

Key Smart Grid Objectives Made Possible with Dynamic Line Ratings

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Our approach to power generation and transmission has changed significantly since the advent of the first power plant and the first generation station. Since the Energy Independence and Security Act of 2007, the growing emphasis on the need for Smart Grid technology has truly revolutionized the industry. Recognized as key to national security and energy independence, system reliability and the need for more efficient means of transmission have become paramount.

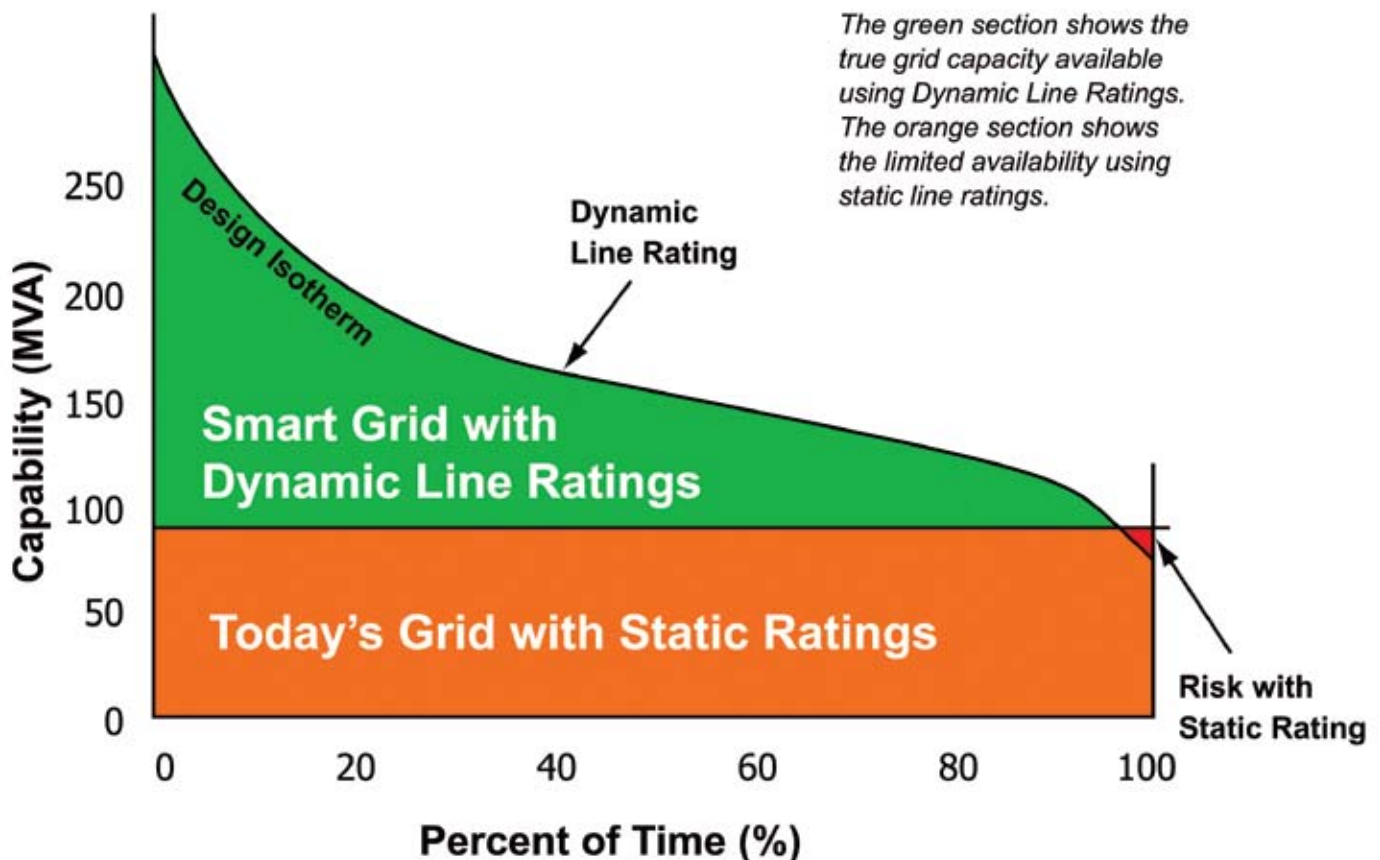
Dynamic line ratings (DLR) have been widely shown to increase the capability of existing transmission lines by 10 to 30 percent while simultaneously increasing reliability by avoiding overheating, excessive line sag, clearance violations, and by reducing the number of times system operators must manually intervene to adjust the optimum secure dispatch.

The systems are also cost effective. A typical DLR system on a 30 km transmission line costs approximately

90 percent to 95 percent less than reconductoring the same line.

VALIDITY OF DYNAMIC LINE RATINGS

Transmission lines are designed to operate at a maximum conductor temperature that will not harm the conductor and will not cause the conductor to sag below its safe clearance to ground. Conductor temperature is the result of a thermodynamic balance between elements that add and remove heat from the conductor.



Ambient air temperature, radiation from the sun, and energy losses generated by current flowing in the conductor add heat, while natural radiation (still air) and convective cooling (wind) remove heat. Knowing the actual line temperature will allow the system operator to maximize performance while ensuring line safety. DLR can do just that.

When DLRs are not available, engineers have no knowledge of weather conditions on line temperature and must exercise good judgment by assuming the worst possible combination of no wind, full sun, and high ambient temperature. Under those assumptions, an engineer would set a static (fixed) rating to be certain that the conductor will never overheat under any conceivable load and weather conditions.

Since those worst conditions rarely occur, a moderate effective wind speed of approximately 2 ft/sec is assumed. Even at this less conservative assumption, a perfectly good transmission conductor is left significantly underutilized nearly all of the time. Figure 1 shows the capability with static rating (in orange) versus the actual line capacity (in green). DLR methods safely capture the underutilized design capacity of the transmission line. Additionally, they protect the transmission line from overheating (red area in the graph above) when the assumed wind speed is not present.

A robust DLR system monitors the actual response of the transmission line to changing weather conditions continuously along the line, not at specific spots or locations. They are deterministic and completely safe. System operators are given advance warning when the load and the transmission line's true rating are converging, and appropriate actions can be taken. Should curtailments be unavoidable, they are likely to be much less severe when using DLR rather than static ratings.

TRANSLATING DLRs INTO SMART GRID OPERATIONS

The primary objective of DLR is to fully employ the true transfer capability of a transmission line with deterministic safety. Or, as described by CIGRE (International Council on Large Electric Systems), "The main purpose of real-time line monitoring is to assist system operators in better utilization of the load current capacity of overhead lines, ensuring that the regulatory clearances above ground are always met."

One of the six recognized characteristics of Smart Grid is that it optimizes asset utilization and operating efficiency.

The U.S. Department of Energy has designated DLR technology as one of eight Smart Grid T&D Infrastructure Metrics in the *Smart Grid System Report*. DLRs are identified as a way to "improve the ability to respond resiliently and adapt to system events." The report encourages an "increase in the penetration" of DLRs as a way to know the "status of the deployment" of a Smart Grid.

The report continues, "The deployment of dynamic line rating technology is also expected to increase asset utilization and operating efficiency." One of the six recognized characteristics of Smart Grid is that it does just this. Specifically, "A Smart Grid applies the latest technologies to optimize the use of its assets. For example, optimized capacity can be attainable with dynamic [line] ratings, which allow assets to be used at greater loads by continuously sensing and rating their capacities."

Transmission lines are traditionally limited to a fixed (static) rating that will permit safe operation under

the worst possible conditions. Since the worst possible conditions rarely occur, a large part of the transmission line's true capacity has been unused. DLR systems make it possible to use all of the line's capacity while still maintaining a complete level of safety. The added capacity can be used to maximize transfer capability, mitigate constraints, manage contingency events, avoid unnecessary service curtailments, permit outages for new line construction, and enhance system reliability.

DLR systems:

- are fully automated and integrated into the EMS/SCADA (management system/supervisory control and data acquisition) system; ratings are delivered to system operators on their existing consoles in the format specified by the operator
- are structured to fold into and to enhance present operating practices; in its simplest form, a DLR looks like and is treated as a significantly higher fixed static rating
- provide the system operator with tools to manage contingency events both before and after the event; real-time short-term emergency ratings are available before the event, and the amount of time available for response after the event are delivered to the operator ☺

Ron Stelmak holds a BSEE and an MBA. His experience spans thermal rating, SCADA, communications systems, and overhead line construction.