Metric #16: Dynamic Line Ratings

M.16.1.0 Introduction and Background

Dynamic line ratings, also referred to as real-time transmission-line ratings, are a well- proven tool for enhancing the capability and reliability of our electrical transmission system. Modern dynamic line rating systems can be installed at a fraction of the cost of other traditional transmission-line enhancement approaches.

One of the primary limiting factors for transmission lines is temperature. When a transmission line current increases, the conductor heats, begins to stretch, and causes the power line to sag. Allowable distances between power lines and other obstacles are specified by the National Electric Safety Code (NESC).

The amount of sag in a span of transmission line primarily depends on the conductor's material characteristics and construction. While line sag can be calculated with reasonable engineering accuracy, the amount of sag an older line will exhibit is less predictable. Transmission-line owners typically use survey techniques to verify the sag condition of their lines.

A standard practice is to apply a fixed rating, which usually is established using a set of conservative assumptions (i.e., high ambient temperature, high solar radiation, and low wind speed), to a transmission line. In contrast, dynamic line ratings utilize actual weather and loading conditions instead of fixed, conservative assumptions. By feeding real-time data into a dynamic line rating system, the normal, emergency, and transient ratings of a line can be continuously updated, resulting in a less-conservative, higher-capacity rating of the line about 95-99% of the time.[1] In a particularly interesting twist, transmission of wind energy might become enhanced by dynamic line ratings given the cooling effect of wind.[2]

Seppa[3] listed three approaches that were being applied to dynamic line ratings in 1997: tension monitoring, surface-temperature monitoring, and weather-based ratings. More recent field trials also reveal some success with more direct approaches to the measurement of line sag. Seppa stated the opportunity we faced in 1999 and still face now for the application of dynamic line ratings: "Thus, we could expect to generate approximately a 10% increase in the real transmission capabilities—the equivalent of 10,000 GW-miles of construction—by equipping less than 10% of transmission lines with real time thermal ratings systems."[4]

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[1]Seppa TO. 1999. *Improving Asset Utilization of Transmission Lines by Real Time Rating*. Presented at the T&D Committee Meeting, IEEE SPM-1999. Accessed October 15, 2008 at http://www.cat-1.com/files/papers/IEEE/ImprovingAssetUtilitization.pdf

[2]Oreschnick P. 2007. "Dynamic Rating Allows More Wind Generation." *Transmission & Distribution World*, November 1, 2007. Accessed October 14, 2008 at http://tdworld.com/substations/power_dynamic_rating_allows/

[3]Seppa TO. 1997. *Real Time Rating Systems*. Presented at the EPRI Workshop on Real Time Monitoring and Rating of Transmission and Substation Circuits: A Technology Increasing Grid Asset Utilization, San Diego, CA, February 26-28, 1997.

[4]Seppa 1999.

M.16.2.0 Description of the Metric and Measurable Elements

(Metric 16.a) Number of transmission lines in the U.S. to which dynamic line ratings are applied

(Metric 16.b) Percentage miles of transmission circuits operated under dynamic line ratings (miles)

(Metric 16.c) Yearly average U.S. transmission transfer capacity expansion due to the use of dynamic, rather than fixed, transmission line rating (MW-mile)

M.16.3.0 Deployment Trends and Projections

The strain on our transmission system is showing, particularly as market participants and regulators are placing new requirements on the infrastructure for which it was not originally designed, such as facilitating competitive regional markets. According to DOE, 70% of transmission lines are over 25 years old.[5]

Trends concerning the status of our nation's transmission infrastructure are perhaps best pointed out by Hirst[6] and paraphrased here: The U.S. transmission grid continues to grow; however, since 1982, the long-term growth of transmission transfer capacity has not kept up with the growth of peak demand. We approach the completion of a 30-year trend that is clearly shown by the numbers in Table M.16.1.

Table M.16.1. Comparison of Growth in Transmission Capacity and Summer Peak Demand for Three Decades[7]

	Percentage Change per Year		
	1982–1992	1992–2002	2002–2012
Transmission (miles)	1.66	0.63	0.73
Transmission (GW-miles)	1.94	0.55	0.63
Summer peak (GW)	2.82	2.68	1.87
MW-miles/MW demand	-0.85	-2.07	-1.12
Miles/GW demand	-1.12	-2.00	-1.12

Clearly, technologies like dynamic line ratings must be adopted unless we choose to reverse this long-term trend. Dynamic line ratings will provide an additional 10-15% transmission capacity 95% of the time and fully 20-25% more transmission capacity 85% of the time.[8]

Attempts to locate secondary sources with tabulations of the suggested measurements were unsuccessful. The number of locations where dynamic line rating is practiced appears to be small, monitoring only a fraction of the nation's transmission lines. According to interviews conducted for this

[5]Anderson KL, D Furey, and K Omar. 2006. "Frayed Wires: U.S. Transmission System Shows It's Age." *Fitch Ratings*, October 25, 2006:1-15.
[6]Hirst E. 2004. *U.S. Transmission Capacity: Present Status and Future Prospects*. Prepared for Edison Electric Institute and Office of Electrical Transmission and Distribution, U.S. Department of Energy, Washington, D.C. Accessed October 14, 2008 at http://www.eei.org/industry_issues/energy_infrastructure/transmission/USTransCapacity10-18-04.pdf
[7]Hirst 2004.
[8]Seppa 1997.

report (see Annex B), on average, only 0.5% of respondents' conductors were dynamically rated, and that number dropped to 0.3% when weighted by the number of customers served by each respondent.

The following is a sampling of products identified as being available, or nearly available, for installation in the nation's transmission system:

- The Valley Group, Inc., CAT-1 system and related products—A cable-tension type system launched in 1992 and tested at locations including SDG&E.[9] The company[10] has installed 300 of these systems, including systems at about 20 of the United States' largest utilities.
- Shaw Power Technologies, Inc., ThermalRate™ system—a weather-based system announced to be available in 2004 and soon to be applied by SaskPower.[11]
- EPRI Quasi-Dynamic Rating approach—a weather-based approach.[12]

M.16.3.1 Stakeholder Influences

There are numerous stakeholders that can be impacted by the successful deployment of dynamic line rating technologies, but the three primary stakeholders include:

- Products and services suppliers including IT and communications—producers of generation, control, and communications equipment that enable dynamic line rating systems are significant stakeholders.
- Transmission providers—depending on the size and location, the insertion of dynamic line rating technologies into existing power transmission assets could enhance asset capacity and defer expensive new infrastructure investments (i.e., new transmission lines).
- End users (customers)—successful deployment of dynamic line rating technologies will result in a power grid that has higher capacity and is more reliable. In addition, electricity customers' costs can remain low through the avoidance of costs associated with installing new transmission lines.

M.16.3.2 Regional Influences

IOUs and transmission-only companies (TRANSCOs) have taken the lead in making investments in expanding the capacity of existing infrastructure and attempting to site and construct new infrastructure.[13] The actions of state and local regulators will continue to have a profound influence on investment decisions in the transmission infrastructure.

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[9]Torre W. 1999. *Dynamic Circuit Thermal Line Rating.* Report P600-00-36. San Diego Gas and Electric, San Diego, California. Accessed October 15, 2008 at http://www.energy.ca.gov/reports/2002-01-10_600-00-036.PDF

[10]TVG—The Valley Group, Inc. 2008. *Products: CAT-1 Transmission Line Monitoring System*. The Valley Group, Ridgefield, Connecticut. Accessed October 14, 2008 at http://www.cat-1.com/.

[11]Thompson N and D Lawry. 2008. "Getting Equipped: SaskPower Uses Dynamic Rating to Increase Line Capacity." *Utility Automation & Engineering T&D*, June 2008. Accessed October 14, 2008 at http://uaelp.pennnet.com/display_article/331131/22/ARTCL/none/none/1/Getting-Equipped:-SaskPower-Uses-Dynamic-Rating-to-Increase-Line-Capacity/

[12]EPRI - Electric Power Research Institute. 2006. *Maximize Overhead Line Ratings through Quasi-Dynamic Rating.* Palo Alto, California. Accessed October 2008 at http://mydocs.epri.com/docs/public/000000000001012135.pdf.

[13]Anderson et al. 2006.

No region is immune to the persistent trend in which transmission growth has been outpaced by demand growth (See Hirst[14] for details about this trend in each U.S. region). One can observe, however, that the WECC and MAPPs region maintain their transfer-capacity-to-peak demand ratios up to 4 times higher than others. This pattern is, we suggest, a result of longer transmission distances and more separated population centers in these regions compared to other U.S. locations.

M.16.4.0 Challenges

Unfortunately, there are several identified barriers that may prevent or significantly reduce the growth in the expanded capacity of existing transmission lines in the United States. Public policy (especially at the Federal level) has found it difficult to provide proper incentives to stakeholders to make the necessary investments to enhance transmission system capacity. As is similar in other industries, regulatory barriers and their economic impacts are more significant in challenging deployment than the technical challenges.

M.16.4.1 Technical Challenges

The goal of dynamic line rating is to enable higher capacity utilization of existing transmission lines. Unfortunately, other limiting factors such as voltage instability and transient stability can also significantly affect transmission-line transfer capacity more than the thermal limitations being monitored by dynamic line ratings.

Besides the equipment associated with measurements for calculating dynamic line ratings, the measurement information must be communicated to system control centers. The SCADA, state estimation, and analysis applications run in the control center must have the features that take dynamic line rating information and continually refresh the alert and alarm mechanisms within the applications so that the operator is notified of potential violations and harmful situations. Typical control center applications deal with seasonal changes in line ratings, but must be augmented to accept dynamic line rating measurements.

M.16.4.2 Business and Financial Challenges

Because the grid traverses multiple regions, industries, and functions, it is challenging to obtain the necessary information on the state of the grid and to know who is responsible for coordinating and sharing responsibility for making enhancements. This leads to challenges to create incentives to invest in additional capacity.

M.16.5.0 Metric Recommendations

Inadequate data were available to quantitatively assess the suggested measurements in this metric. A small number of sites exist where dynamic line rating is practiced, and that number is growing. However, a more comprehensive interview approach with representative service providers will be needed to quantitatively identify, track, and measure the advantages achieved at those sites.

[14] Hirst 2004.