UNITED STATES OF AMERICA

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

Managing Transmission Line Ratings	**)**	**AD19-15**

Post-Technical Conference Comments of the WATT Coalition

November 1, 2019

I. Introduction

Pursuant to the notice issued by the Commission on October 2, 2019 in the above-captioned docket, the WATT Coalition offers these post-technical conference comments. The WATT Coalition applauds the Commission for this inquiry into transmission line ratings. Setting line capacity more dynamically is one of a suite of technologies and operations methods that can increase the utilization and efficiency of the existing transmission network while also supporting system reliability.

The WATT Coalition is an ad hoc coalition of companies who support greater deployment and use of grid operating technologies such as Dynamic Line Ratings, Power Flow Control, and Topology Optimization. The WATT Coalition includes Ampacimon, a global leader in grid monitoring solutions that utilize patented sensors and software to increase the capacity of transmission and distribution assets; Lindsey Manufacturing Company which provides innovative and cost saving products including transmission line monitors and software for measuring and forecasting line capacity to the global electric utility industry; LineVision which provides utility solutions that serve to increase the capacity, flexibility, and reliability of existing transmission lines; NewGrid, a software firm that provides transmission topology optimization for the electric power industry; Smart Wires, which delivers grid optimization solutions around the world that work to create a more flexible and efficient transmission grid including power flow control technology; and WindSim which uses computational fluid dynamics to simulate terrain effects on wind conditions.

Grid Strategies LLC serves as the convener of the WATT Coalition.

II. Responses to Commission Questions in the October 2 Notice (*questions in bold italics*)

1. Discussion of a Possible Requirement for Transmission Owners to Implement AARs

a. Should transmission owners be required to implement AARs? If so, to which lines would the requirement apply? What criteria (e.g., congestion, facility age) and process would be used to determine to which lines the requirement would apply? What would be the benefits or drawbacks to such a requirement?

WATT does not believe that Transmission Owners (TOs) should be required to implement AAR or DLR everywhere. Instead, WATT recommends that for each line that is heavily congested, forecasted to be heavily congested, or is otherwise thermally limited, TOs should be required to:

- Disclose the nominal ratings for the different equipment of the line (e.g., conductor and each terminal equipment device);
- For lines that are conductor limited, perform a cost-benefit study of the deployment of DLR or other congestion mitigation technologies;
- For lines that are not conductor limited, perform a cost-benefit study of the upgrade of the terminal equipment or other congestion mitigation technologies.

In addition, separate from economic congestion considerations, the Commission should consider integrating DLR and associated real-time line data into existing reliability standards. Emergency Preparedness and Operations (EOP), Interconnection Reliability Operations and Coordination (IRO), Modeling, Data, and Analysis (MOD), Transmission Operations (TOP), and Voltage and Reactive (VAR) standards could all be informed by real-time line data.

WATT believes that to the extent the Commission decides to set a requirement on using specific ratings, those requirements should be for comprehensive weather-based ratings. AAR as being implemented today, based solely on prevailing ambient temperatures and with no monitoring of resulting line behavior, is less conservative than it may appear. While AARs may be an acceptable solution under non-contingency conditions, it poses risk under contingency operation. Conversely, DLR takes into account all weather parameters, measures and monitors line behavior, and actually reduces risk during contingency conditions.

WATT recognizes the familiarity, assumed simplicity of implementation, and perceived low cost of AAR. However, AARs are generally not conservative, and DLRs are much more accurate, as explained below.

<u>AARs are not conservative</u>

Base (i.e., static/seasonal) transmission line ratings assume very conservative weather conditions, including both relatively low wind speed and a high ambient temperature.
In August 2006, a joint task force (JTF) between the IEEE and CIGRE produced a report titled, "GUIDE FOR SELECTION OF WEATHER PARAMETERS FOR BARE OVERHEAD CONDUCTOR

RATINGS." This was published by CIGRE as Technical Brochure 299[1] (TB299). Because of its publication as a CIGRE, and not an IEEE document, the awareness of this report is fairly low in the United States. This document discusses base, ambient adjusted, and real-time (i.e., DLR) rating methods. The following passages explain how AARs may over-state capacity:

Section 1.5.3.1 of TB299, the summary section pertaining to AAR, states: "Ratings can be adjusted based on varying ambient temperatures measured at the time. These are termed continually ambient-adjusted ratings. In this case, unless real time rating systems are used, the wind speed should be based on the assumption of a more conservative effective wind speed than Base ratings. The extensive literature review by the JTF clearly indicates that ambient temperature and wind speed are not independent parameters, higher wind speeds being associated with high ambient temperatures."

Section 4.5.1 of TB299 on Ambient-Adjusted Ratings states: "ambient temperature change affects conductor temperature in a one-to-one relationship, as long as all other variables remain well behaved. In reality, as discussed in section 4.3.4, solar radiation and wind speed are statistically dependent upon ambient temperature."

Section 4.5.3 states (underline added); "Certain utilities and transmission system operators adjust their line ratings either continually or in steps depending on the ambient temperature…Such adjustments can be considered justified if based on an adequately conservative wind speed, e.g. zero wind. Use of conservative wind speeds is necessary because of the previously discussed correlation between ambient temperature, solar radiation and wind speed."

It was clear from the discussions and presentations made by the various TOs during the Conference, that AAR as implemented today in the United States is done only by adjusting the ambient temperature. In contrast, the recommendations per the IEEE/CIGRE Joint Task Force indicate that these ratings should be tempered with lower wind speeds. This would suggest that temperature-only based AAR as implemented today is less conservative than base ratings. Under contingency conditions, this is of concern.

To explain how the use of AAR increases risk, see Table I (shown below) from TB299 which provides an example of how conductor temperatures vary with wind speed and the amount of current flowing in a line. The assumption in the table is a maximum operating conductor temperature of 100C. Exceeding that would result in a clearance violation and/or damage to the conductor.

Base line ratings are commonly developed using 0.6 m/sec (2 ft/sec) wind speed.

So, with a 0.6 m/s wind speed, the example line can carry 1047A (green circles).

[1] "TB 299 GUIDE FOR SELECTION OF WEATHER PARAMETERS FOR BARE OVERHEAD CONDUCTOR RATINGS," CIGRE, Working Group B2-12, August 2006.

Simply to use the numbers in the provided table, assume the ambient drops by 21C in the case of zero wind. Assuming the conductor temperature drops an equal amount (from 100C to 79C), this implies the line can now operate a higher current, which would result in heating the conductor back to the 100C operating limit.

However, per TB299, if one is doing ambient adjusted ratings, one should also drop the wind speed to a lower value, ranging from 0.4 m/sec to 0 m/sec. In this example the air temperature is assumed constant, but one can see the net effect of this change in wind speed is to drop the current capacity from 1047A to 861 to 801A (at 0.3m/sec and 0 m/sec respectively). See the red circle and arrows.

Assumed Wind speed m/s	Assumed Wind angle degrees	100°C max. temperature rating (A)	Temperature at wind speed = 0	Temperature at wind speed = 0.6
0		803	100 °C	79 °C
0.3	90	861	106 °C	98 °C
0.6	90	1047	127 °C	100 °C
0.6	45	977	119 °C	93 °C
0.6	20	874	107 °C	84 °C
0.9	90	1135	139 °C	109 °C
1.2	90	1203	148 °C	117 °C

This is an -17% to -23% difference in assumed power capacity simply from reducing wind speed as TB299 says should be done if ambient temperature is reduced.

Therefore, simply assuming a lower ambient will likely assume a greater current capacity than truly exists.

Under normal operating conditions, transmission lines are operated well below 80% of base rating. A 10 - 20% error in an adjusted rating will not be noticed under these conditions. However, under retail wheeling and contingency conditions lines are often needed to operate up to their limit. The error caused by adjusting line rating based only on ambient can be seen to increase the risk of clearance violations or conductor overheating and damage.

<u>Impacts of over-stating capacity</u>

Section 4.6 of the IEEE/CIGRE JTF is titled “Consequences of too optimistic rating assumptions.” The first two are:

- “The most common consequence of too optimistic rating assumptions is a clearance violation…” This safety concern is self-explanatory.
- “Annealing of aluminum or copper causes loss of conductor strength.” Should this occur to an excess degree, this necessitates the replacement of the line’s conductor, which would be an avoidable expense to consumers if the line had not overheated.

This was recognized by Mr. Kramer on Day 1 of the conference, when he stated, "From an operations standpoint, the answer is relatively clear in that the applied rating must ensure continued public safety and bulk electric system reliability[2]."

DLRs are more accurate than AARs

DLR avoids the uncertainty with AAR. In Panel Session 3 on AAR, Mr. Wander observed, "… we think with uncertainty in terms of resolution of the information without DLRs, you know, DLRs can solve a lot of that but we're talking AARs here. We expect them to use a transmission reserve margin or something equivalent to that in a safety margin on AARs[3]." Further, he stated, "…if you can't ambient adjust to the full extent…you have to apply significant transmission reserve margins, or whatever you want to call it…DLR's could solve that[4]."

Regarding real-time ratings (i.e., DLR) Section 4.5.4 of the IEEE/CIGRE JTF further states; "When lines are monitored in real time the operators have accurate information on the sags, clearances and conductor temperatures, as long as the monitoring equipment is accurate, reliable and applied in appropriate locations. Transmission owners and operators can then adjust their line rating criteria commensurate with the monitoring equipment capabilities to provide the operators advance warnings of impending rating violations. Thus, transmission planning may be based on probabilistic criteria as long as the monitors ensure deterministic operational reliability and safety."

During Panel Session 4 of the Conference, Mr. Morash properly stated, "…these are solved technical problems. We are not all experts in all of these. I am certainly not, yet. And we heard yesterday from a number of experts in certain areas of these, but IEEE 738[5] shows us how to rate a line…[6]". Further, Mr. Morash properly observed, "…stepping forward is better than standing still. Often with these new technologies, the promise of potential can stunt growth. The promise of potential allows us to consider multiple use cases and stack values and unlock all these possibilities. And quickly, dynamic line rating can become a tool for everyone in the decision-making world, whether that's the operational system optimizing its state estimator, human operations looking for improved situational awareness, or maybe its planners looking for asset health monitoring or attempting to utilize dynamic ratings for wind plant interconnection studies[7]." WATT wishes to point out that IEEE Std. 738 requires the use of temperature, wind, and many other weather variables to properly determine a line rating, variables used by DLR systems. Again, AAR only uses ambient temperature.

---

[2] FERC Technical Conference Day 1 Transcript, "20191008134412-091019ManagingTransmissionLine - Day 1 Transcript.pdf", p146, lines 23 – 25.
[3] ibid, p174, lines 13-18
[4] ibid p217, lines 11-14
[5] IEEE Standard 738, "IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors"
[6] FERC Technical Conference Day 2 Transcript, "20191008134514-Day 2 Transcript.pdf, p230, lines 4-8
[7] Ibid, p11, lines 14-24

During the conference, Mr. Kramer of Ameren Services Company stated, "There seems to be kind of an undercurrent here that we have reliability ratings and we have economic ratings, and that they are somehow disconnected or separate. FAC-008 says there is an accurate rating, and that's what we are striving to do[8]." WATT again posits that DLR, and not AAR, is "the" accurate rating.

NYISO stated that their Summer/Winter rating sets are based on weather study performed in the mid-1990's[9]. With the increased variability and severity of weather observed over the recent past, basing grid operations on a binary summer/winter rating set based on 20-year old data, clear advantages can be seen over AAR in the use of DLR which monitors actual conductor behavior and weather conditions.

b. If AARs are required, should they be required for modeling in both the day-ahead and real-time markets?

In order to maximize market efficiency and minimize congestion costs, consistent ratings should be required for modeling in both day-ahead and real time markets.

c. What type of forecasting (e.g., how frequently, how granularly, and of what variables) is needed to incorporate AARs and DLRs into both real-time and day-ahead markets? If forecasts submitted in day-ahead markets differ from the real-time rating, how should the difference be treated by the transmission system operator? Who is liable if forecasted ratings are wrong?

Requirements may vary by RTO/ISO and should be defined by each for the operation of their real-time and day-ahead markets. It would be expected that forecasted ratings would be requested with hourly increments for 24 hours to 7 days ahead of the operating hour. Forecasts should be able to be updated at any interval desired by the system operator to ensure compatibility with existing systems. The forecasted ratings provided by the transmission operator may reflect a confidence interval due to the inherent uncertainty of weather forecasts.

Discrepancies between day-ahead and real-time ratings are inevitable and similar to discrepancies between day-ahead and real-time demand forecasts or renewable generation forecasts and wholesale market participants should be well equipped to understand and model the uncertainties inherent in forecasted line ratings.

d. Aside from ambient air temperature, are there other ambient conditions that can be forecasted or calculated without need for local sensors that should be considered in AARs? Should maximum possible solar irradiance intensity (conservatively calculated or forecast assuming no cloud cover) be included in calculation of any required AARs? Are there any

[8] ibid, p 321, lines 14-18
[9] Ibid, p 274, lines 4-11

instances where wind can be conservatively forecast without local sensors, such that wind should be considered in AARs for such lines?

As detailed in the response to Question 1.a), AAR is a higher risk implementation of line rating increase than is DLR. Adding additional forecasted or calculated parameters to AAR does little to improve the methodology, and will more likely than not increase the risk. As pointed out in TB299, any method of AAR that does not DECREASE wind speed increases risk.

The best approach is to add local sensors. This is exactly what DLR does; it adds the local sensing needed to compute actual line ratings and then uses calculations based on IEEE Standard 738 to develop line ratings.

2. Reducing Barriers to DLRs

a. Can RTOs/ISOs currently accept and use a DLR data stream from a transmission owner in both real-time and day-ahead markets? Can transmission owners outside of RTO/ISOs currently automatically implement a DLR data stream in operations? Are there limits on what type and amount of data can be received and incorporated into dispatch? Would a transmission owner's or RTO/ISO's implementation of AARs be sufficient to also implement DLRs? If not, what additional changes would be necessary and how feasible are such changes?

The conference record indicates that ISO/RTOs and utility transmission operators vary in their ability to incorporate dynamic ratings at the present time. Nothing in the conference record indicates this is an unachievable goal. We encourage the Commission to ask operators whether or not they can, and to encourage operators to develop this capability.

b. Would a requirement for transmission owners or other entities (e.g., RTOs/ISOs) to study the cost effectiveness of DLRs on their most congested lines be appropriate? If so, what metrics for congestion (e.g., congestion cost, hours of congestion) would be appropriate for determining the most congested lines?

Yes, RTO/ISOs should study the benefits and effectiveness of DLR on their most congested lines, at least those which are thermally limited. As DLR deployments are fairly inexpensive,[10] a reasonable threshold would be where either historical annual congestion costs exceed $2 million per year, or where congestion is anticipated in any prospective planning or operations planning analysis.

3. AARs/DLRs in Available Transmission Capacity (ATC) Calculations

a. In the non-RTO/ISO regions, a transmission owner's use of AARs could affect ATC for transmission customers. ATC could also be affected at RTO/ISO seams. Given the importance of ATC calculations, should AARs/DLRs be incorporated into the determination of ATC?

Yes. DLRs would have similar impact at seams as on internal lines and with less risk.

[10] *Day 1* (n-1), p 52, line 2

Specifically:

i. At what times in advance of transmission reservation and/or scheduling deadlines should ATC made possible through AARs/DLRs be made available to point-to-point and network customers?

DLRs should be adjusted in each of the existing scheduling time frames. Probability levels can be incorporated, such that more capacity can be offered closer to real time.

ii. Should AARs/DLRs affect when network customers (and the transmission provider's own resources) are subjected to redispatch, load shedding, and/or curtailments under sections 30.5 and 33 of the pro forma open access transmission tariff (OATT)?

Yes. The OATT requirements can still apply with DLRs altering the capacity of transmission lines.

iii. Would any revisions be needed to section 30.5, section 33, or Attachment C of the pro forma OATT to accommodate a requirement to implement AARs or voluntary implementation of DLRs? Are there any other sections of the pro forma OATT that would be relevant to or affected by AAR/DLR implementation?

We are not aware of changes that are needed to the OATT. Line ratings are an input to transmission service and scheduling protocols.

4. Discussion of Transparency of Transmission Line Rating Methodologies. Currently, some transmission line rating methodology information is made available through certain transmission expansion processes or voluntarily on certain transmission owners' websites. Transmission line rating methodologies are also sometimes provided in annual FERC Form 715 part 4 filings. Lastly, some RTO/ISOs post actual facility ratings on their open access same-time information system (OASIS) pages. However, there appear to be concerns about the inaccessibility of transmission line rating methodologies and resulting ratings.

a. Should transmission owners' transmission line rating methodology be made more transparent? If so, how and how much additional transparency? Should underlying assumptions be made available? Should transmission line ratings be made more transparent? If so, how? For both transmission line rating methodologies and resulting ratings, who should have access to such information?

Yes. WATT recommends that for each line that is heavily congested or forecasted to be heavily congested, the TO would be required to disclose the nominal ratings for the different equipment of the line (e.g., conductor and each terminal equipment device), and publicly post its line rating methodology.

b. Should transmission owners or other entities (e.g., NERC regional entities or RTOs/ISOs) be required to develop a database to document each transmission facility's most limiting element? Should limiting elements consider first and second contingency operating conditions? Please describe the burden associated with reporting and maintaining such a

database. Who should have access to such a database and what levels of confidentiality protections would need to exist for such a limiting elements database?

Yes. The requirement should apply at the very least for each line that is heavily congested or forecasted to be heavily congested. CEII protections are appropriate and should resolve any security concerns in this context as they do in others.

c. If a transmission system operator contacts a transmission owner to request an ad hoc increase in transmission line ratings above static or seasonal ratings, should information about the request be publicly posted? If so, where, when, and how often should such information be posted?

If DLR is used to develop line ratings, there should be no need for an ad hoc increase as this will be the line's correct (thermal and clearance limited) rating.

5. Review and Audit Procedures for Transmission Line Rating Practices

a. Are the current review and audit procedures for transmission line ratings sufficient to ensure that such transmission line ratings are consistent with the methodology set forth by the transmission owner under FAC-008?

FAC-008 is only for reliability, not just and reasonable and not unduly discriminatory service. Therefore, further review and audit by the Commission, RTO/ISOs, and market monitors should be performed to ensure compliance with open access requirements.

b. What entities currently review or audit transmission line rating methodologies, assumptions, and values? What standards or criteria do these entities use in their reviews?

Regional Reliability Councils review line rating methodologies in some cases as reported at the technical conference. This oversight is inconsistent and should be improved.

c. What changes, if any, should be made to the review and audit procedures for transmission line ratings?

FERC should occasionally audit for just and reasonableness and to ensure open access requirements are being followed to ensure non-discriminatory service.

d. What, if any, changes to information and document retention with respect to transmission line ratings might be needed?

OASIS posting may be an option.

e. Where should any non-reliability criteria (e.g., economic) for transmission line ratings be established (e.g., regulations, tariff, policy statement)? What should these criteria be, and how would the Commission ensure that such criteria for transmission line ratings are consistent with reliability criteria?

FERC regulations should state that line ratings should be dynamic on thermally congested lines, and methodologies should be transparent. FERC can and should ensure that non-reliability and reliability criteria are consistent and compatible.

f. In implementing DLR, is there any data verification necessary from devices that measure DLR by the transmission system operators or transmission owners? If so, what data and why?

All DLR implementations should include one or more spare or redundant sensors (devices) to ensure enough data is collected in case a sensor stops reporting for any reason. Additionally, the DLR system should provide reasonableness checking of all collected data and deal appropriately with any data that appears to be inconsistent.

6. NERC Reliability Standards

a. Are there security concerns associated with implementing AARs and DLRs with respect to communicating line ratings and field measurements?

Current NERC CIP V5/6 Standards should address any security concerns involved with communicating line ratings and field measurements.

II. Responses to Commission Questions in the September 10-11 conference agenda (*questions in bold italics*)

Are there any anticipated benefits, challenges, or costs related to incorporating AARs into RTO/ISOs' energy management systems (EMS) (or other systems) that should be considered when evaluating this proposed requirement?

Any challenges to incorporate AAR into energy management systems will be the same for incorporating DLR. The greater situational awareness, confidence in actual line capacity, and increased forecasting capacity of DLR provides substantial additional benefits over AAR. The only true advantage of AAR over DLR is the lack of investment needed in line sensors. However, it is these line sensors that enable the benefits of DLR. WATT encourages the establishment of appropriate cost/benefit sharing for such investments to avoid the inherent disincentive that makes lower cost, and lower benefit, AAR, appealing.

What, if any, updates would need to be made to RTO/ISO and/or transmission owner software and communications to accommodate their accepting and using an AAR data stream? Can RTOs/ISOs currently accept and use a DLR data stream from a transmission owner? What needs to be modified to address any barriers to RTOs/ISOs accepting and using DLR data streams?

Every RTO/ISO differs in its ability to accept and use a data stream based on EMS vendor, application capabilities, and current software version. Some EMS software is fully capable (as is PJM's Siemens EMS implementation and SPP's GE EMS implementation, per WATT's understanding) and some may not be. Similarly, some TOs do not have the latest software version installed that supports this functionality even if the EMS itself has the capability.

Additionally, RTO/ISO operation manuals define what will be accepted and this is determined by the individual RTO/ISO. Therefore procedural changes may be required but this is separate from the capability of the software.

How does the implementation of AARs by an RTO/ISO differ from implementation of DLRs? If an RTO/ISO implements the use of AARs in its software and communications capabilities and

standards (data formats, internet protocols, cyber security requirements, etc.), what else must it do to implement DLRs?

There should be no difference between accepting AAR and DLR ratings at the RTO level. The RTO/ISO does not require the criteria justifying the rating transmitted by the TO.

What responsibilities, if any, should the RTOs/ISOs have with regard to any verification of values provided by the transmission owners? How should any disputes regarding disagreements of values between the transmission owner and RTO/ISO be resolved?

Presently, the RTO/ISO does not require the criteria justifying the rating transmitted by the TO. WATT sees no reason

If DLRs or AARs were adopted, what if any additional coordination might be necessary? For instance, coordination across RTO/ISO seams, across transmission owner seams, or within or between reliability coordinators.

If DLR or AAR are used on monitored elements of constraints across RTO/ISO seams, across TO seams or within or between RC entities, the ratings should be used consistently by all parties that monitored such constraint.

Are there examples of best practices for documenting line rating methodologies, either in tariffs or other documents, which might serve as models for how to make such methodologies transparent?

The IEEE/CIGRE Joint Task Force report TB 299, issued by CIGRE, details best practices for line rating methodologies.

Additionally, some RTO/ISOs have prescribed to their TOs those variables to be considered. For example, PJM prescribes the use of conductor emissivity and solar absorption coefficients.

Should methodologies, assumptions, and/or line ratings for specific transmission lines be available for review and challenge by market participants, and/or for audit by the Commission? What, if any, changes to information and document retention with respect to line ratings might be needed?

See WATT answers to Question 5.

Respectfully submitted,

Rob Gramlich

Grid Strategies LLC

On behalf of the WATT Coalition: Ampacimon, Lindsey Manufacturing, LineVision, NewGrid, Smart Wires, and WindSim

rgramlich@gridstrategiesllc.com

202-821-6943