Grid-Enhancing Technologies

Dynamic Line Ratings: Enhancing Reliability in the Modern Grid

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Overview

As the grid rapidly evolves, the use of Dynamic Line Ratings (DLRs) equipment is being touted to expand the capability of the transmission system. DLRs hold potential to cost effectively and quickly expand the capability of the transmission grid using existing rights-of-way. However, deployment of DLRs is not straightforward, and a number of implementation issues must also be addressed to reap their full potential. Transmission capability may be limited by elements of the system, such as breakers, switches, and bus conductors, as well as by the line's conductor (i.e., wire in the air). In other cases, stability considerations may limit facility ratings. In instances like these, DLR deployment may **not** effectively increase transmission capability. In all cases, the communications channels used to enable DLRs must be cyber secure, and grid operators must have real-time awareness of DLR deployment on their systems as well as those of their neighboring systems to accurately model power flows across the grid. DLRs on tie lines must be appropriately coordinated among impacted Transmission Owners (TO), Transmission Operators (TOP), and Reliability Coordinators (RC).

Reliability Benefits and Critical Issues

The maximum amount of power that can safely flow on a line is limited by physical properties, like conductor heating and sagging limitations, and a variety of substation equipment ratings. DLR equipment and software calculate real-time transmission line capacity based on current weather conditions, such as ambient and conductor temperatures, wind speeds, and solar irradiation. Unlike static line ratings, which typically assume conservative seasonal worst-case conditions, application of DLRs result in real-time adjustments in line capacity by reflecting actual environmental conditions when determining the conductor loading. This allows for expanded transmission capability under certain conditions and can avoid or delay the need to develop new rights-of-way and transmission infrastructure by making more effective use of existing infrastructure and rights-of-way.

DLRs can provide real reliability benefits under appropriate circumstances, such as:

- **Increased Transmission Capacity:** The use of DLRs can increase the transmission capacity during favorable weather conditions.
- **Enhanced Grid Flexibility and Increased Situational Awareness:** DLRs enable higher levels of situational awareness for system operators, allowing them to manage the grid with more flexibility while maintaining reliable operations. This awareness could eliminate the need for unnecessary system operator actions to curtail generation schedules, or—when the environmental conditions are not favorable—result in lowering the line capacity.

- **Real-Time Data:** DLRs provide real-time situational awareness of on-line conditions, such as conductor closeness to sag limits, thereby reducing the risk of unexpected outages.
- However, with all the benefits DLRs could bring, there are several critical issues that need to be considered and addressed to implement them reliably:
- **Data Accuracy:** The ability to use DLR depends on the reliability, accuracy and precision of the sensors and weather data.
- **Communication Infrastructure:** DLRs require robust and secure communication systems to transmit real-time data to and between grid operators. DLRs can be used to provide system operators with real-time awareness of additional transmission capacity, which may only be needed a few hours out of every year. RCs and TOPs must be aware of the DLRs not only their own systems, but also of adjacent transmission systems and potential parallel flow impacts during events. Further, DLRs on tie lines must be appropriately coordinated among impacted TOs, TOPs, and RCs in real-time operations. Transmission of this data must also be performed within the context of the NERC CIP Reliability Standards. In addition, the sensors used to implement DLRs must be protected, both physically and electronically, based on the important role they provide for situational awareness to grid operators.
- **Integration with Existing Systems:** DLRs must be seamlessly integrated with existing grid management and control systems.
- **System Operating Limits (SOLs):** As capacity increases, resolving system criteria challenges and first contingency violations becomes critical to maintaining overall grid reliability. This is aligned with NERC Reliability Standard TOP-001-6, which requires Transmission Operators to mitigate SOL exceedances.
- **Terminal and Auxiliary Equipment:** TOs must consider terminal equipment ratings in addition to conductor rating, ground clearances, etc. when determining facility ratings. Some circuits cannot be physically loaded to their line conductor thermal limitations because of terminal equipment rating limitations (e.g., breaker, switch, bus conductor).
- **Stability Limitations:** TOs must consider stability limitations rather than just thermal limitations. Simply increasing a facility rating may not provide the desired benefits, and the implementation of DLR will not provide any reliability benefits.
- **Limitations for Operational Planning and Long-Term Planning Studies:** Transmission planners face difficulty in predicting DLRs in future timeframes with the accuracy needed to determine the expected line ratings for SOLs and planning time-horizon transfer capability due to high dependency on specific ambient conditions.

Conclusion

In comparison with constructing new circuits, DLRs can provide several benefits, including:

- **Cost-Effectiveness:** DLRs enhance the capacity of existing transmission lines without the significant costs associated with new construction.

- **Faster Implementation:** DLRs may be installed in less time than it would take to build new lines, providing more immediate benefits to grid capacity.
- **Reduced Environmental Impact:** The installation of DLRs minimizes the environmental impact compared to new transmission line construction that may require extensive land use and face regulatory hurdles.

DLRs can provide significant benefits—increased transmission capacity, enhanced grid flexibility, and real-time data to enhance grid management—to expand the capability of the transmission system rapidly and cost-effectively; however, their deployment is not straightforward and requires the mitigation of several critical reliability issues addressed above. Due to the identified reliability issues, these technologies should be pursued in tandem with other investments to boost reliability, resilience, and security, including the development of new corridors and transmission expansion.

Regulatory Activity

NERC and the Regional Entities filed joint comments on October 15, 2024, in support of FERC's consideration of potential security and reliability impacts of DLRs in its Advance Notice of Proposed Rulemaking. The ERO Enterprise appreciates the opportunity to comment on the proposed rule, which proposes requiring the use of DLRs to improve the accuracy of transmission line ratings and system transfer capability.