee.org/dynamic-line-rating-grid-congestion

Heimdall Power's orb tracks line sag, ambient temperature, sunlight intensity, and other metrics on a transmission line in southwestern Norway. HEIMDALL POWER

Oslo-based Heimdall Power, the manufacturer of the orb, has installed 10 on the transmission lines of Schleswig-Holstein Netz, the grid operator in the northernmost part of Germany. (The company has installed 250 in Germany as a whole, and 200 on the lines of Austrian operator Netziederosterreich.) For each operator, the orbs form a system that calculates how much current its high-voltage lines can safely carry based on real-time weather conditions.

Historically, grid operators have estimated the capacity of lines based on average seasonal temperatures-a fixed value called static line rating. For safety, the estimates must be highly conservative and assume that the weather is always warm for the respective season. (A line's resistance increases as its temperature increases, lowering its capacity.) For all but the hottest days, transmission lines could carry significantly more electricity, if grid operators only knew the actual temperature of the wires.

Tools like Heimdall's orb, dubbed the Neuron, and schemes from other companies including Line Vision in Boston and Gridraven in Tallinn, Estonia, can fill in that blank. The system can track information such as how much the line sags and air temperature to more accurately determine the temperature- and therefore he real-time capacity- of the line. It also uses weather data to predict the temperature and capacity of the lines for the next day.

Neuron-enabled DLR is being rapidly adopted in North America and Europe as an antidote- at least in the short term – to grid-congestion woes. New transmission lines are needed to accommodate the explosion of AI data centers, vehicle electrification, and renewable-energy generation, but building them is a notoriously slow task, requiring a decade or· longer. In the interim, grid operators must do more with existing infrastructure.

In Heimdall's approach, line sag is one of the key metrics its sensors track; as metal wires get hotter, they expand and make the line droop. Measuring sag helps determine how much capacity has dropped. The sensors also track other information such as ambient temperature and sunlight intensity. Heimdall combines the information with local weather-forecast data-particularly wind speed, which has a cooling effect on power lines and can thus increase their capacity.

A machine learning system the company developed then uses the data to help grid operators plan how they'll route electricity for the next day. In urgent situations, they can use real-time data from the sensors to adapt on the fly.

3.1.1. Heimdall's U.S. Entry

After working mostly with utilities in Europe, last year (2024) the company opened a headquarters in Charlotte, N.C., to better access the U.S. market. Its first major U.S. project, in Minnesota, has resulted in a 25 percent capacity increase for the utility Great River Energy nearly 70 percent of the time. Heimdall has deals with six additional U.S. utilities that will bring its technology to 13 states.

"We've spent the last 80-plus years building the North American power grid, and we're basically still running it the way we did in the beginning," says Brita Formato, the president of Heimdall 's U.S. subsidiary. "DLR lets us bring the existing grid into the digital age- essentially overnight- and with relatively low cost and effort."

4. Linevision’s Lidar Sensors Enhance DLR

Linevision, another dynamic line rating provider, uses lidar sensors to monitor line sag, and combines the data with weather forecasting and computer analysis of how wind is affected by objects near power lines. Instead of putting its sensors directly on the power lines, the company mounts them on the towers. This makes installation and operation easier, according to Linevision.

The company originally used electromagnetic sensors to indirectly measure loading on each line but pivoted to lidar as it became cheaper and more widely deployed in self-driving cars. “When we made that switch, we were riding the wave of autonomous vehicles,” says Jon Marmillo, Linevision’s cofounder and chief business officer.

For the wind prediction, Linevision starts with a detailed, publicly available spatial map that includes buildings and trees, then uses machine learning to interpret how obstructions change wind near power lines. Marmillo says it takes about 90 days of learning for the system to create accurate predictions of line capacities after it’s installed. Utilities then integrate that into their grid-management software.

After completing an earlier project with Linevision, National Grid, the grid operator for England and Wales, in June announced a new, bigger project with the company, on 263 kilometers of 400-kV lines. The first project increased capacity by 31 percent on average, freeing lines to carry an additional gigawatt of power and saving customers £14 million annually (US $19 million). The new project is expected to save customers £20 million annually ($27 million).

5. Gridraven's Wind Forecasting Boosts DLR

In Estonia, DLR provider Gridraven takes a different tack: It doesn't use hardware at all. Instead, it relies on machine learning to make accurate, hyperlocal wind predictions. The predictions are based on weather forecasts and a detailed terrain map made from satellite and lidar scans.

Georg Rute, the CEO and cofounder, was working for Estonia's national grid operator in 2018 when he noticed that forecasts of wind around power lines were "really bad," he says. Rute came back to study the question in 2023 with Gridraven's other two cofounders, finding that two-thirds of the error in wind prediction was caused by the landscape—mainly buildings and trees.

Gridraven began its first large rollout last month, covering 700 km of Finland's 400-kV lines, and plans to expand to the country's entire 5,500-km network of high-voltage transmission lines. "With DLR, it is particularly possible to support the integration of wind power into the grid," said Arto Pahkin, a manager at Fingrid, Finland's transmission system operator. "This makes DLR a strategically important part of the integration of renewable energy." Gridraven's system can increase capacity of power lines by 30 percent on average, according to the company.

DLR companies are quick to point out that the technology is not a cure for all that ails our grids; over the long term, we will simply need more transmission. Congestion is already raising electricity prices and increasing outages. Since 2021, grid congestion has cost American consumers $12–$21 billion per year, depending on electricity prices and weather.

Other grid-enhancing technologies can help in the meantime. For example, reconductoring existing lines with advanced materials can double their capacity. But that approach also takes the lines out of use while the new materials are installed, and it's more expensive than DLR.

"The potential of DLR is to unlock up to one-third more capacity in the existing grid globally," said Rute. "This would boost economic growth and increase affordability right away while more grid is being built."