Counterflow

By Steve Huntoon

Waste Not, Want Not

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Last month, FERC had a technical conference on one of the most effective and economic measures that could be taken to fight climate change (AD19-15).[1] It's akin to other no-brainers like LED lighting, energy efficiency standards, rational forest management, less red meat, keeping economic nuclear plants (here and abroad) and a carbon tax (aka "carbon dividends").

This particular measure is dynamic/ambient transmission line ratings. It surfaces every 10 years or so and, sadly, nothing much gets done.[2]

No, it's not glamorous like giant offshore wind turbines, huge batteries and cross-country HVDC transmission lines, and maybe that's the problem. Fingers crossed that this conference will be a breakthrough.

Here's the thing in a nutshell: In most of the country, transmission circuits are given a static (fixed) maximum capacity rating based on worst-case assumptions about temperature and wind speed. Of course, *virtually none of the time are worst-case assumptions reflective of actual temperature and wind speed.*

It's like having a national speed limit of 25 mph because it snows occasionally. Yes, it's that simple.

Studies and actual experience show that dynamic/ambient ratings are 30% or more than static ratings.[3] The value proposition is illustrated in the chart below from a U.S. Department of Energy study.[4] Our grid has an enormous amount of capacity that is wasted because it is not measured.

This causes needless congestion, curtailment and artificially low revenue for some generators. And the anticipation of future congestion, curtailment and artificially low revenue discourages new renewable energy development.

So why is this no-brainer still stuck in neutral? Well, the entities that control ratings, the transmission owners, don't benefit from change, and may have perverse incentives to deter new generation entry competing with their units, and/or expand their own transmission facilities instead of efficiently using them.

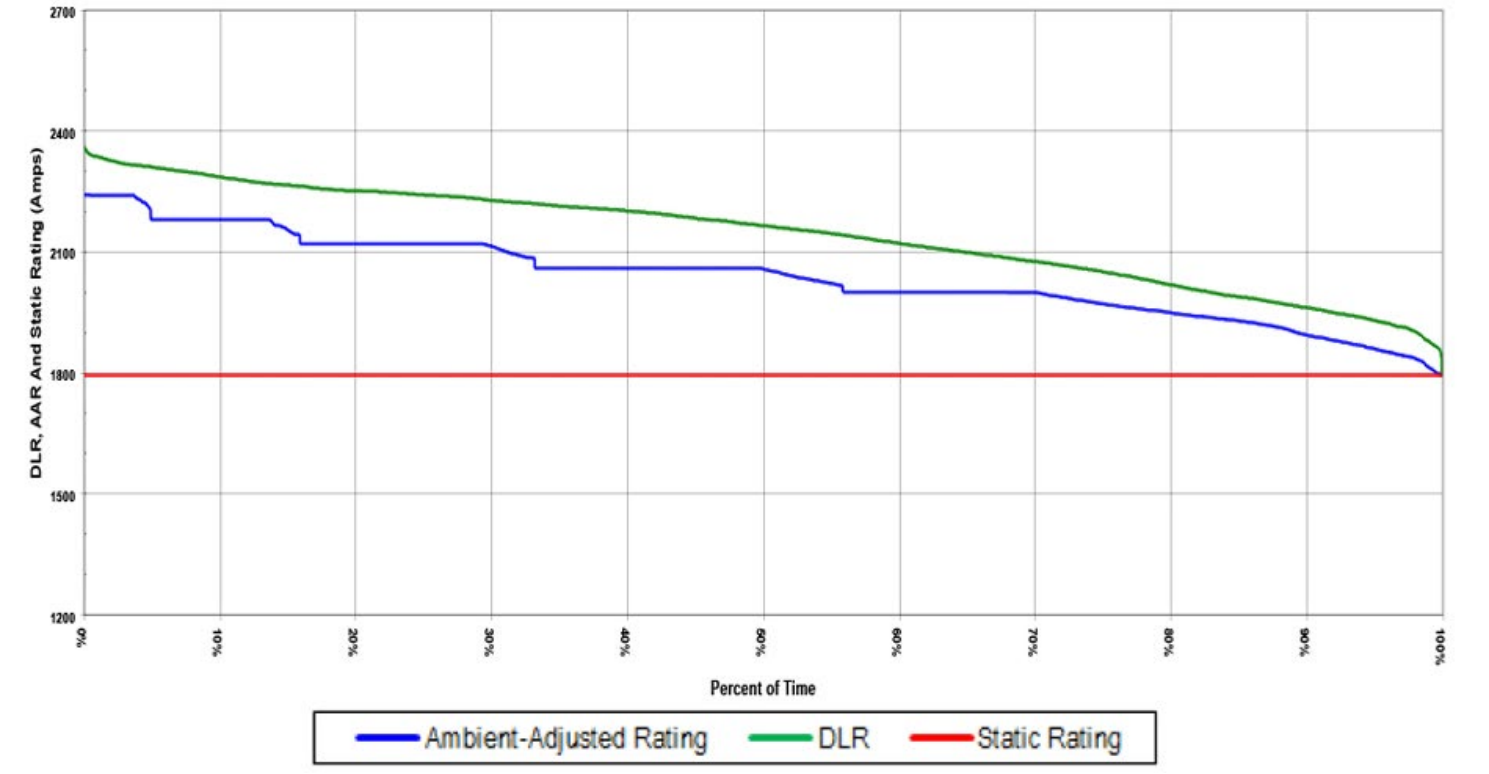
At the technical conference, some TOs posited various objections to dynamic/ambient ratings, none of which are valid. Let's check them out.

TOs: Circuit Ratings Can be Limited by Substation Equipment, not the Line (Conductor)

It is true that a circuit's rating is based on the rating of the most limiting element, and for a given circuit, that element may be a piece of substation equipment rather than the transmission line (conductor) between two substations.

This is not the typical situation, and even when it happens, it does not follow that that's the end of the story. Substation facilities also have (or should have) ratings that vary by temperature (and sometimes wind as well). These include transformers, with dynamic ratings based on fluid-temperature monitoring that has been available for 20 years[5] and voltage (reactive) devices. In PJM, there are many temperature-adjusted ratings for transformers and voltage devices.[6]

Transformers and voltage devices that have (or should have) weather-variable ratings are the



NRT-based ambient-adjusted rating and static rating probability distribution (Temple Pecan Creek-Temple Switch, September 2011) | *Oncor*

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most expensive substation facilities. There are other types of substation equipment that may or may not also be susceptible to weather-variable ratings, but more important, these types of equipment (breakers, wavetraps, etc.) are relatively cheap to upgrade.

The substation equipment objection lacks merit.

TOs: Transmission Limits Can be Voltage-based Rather than Thermal-based

Another truism that is immaterial. As noted above, voltage devices have (or should have) dynamic/ambient ratings. And where they don't, the cost of adding new voltage devices may be small. System operators should get the information they need to make rational decisions about this.

TOs: Ambient Conditions Can Differ Along a Given Transmission Line

Another truism that is immaterial. Sure, ambient conditions might be materially different where a given transmission line goes say, into a valley, than say where it goes over a hill. In those circumstances, the transmission operator/owner can install more than one set of weather (or other) sensors on that line, and base the dynamic/ambient rating on the lowest of the resultant ratings. Not rocket science.

TOs: This is Really Complicated, Needs more Study, etc.

This kind of objection to technology that's been around for decades comes from entities like the MISO TOs that somehow manage to do things like … hmm … operate 10 nuclear plants.

Ambient ratings, at least for temperature, have been used in PJM for decades.[7] One example of thousands of these ambient rating sets is below (Degf is temperature Fahrenheit; Norm is normal rating; Long and Shrt are emergency ratings; and Dump is load-dump rating; values are MVA).

And PJM now has the capability to use dynamic ratings as well.[8]

Same with CAISO: "Now with the new EMS that we have, we have the capability of implementing any type of an AAR or DLR, you name it" (Tr. 149).

Same with NYISO, which has the "capability to accept DLRs" and use them in its EMS.[9]

Same with MISO, which testified that it has the capability to handle rating changes in real time (Tr. 239-240).[10]

Basically, most of the RTOs have the capability now to use dynamic and/or ambient ratings.

It's the TOs that need to step up.

TOs: NERC Standards Take Care of This

In a "nothing to see here" gambit, various TOs claimed that NERC Reliability Standard FAC-008 somehow takes care of all this. In fact, this standard basically says that a TO has to have a ratings methodology and has to comply with whatever that methodology says. Nothing in it says the methodology has to be reasonable, satisfy any other criterion or is subject to review by an objective entity.

Take FAC-008's requirement that a TO's ratings methodology explain how "ambient conditions" are considered. It appears that for MISO TOs (other than Entergy) and for countless TOs elsewhere, the explicit or implicit answer is "considered and tossed." And, tragically, this seems to satisfy FAC-008.

Having gone through the TO objections, let me touch on a couple key points.

Substn: ORCHARD kV: 500 KV Dev: ORC-SAL End: END B
Descr: ORCHARD-SALEM 5021

	Day				Night			
Degf	Norm	Long	Shrt	Dump	Norm	Long	Shrt	Dump
95	2654	3016	3016	3469	2654	3016	3016	3469
86	2709	3065	3065	3524	2709	3065	3065	3524
77	2762	3112	3112	3579	2762	3112	3112	3579
68	2815	3159	3159	3633	2815	3159	3159	3633
59	2867	3205	3205	3686	2867	3205	3205	3686
50	2917	3250	3250	3738	2917	3250	3250	3738
41	2967	3295	3295	3790	2967	3295	3295	3790
32	3016	3339	3339	3840	3016	3339	3339	3840

| PJM

The Importance of Wind

With apologies for getting into the weeds, it is critical that wind speed and direction be included along with temperature. Wind dramatically increases ratings, and typically is more significant than temperature as numerous witnesses testified at the conference.[11]

Wind dramatically affects ratings almost all the time. PJM has 26 years of data showing this.[12] These data show that when temperature is the highest, the prevailing wind increases the rating *98% of the time*. Amazing.

This also responds to a question at the conference about whether dynamic/ambient ratings might sometimes be less than the static rating (Tr. 104). The answer is that if wind speed is considered, this will almost never occur. And in the incredibly rare hour or two that it does occur, then that slightly lower rating could be used.[13]

The Importance of Emergency Ratings

This isn't really about dynamic/ambient ratings but something that may be even more consequential.

Emergency ratings are short-term ratings that apply to contingencies (i.e., N-1 events) because the nature of contingencies is the loss of a given circuit, causing increasing loading on adjacent circuits, and redispatch within an hour or so to get all circuits back within normal ratings.

PJM for example has had ratings for normal (continuous), emergency and load dump conditions for decades (and as noted earlier also differentiates ratings by temperature).

OK so here's the news. At the conference it surfaced that there are some TOs, including a lot of the MISO TOs, that use normal ratings as their emergency ratings as well.[14] This is a tragedy.

In operations (dispatch), that means artificial congestion with too low prices and curtailments for some generators, and dispatch of higher-cost generators causing too high prices to load.

In planning, it means unnecessary transmission upgrades to alleviate fantasy overloads, and excessive interconnection costs and delays for new entrants like wind and solar projects.

FERC should put a stop to that as soon as possible regardless of what actions it takes on dynamic/ambient ratings. One way would be to investigate the cost of transmission upgrades that have been based on an N-1 "overload"

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of a normal rating that is wrongly doubling as an emergency rating. It could also open an investigation into the withholding of available transmission capacity.

Renewable energy developers (and consumers) should not stand for this.

Transition

We know Rome wasn't built in a day. So we'll need some sort of transition.

There are two ways of looking at it. What can we do right away? And how do we prioritize the rest?

There's no apparent reason why TOs across the country can't do what all the PJM TOs do now, as illustrated above, provide ambient temperature-differentiated normal, emergency and load dump ratings. This is the lowest hanging fruit and can be done on a "desk" basis. No new equipment needed.

From there, priority for installation of dynamic rating capability should focus on the most heavily congested circuits. But if a TO can justify another approach, so be it.

But let's get going on making the most of the grid we have. ■

[1] References here are to presentations and transcript (Tr.) from the conference. See also FERC Considering Tx Line Rating Rules.

[2] For example, the first CAT-1 Transmission Line Monitoring System was installed in Virginia in 1991. http://sgemfinalreport.fi/files/D5.1.55%20-%20Dynamic%20line%20rating.pdf (page 20).

[3] Thirty percent was the low end of the ranges in the U.S. Department of Energy's report on the New York Power Authority and Oncor projects. https://www.smartgrid.gov/files/SGDP_Transmission_DLR_Topical_Report_04-25-14_FINAL.pdf (page vi). These results were consistent with testimony at the conference, such as the Ampacimon presentation and at Tr. 34.

[4] https://www.smartgrid.gov/files/SGDP_Transmission_DLR_Topical_Report_04-25-14_FINAL.pdf, pdf page 103.

[5] See for example this paper, https://kth.diva-portal.org/smash/get/diva2:1155097/FULLTEXT01.pdf. The Exelon representative erroneously said that transformer ratings are not affected by temperature (Tr. 320).

[6] https://edart.pjm.com/reports/PJM_Line_ratings.txt (word search for "xformer" and "ser dev").

[7] https://edart.pjm.com/reports/PJM_Line_ratings.txt.

[8] PJM presentation, page 1.

[9] NYISO presentation, page 2.

[10] And Entergy, a MISO TO, uses ambient temperature ratings and communicates them to the RTO (Tr. 154-158).

[11] Tr 33-34, 38, 52, Lindsey Manufacturing presentation (slide 7).

[12] https://pjm.com/~/media/planning/design-engineering/maac-standards/bare-overhead-transmission-conductor-ratings.ashx (Appendix 1). Looking at the row for the highest temperature of 35 degrees Celsius (95 F), the frequency of 0 to 2 knots (0 to 1 m/s) is 0.104, and the frequency of 3 knots and more is 5.427. This means that when temperature is the highest, wind will increase the rating 98% of the time (1 minus 0.104/5.427).

[13] Even if a slightly lower rating isn't used, it would be inconsequential. In the most common situation where the rating is based on the thermal capacity of the conductor (rather than a sag/clearance issue), the consequence of exceeding the limit is simply a reduction in useful life of the conductor, i.e., accelerated depreciation. And if it's for a short time, the reduction is trivial. And we need to keep in mind that transmission lines are being replaced when they reach their "end of life" for various reasons, which usually involve the structures (towers) and rarely involve the conductors themselves. So a trivial loss of life for the conductor is inconsequential.

[14] Tr. 311. By contrast, in PJM, the only TO that had identical normal and emergency ratings is American Electric Power, and then only for 345-kV and above circuits. Last year AEP changed to using different emergency ratings for all circuits.