Dynamic Limit Rating

Smart algorithms and real time calculations can provide a cost-effective solution to power line capacity issues.

In many regions, power transmission and distribution networks face significant capacity pressure. Much of that pressure comes from rising demand, as more energy users connect to existing infrastructure, and as users switch to electricity for more of their energy needs. Demand on the peripheral parts of power networks is also rising due to the growth of distributed power generation and storage, including embedded wind and solar power and fossil fuel combined heat and power (CHP) installations.

The ampere capacity, or ampacity, of an individual power line is limited by temperature. The higher the current that flows through the line, the greater the heating effect on the conductor. That heating results in thermal expansion, which can cause lines to sag to the point where there is no longer a safe clearance between the line and the ground or other nearby structures. Prolonged high temperatures can also damage insulation and weaken the line through annealing of the conductor.

To prevent these undesirable and potentially dangerous outcomes, most powerlines are given a maximum current rating calculated using a conservative approach.

The overall capacity of the line is determined by its weakest link, usually the span where clearances are lowest. Line sag is calculated for the worst possible operating conditions: a hot, windless day.

This method is robust and well-proven. But it is also expensive for network operators. If demand begins to exceed the capacity of the line on a frequent basis, they may be forced to make significant upgrades, installing additional lines, bigger conductors or new transformers to operate at a higher voltage.

A more dynamic approach

In many cases, those investments may be unnecessary. Analysis of real world behaviour shows that many power lines can be operated at up to 130 percent of their static rated capacity for 90 percent of the year[1]. That's because most of the time ambient temperatures are lower than those used in the static rating calculation, and because wind and humidity provide additional natural cooling that keeps conductor temperature down.

Furthermore, the environmental characteristics that allow lines to carry more power are often closely correlated with periods of high demand. Power demand for space heating is highest when outside temperatures are low, for example, and when wind generation peaks, so does the wind's cooling effect.

To take advantage of these effects, operators need systems that allow them to understand the impact of changing environmental conditions on the most congested parts of their networks, and to integrate that information into control and management decisions. This approach is known as Dynamic Limit Rating (DLR).

[1] Dynamic Line Rating in the world – Overview, Dalibor Kladar, 2014. http://www.researchgate.net/publication/260229962

Various DLR technologies have been developed over the years, including hardware solutions designed to monitor line temperature, tension and sag in real time. Deploying such hardware solutions involves adding components to the transmission and distribution lines, which increases CAPEX costs. Such solutions will be very costly if rolled out throughout the whole network, not to mention the significant OPEX costs for the utility company in maintaining such equipment. As a result, transmission and distribution companies tend to install such hardware equipment only on selected areas where they believe power congestion to be an issue. Therefore, there is a need for a cost-effective solution that can be applied across the whole power network.

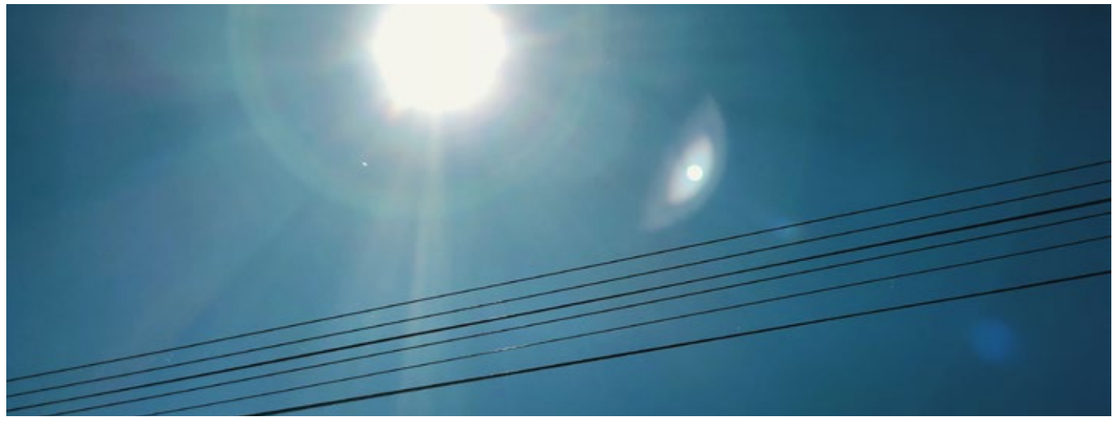
Smart, software-based DLR

Today, a new generation of DLR systems has emerged that can be implemented entirely in software, using data on environmental conditions obtained from existing sensors in the network, or from reliable external sources via the internet. This new approach allows operators to extend the use of DLR to smaller transmission lines and into the distribution network, giving them a new way to address capacity constraints across all parts of the power system. Capula is now able to offer DLR solutions through its strategic partnership with PSI Software AG. PSI has developed an advanced, well proven software platform including DLR capabilities as part of its comprehensive, modular energy management system solution.

Software-based DLR works using a mathematical model that calculates the effect of environmental conditions on the ampacity of transmission and distribution lines in a power network. The current, voltage and power inputs to the model are obtained from the operator's existing Energy Management System (EMS) or Distributed Management System (DMS). If real measurements are not available, the system can use Capula's well-proven power flow and state estimation model to calculate the relevant values.

This information is combined with meteological data, such as ambient temperature, wind speed and direction, and used to calculate maximum loads and currents for each line. These values are then passed back to the EMS or DMS.

The DLR solution can be fully integrated with the existing control system and uses its standard, well proven algorithms of power flow, state estimation and network stability analysis. The system operates automatically, calculating the line capacity based on real time network operation parameters and environmental data. To maintain the stability of the network control system, the system recalculates the line limits at a frequency defined by the operator, and then only when required due to switching operations in the network, or when measurements used in the calculation change by more than a defined threshold.



Software-based DLR is already in use in a number of applications around the world, where it is delivering significant benefits for network operators. While the additional capacity provided by DLR is determined by the characteristics of each installation, its benefits can be considerable. For example, the PSI DLR system was implemented on one power line in Europe with static line rating of 415A. With an ambient temperature of 20°c, and a wind speed of 8m/s at a 30° angle of attack, the system allowed that rating to be raised dynamically to 615A, an increase of almost 50 percent.

Since it can be rolled out more easily to more parts of the network than traditional hardware-based solutions, our smart software-based DLR allows operators to squeeze more capacity out of their existing networks. Where, as is commonly the case, line rating increases permitted by DLR are closely aligned with local peaks in demand, this approach can allow operators to postpone or avoid capital expenditure programmes that can run into millions of pounds. And when upgrades are required, historical data from the DLR system allows operators to plan their investments based on real-world capacity values, not just conservative estimates.

How Capula can help

With more than 40 years of experience in the design, operation and support of industrial automation systems, Capula is the right partner to support your organisation on its Industry 4.0 journey.

For more information visit **www.capula.co.uk** or contact:

marketing@capula.co.uk

Head Office Orion House (HQ) Stone Business Park Stone Staffordshire ST15 0LT
+44 (0)1785 827000

Follow us on LinkedIn and Twitter

www.capula.co.uk