COLUMN



Transformer Loading Capability vs Transformer Rating: Resolving a 100-year-old dilemma

Part II

Oleg Roizman



ABSTRACT

Building on the historical analysis in Part One, this article examines how rating methodologies have developed into formal requirements for power-system planning and operation. It considers the approaches established by NERC and FERC and what they may offer for transformer thermal ratings. From this foundation, it develops clearer definitions of Transformer Thermal Rating and Dynamic Transformer Thermal Rating and separates them from transformer loading capability. It also explores why this distinction matters for technology deployment, standardisation and research.

KEYWORDS:

transformer rating, loading capability, dynamic rating, terminology

FAC-008 addresses a practical reliability risk: facility ratings may be unavailable, inconsistent, unsupported by sound engineering or applied differently by the entities that rely on them

7. NERC FAC-008: Rating methodology becomes mandatory

The next development was more consequential. In North America, NERC FAC-008 [28] made the determination, documentation and communication of facility ratings a formal reliability obligation for the Bulk Electric System. Transmission Owners must maintain a documented Facility Ratings Methodology.

FAC-008 addresses a practical reliability risk: facility ratings may be unavailable, inconsistent, unsupported by sound engineering or applied differently by the entities that rely on them. Facility ratings are used in planning and operations, and they constrain the System Operating Limits intended to protect the interconnected system.

The standard requires more than a thermal calculation. A facility rating must be supported by a documented methodology, applicable equipment ratings, design criteria, ambient conditions and other relevant assumptions. The methodology may use manufacturer information, industry standards or engineering analysis, but it must be available for technical review and applied consistently.

FAC-008 also establishes a simple but important principle. The facility rating must not exceed the most limiting applicable equipment rating of the individual equipment comprising the facility. A line, transformer, bus or generating unit may therefore be limited by any associated component, including terminals, bushings, current transformers, leads, cooling equipment or protection-related constraints.

FAC-008 does not prescribe one thermal method for every type of equipment. Instead, it requires each owner to establish, document and apply its own methodology. This methodology may use loading-guide calculations and real-time thermal information where appropriate. It may also use manufacturer ratings, design criteria or other approved engineering rules. Its purpose is to convert the relevant technical information, including calculated loading capability where applicable, into a documented facility rating that can be relied upon for planning and operation.

7.1 Duke Energy: The methodology in practice

If FAC-008 tells a utility that it must have a documented rating methodology, David Wallach's 2022 review [29] of Duke Energy's practice shows how one of the largest utilities in North America actually builds one. Duke Energy's transformer rating program is built directly on IEEE C57.91, the modern descendant of the 1945 loading guide, and on EPRI's PTLOAD software to run the calculations.

Duke Energy's transformer rating program is built directly on IEEE C57.91 and on EPRI's PTLOAD software to run the calculations

What makes the Duke Energy example so useful is how explicitly it treats "ratings" as a family of numbers, rather than a single value. Duke's methodology defines five separate ratings for every transformer, distinguished purely by duration: Continuous, 12-month, 12-hour, 2-hour, and 15-minute. Each is described using the language of capability, not designation, the "available peak load ability of a transformer for a given daily peak ambient temperature and load cycle curve." The shorter-duration ratings are explicitly built as contingency overlays: the continuous rating becomes the pre-load condition, and the calculation asks how much more the transformer can carry for 15 minutes, 2 hours, or 12 hours on top of that starting point.

Duke Energy runs these calculations across thirteen discrete peak ambient temperatures per transformer, sixty-five scenario combinations in total, using PTLOAD in batch mode, then feeds the results into an in-house Facilities Ratings Database that planners use to build path ratings for the whole network.

Wallach's conclusion is the cleanest statement of the theme this article has traced for a hundred years:

> *"A transformer does not have one overload rating but has permissible ratings depending on specifically defined conditions such as load shape, duration, environmental factors, design characteristics, and transformer condition."*

Read carefully, that sentence describes condition-dependent loading capability: a value calculated for specified assumptions and duty. Duke Energy calls each calculated value a "rating," then carries those values into its Facilities Ratings Database, where planners develop ratings for the complete facility and publish the resulting limits for use by the Energy Control Center and system operators. The outcome is not merely a thermal-model output; it is a documented, auditable operational rating process.

7.2 The regulator widens the frame: FERC Order 881 and the AAR

While NERC's FAC-008 was requiring a documented rating methodology at the utility level, Federal Energy Regulatory Commission (FERC) took a parallel step affecting wholesale transmission service in December 2021 with Order No. 881, Managing Transmission Line Ratings [30]. Its purpose was narrow and precise: to improve the accuracy and transparency of transmission line ratings because inaccurate ratings can distort wholesale electricity rates. Its central mechanism was the Ambient-Adjusted Rating, or AAR. The Order primarily ad-

dresses overhead transmission lines, but its methodology-based approach to establishing time-varying operating limits offers a useful model for other transmission assets, including power transformers.

FERC's own definition of AAR is worth reading closely, because it is built entirely from operational, time-bound criteria rather than a static nameplate figure. An AAR applies for no more than one hour, reflects an up-to-date forecast of ambient air temperature during that period, recognizes the absence of solar heating at night, and is calculated at least hourly.

> *An Ambient-Adjusted Rating is a transmission line rating that: applies to a time period of not greater than one hour; reflects an up-to-date forecast of ambient air temperature across the time period to which the rating applies; reflects the absence of solar heating during nighttime periods, with local sunrise and sunset times updated at least monthly; and is calculated at least once every hour.*

Every clause in that definition describes a time-bounded recalculation, not a fixed design value. An AAR is, in the vocabulary this article has been building since 1930, a loading-capability calculation performed in accordance with a written utility rating methodology. FERC nevertheless defines the resulting value as a rating.

Order No. 881 is not a transformer-rating rule. It is an overhead-transmission-line rule whose structure provides a useful regulatory model: an authorised rating methodology, defined inputs, a defined validity period, a required update frequency and an operating limit made available for transmission-service and system-operation use.

7.3 The DLR NOI: Naming the next step

Order No. 881 established AAR as a floor, not a ceiling. Soon after issuing the final rule, FERC opened a Notice of Inquiry in Docket No. AD22-5 [31] to examine whether Dynamic Line Ratings (DLRs)—ratings based on "a wide range of weather and line-specific factors affecting the operation of electric transmission lines"—should become the next regulatory standard. Where AAR is based on forecast ambient air temperature and the presence or absence of solar heating, DLR was framed to incorporate wind speed, wind direction, solar heating intensity, cloud cover and other real-time, line-specific conditions.

FERC's own definition of AAR is worth reading closely, because it is built entirely from operational, time-bound criteria rather than a static nameplate figure

That inquiry led to a further rulemaking step in June 2024, when FERC issued an Advance Notice of Proposed Rulemaking building directly on the DLR NOI [32]. The ANOPR sought comment on a framework under which transmission line ratings would incorporate solar heating based on the sun's position and cloud cover, together with wind-speed and wind-direction forecasts for lines in windy, congested corridors. FERC's plain-language explainer describes DLR technology as continuously monitoring and adjusting line ratings using real-time data, enabling more precise, efficient and dynamic use of transmission lines.

Read against the article's central thread, the AAR-to-DLR progression is the regulatory counterpart of Davis's 1977 real-time thermal-rating system: a fixed, conservatively assumed limit giving way to one that is repeatedly recalculated as conditions change. **FERC's definition** of a transmission line rating also requires consideration of the conductor and relevant transmission equipment, **which may include circuit breakers, line traps and transformers**. Thus, although the DLR rulemaking concerns overhead transmission lines, its rating framework recognizes that the transfer limit of a circuit can be set by associated equipment, including transformers, not the conductor alone.

8. Developing the definition of Dynamic Ratings

At the time of writing, a search for "Dynamic Ratings" in the leading electrical-industry dictionaries, the IEC International Electrotechnical Vocabulary (IEV) and the IEEE Standards Dictionary Online, returned no result. No wonder engineers, academics and researchers have interpreted and conflated these terms differently. This raises a larger question: how can an industry that is rapidly digitising multi-million-dollar assets lack a unified definition for one of its most critical operational metrics?

Every thread this article has traced - the 1925 nameplate, Dann's 1930 warning, the 1945 loading guide, Davis's 1977 real-time system, PJM and PTLOAD's conversion of loading capability into rating, and FAC-008's rating methodology - converges in FERC Order No. 881. Read in the right sequence, its definitions provide a regulatory taxonomy that earlier engineering literature did not consistently provide: they identify the building blocks and show how they fit together, closing the loop back to 1925.

8.1 Transmission Line Rating: The modern nameplate, formalized

FERC does not start with AAR or DLR. It starts by defining the Transmission Line Rating itself:

> *"Transmission Line Rating is the maximum transfer capability of a transmission line, computed in accordance with a written Transmission Line Rating methodology and consistent with Good Utility Practice, considering the technical limitations on conductors and relevant transmission equipment, as well as technical limitations of the Transmission System (such as system voltage and stability limits)." Critically, the Commission specifies that "relevant transmission equipment may include … circuit breakers, line traps, and transformers."*

Three details in that definition matter greatly to this article's argument.

First, the rating is a maximum transfer capability (for transformers, this is

Transmission Line Rating must be computed under a written Transmission Line Rating methodology

maximum apparent power) constrained not only by the conductor but also by associated equipment and system limitations. Where a transformer is the limiting element, its permissible MVA loading can therefore determine the applicable transmission line rating. This is closely related to the quantity that **AIEE No. 13-1930** described as transformer rating: a stated apparent power in kVA under defined conditions.

Second, the Transmission Line Rating must be computed under a written Transmission Line Rating methodology. The responsible transmission provider must therefore establish and apply a documented method suited to its system, rather than relying on an informal or purely descriptive engineering guide.

Third, that methodology must be consistent with Good Utility Practice. For transformer-limited facilities, IEEE and IEC loading guides are natural sources of the technical assumptions and calculations that may support such a methodology, even though FERC does not prescribe either document by name.

In other words, a Transmission Line Rating is an authorised, documented and auditable operating limit established under a written methodology. It may be static or time-varying. AAR and DLR do not create a different physical quantity; they provide more responsive ways to determine and update the same category of operating limit. In that sense, they serve a role comparable to the transformer nameplate in 1925 and to Duke Energy's duration-based values today: calculated capability, converted through an established methodology into a rating that can be used in planning and operation.

8.2 AAR and DLR: Only after the Rating is defined

Only after establishing the Transmission Line Rating does FERC define the Ambient-Adjusted Rating.

> *"An AAR is a Transmission Line Rating that: applies to a time period of not greater than one hour; reflects an up-to-date forecast of ambient air temperature across that period; reflects the absence of solar heating during nighttime, with sunrise and sunset times updated at least monthly; and is calculated at least once every hour".*

Every clause specifies the building blocks, such as a validity period, forecast basis and update frequency, and none redefines what is being measured. An AAR does not change the definition of transfer capability; it changes the conditions and frequency under which that capability is calculated.

Dynamic Line Rating follows the same grammatical pattern but permits a broader set of inputs. FERC defines a DLR as a Transmission Line Rating that applies for no more than one hour and reflects up-to-date forecasts of inputs such as ambient air temperature, wind and solar-heating intensity. The definition may also reflect transmission-line conditions, including tension or sag. In practical terms, DLR can use weather and line-specific information that captures more of the conditions governing conductor temperature and clearance than the ambient-temperature and day/night solar assumptions used for AAR.

This provides a structural framework for resolving the hundred-year confusion with which this article opened. FERC did not create three unrelated quantities called Transmission Line Rating, Ambient-Adjusted Rating and Dynamic Line Rating. It defined one quantity: transfer capability, computed under a written methodology consistent with Good Utility Practice. Then it defined AAR and DLR as increasingly responsive methods for determining that quantity. The additional inputs may be forecast weather data, more detailed solar information or direct evidence of line condition; the category of result remains a rating.

8.3 A working definition of transformer thermal ratings

Adapting FERC's framework for transmission line ratings, a rigorous definition of a transformer thermal rating requires five components.

An AAR does not change the definition of transfer capability, but the conditions and frequency under which that capability is calculated

The first is the quantity and its unit of measurement. For a transformer, the quantity normally rated is apparent power, expressed in kVA or MVA. It may also be expressed as current in amperes, or as a load factor where that is more useful operationally.

The second is an established loading methodology. IEEE C57.91 and IEC 60076-7 provide thermal models and guidance for assessing loading above nameplate rating. The owner's methodology determines how those methods, together with asset data, operating requirements, risk tolerance and engineering judgement, are applied in establishing a rating.

The third is the set of technical limitations that must be respected: top-oil and winding hot-spot temperatures, insulation loss of life, moisture and bubble-risk criteria where applicable, cooling-system availability, current limits, condition limits and other relevant constraints. These constraints are interrelated. For example, loading guides recognize that elevated hot-spot temperatures may accelerate insulation ageing and, in certain moisture and gas conditions, create a bubble-evolution risk.

The fourth is the applicable equipment boundary. The assigned operating limit cannot exceed the applicable limits of bushings, current transformers, leads, load tap changers, terminals or other

equipment that constrains the transformer installation or the facility of which it forms part.

The fifth is time. The methodology must state whether the value is continuous, cyclic, seasonal, planned-overload, long-time emergency, short-time emergency or another explicitly defined duty, and the period for which that value remains valid.

Based on these elements, this article proposes the following definition:

Transformer Thermal Rating (TTR) is the authorised operating limit of a transformer, normally expressed as apparent power, assigned for planning and operations in accordance with an established rating methodology, considering the applicable technical limits of the transformer and its associated equipment.

The word authorised matters, but it does not require an engineer to approve every revised value manually. A utility can authorise an automated methodology in advance: its data sources, thermal model, limiting criteria, margins, data-quality checks, fallback rules, publication process and override arrangements. The system can then calculate and publish each resulting rating automatically within that approved framework.

8.4 Dynamic Transformer Thermal Rating, defined

Dynamic Transformer Thermal Rating (DTTR) is a Transformer Thermal Rating that is automatically recalculated and published under a utility-authorised rating methodology, using updated measurements, forecasts, equipment-status data and applicable equipment constraints, for a defined validity period.

A DTTR is therefore more than a real-time thermal-model output. The thermal model determines the transformer's updated loading capability. The approved methodology determines which capability value—subject to all applicable constraints, data-quality requirements and operating rules—becomes the operating limit issued to planners and operators.

The methodology should make its update frequency and validity period explicit. It should also identify the inputs that change with time, such as ambient and cooling-medium temperatures, winding or hot-spot temperatures where measured or estimated, load history and forecast, cooling-system status, and moisture condition where relevant and available. It should define the limiting criteria, data-quality requirements, fallback arrangements, publication process and authority for operator override. It should also identify the applicable industry standards, utility policies, engineering guidelines and document revisions on which the methodology is based.

This article proposes the definitions of Transformer Thermal Rating and Dynamic Transformer Thermal Rating

8.5 The Rating–Loading Quadrant

The distinction becomes easier to see in the Rating–Loading Quadrant shown in Figure 2. It separates two independent concepts. Rating was defined in the preceding sections. Loading capability can be defined as follows:

> *Transformer Loading Capability is the maximum load a transformer can sustain for a specified period under specified operating and environmental conditions, while satisfying the defined technical limits.*

A rating is the authorised operating limit, while loading capability is the calculated physical capacity of the transformer under the stated conditions. Either may be static or dynamic.

This distinction resolves a common misunderstanding. A static rating is a fixed value used for a defined season, duty or operating condition. It may be the rating-plate value, or it may be another fixed normal or emergency limit adopted in the owner's rating methodology. A dynamic rating is an authorised limit recalculated as relevant conditions change, using an approved methodology.

Similarly, static loading means that transformer load is treated as constant, or approximately constant, over the relevant assessment interval. Dynamic loading means operating the transformer above its prescribed nameplate rating for a specified period, within its calculated loading capability and subject to the applicable thermal, insulation-life, equipment and operating limits. Dynamic loading is therefore concerned with the controlled use of available loading capability, including operation above the prescribed nameplate rating when permitted by the applicable methodology. The relevant limit depends on the specified duration, transformer thermal state, environmental conditions and associated equipment constraints.

The four quadrants are shown in Figure 2.

Note: In this paper, rating refers both to the process of assigning an authorised operating limit and to the resulting limit itself. Loading refers to the process of operating the transformer under load.

The important point is that **static versus dynamic** does not distinguish rating from capability, but describes whether the relevant conditions and resulting value are fixed or time-varying.

9. Capability or Rating? Why it matters

At first glance, the distinction between capability and rating may appear academic and semantic, but in practice, it

A rating is the authorised operating limit, while loading capability is the calculated physical capacity of the transformer under the stated conditions

In a regulated power system, terms determine how information is interpreted, communicated and ultimately used to operate the network

is consequential. In a regulated power system, terms determine how information is interpreted, communicated and ultimately used to operate the network. Confusing a physical limit with an approved operating limit can create uncertainty precisely where clarity is essential.

A transformer thermal model can calculate what a unit may be able to carry under defined conditions. That result is loading capability. A rating, however, is the value adopted by the asset owner for planning and operation under its documented Facility Ratings Methodology. It incorporates not only the thermal calculation, but also applicable equipment limits, assumptions, duty duration, condition information, margins and operating requirements.

This brings together the preceding definitions cleanly: capability is the technically calculated result; rating is the controlled value released for operational use. That distinction is consistent with FAC-008's requirement that facility ratings be determined under documented methodologies and not exceed the most limiting applicable equipment rating.

9.1 Delaying technology deployment

The most immediate consequence of conflation is hesitation in the deployment of DTR technology. When a control-room user receives a dynamic loading value, its meaning must be unambiguous. Does it represent an instantaneous thermal limit, a permissible load for a specified duration, a forecast-based value, or an approved and communicated operating limit?

Those are not interchangeable quantities. A value calculated from a thermal model may be technically credible, yet may require validation, coordination with bushings and associated equipment, selection of applicable thermal, voltage and stability limits, treatment of uncertainty, and incorporation into the owner's operating procedures before it can be used as an operational rating.

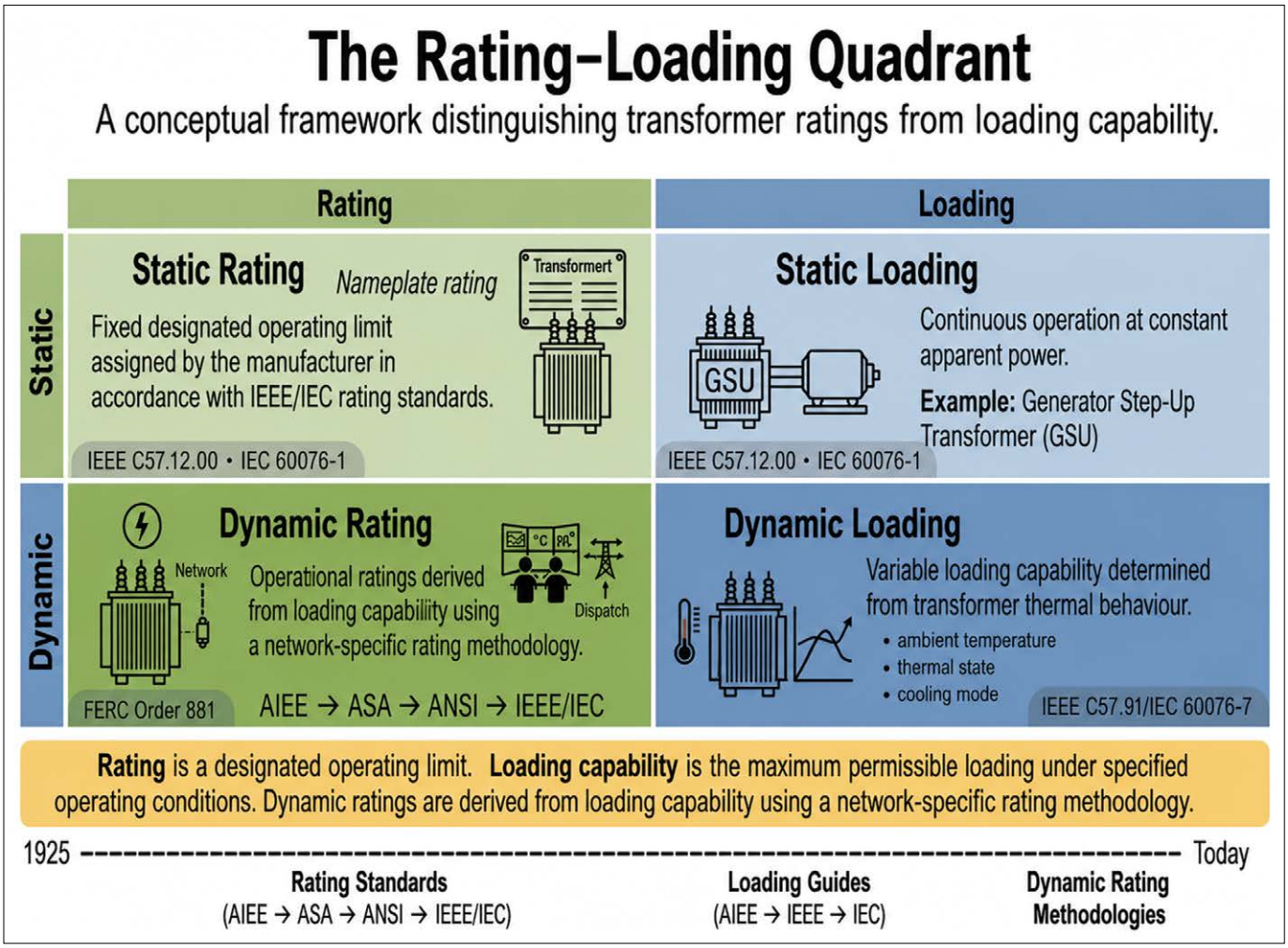

Figure 2. The Rating–Loading Quadrant. Rating is the authorised operating limit assigned under a utility rating methodology; loading capability is the permissible loading level calculated using a transformer thermal model. "Static" and "dynamic" are independent descriptions that can apply to the rating, the loading, or both.

Operators cannot be expected to infer these distinctions from a label such as "DTR". If the provenance, validity period and conditions of a dynamic value are unclear, the prudent response is to retain the established static rating. Clear terminology therefore supports, not obstructs, the practical adoption of dynamic-rating technology.

9.2 Complicating the standardization process

The distinction also matters for standards development. A Guide for thermal modelling answers questions such as: *How should temperature be calculated from load, ambient conditions and equipment parameters?* A facility-rating methodology answers different questions: *Which limits apply? Which components govern? What margins, data quality requirements and durations are acceptable? How is the result approved, communicated and revised?*

These questions must be connected, but they should not be confused. A heat-balance equation cannot determine an owner's risk tolerance, operating policy or compliance responsibility. Equally, a rating methodology cannot replace the need for a sound, validated thermal model.

This is particularly important for transformers. The principal international documents developed for transformer overloading are loading guides. They support evaluation of thermal state, ageing, permissible loading and thermal reserve, but they do not themselves assign an owner's operating ratings. A loading guide can support a Facility Ratings Methodology; it is not a substitute for one.

9.3 Clouding the research record

The same ambiguity appears in research on dynamic transformer operation.

The most immediate consequence of conflation is hesitation in the deployment of DTR technology

Much of the work described as Dynamic Thermal Rating is concerned, in substance, with dynamic loading capability

Much of the work described as Dynamic Thermal Rating is concerned, in substance, with dynamic loading capability. It develops improved thermal models, estimates winding hot-spot temperature, incorporates ambient conditions and load history, considers insulation ageing, moisture and bubble risk, and calculates the permissible loading for a stated period.

This work is valuable. In fact, it provides much of the technical foundation required for any future Dynamic Transformer Rating system. However, a thermal model does not itself assign a rating. It calculates the loading capability of the transformer under specified assumptions. The value obtained depends on the initial thermal state, selected thermal limits, loading duration, cooling conditions, ambient temperature, condition of the insulation system, and the limits of associated equipment.

Lupandina *et al.* provide a useful example of this distinction. Their paper is titled *"Evaluation of dynamic loading capability for optimal loading strategies of power transformers"*. It uses a dynamically calculated thermal state, selected thermal limits and a dynamic thermal model based on IEC 60076-7. The method calculates steady-state loading limits and permissible dynamic loading for a specified duration from the available thermal reserve. The authors consistently refer to loading capability, thermal limits, thermal reserve and permissible loading. They do not describe the calculated result as a Dynamic Transformer Rating.

This terminology is precise. The physical question is: *What can the transformer carry under the specified conditions?* The answer is loading capability. A separate operational question is: *What limit has the asset owner adopted for planning or real-time operation?* The answer is rating.

Research can contribute at several levels. Thermal models improve loading-capability calculations; monitoring improves the inputs; and condition assessment identifies limits associated with moisture, bushings, cooling equipment and ageing. These elements support Dynamic Transformer Rating, but do not create it. A DTTR exists only when the asset owner applies this information through an approved rating methodology that defines limits, margins, data quality, validity period, fallback arrangements and publication of the operating value.

Using the terms accurately will make academic literature easier to interpret. Researchers can state clearly whether their work improves the assessment of transformer loading capability or develops the methodology by which a utility converts that capability into an authorised operating rating. Utilities, vendors and regulators can then identify more readily what a proposed system actually provides, and what further work is required before its output can be used in the control room.

10. Closing the loop

The industry does not lack transformer thermal models. It lacks a consistently applied vocabulary that distinguishes the result of a thermal calculation from the operating limit formally adopted for use.

Loading capability is physically determined and assessed by calculation. Rating is assigned. Loading is imposed. Dynamic Transformer Thermal Rating is the authorised operating limit automatically recalculated and published under a utility-approved methodology using updated conditions.

The distinction does not diminish the value of IEEE and IEC loading guides, contemporary research in thermal monitoring, or the science involved, but simply puts each in its proper place: they provide the technical evidence from which a utility can develop, govern and continuously improve the ratings that guide real-world transformer operation.

A DTTR exists only when the asset owner applies this information through an approved rating methodology that defines limits, margins, data quality, validity period, fallback arrangements and publication of the operating value

11. References

[1] Daminov, I., Gradnik, T., Laneryd, T. "Dynamic Thermal Rating of Power Transformers: Concepts, Standards, and Applications," ICTRAM, 2026

[2] AIEE Standard No. 13-1930, American Institute of Electrical Engineers, 1930.

[3] IEEE C57.12.00-2021 IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

[4] Dann, W. M., "Operating Transformers by Temperature," AIEE Transactions, 1930.

[5] AIEE Subcommittee on Transformers, "Interim Report on Guides for Overloading Transformers and Voltage Regulators," 1942.

[6] AIEE/ASA, "Guides for Operation of Transformers, Regulators, and Reactors," 1945.

[7] Davis, M. W., "A New Thermal Rating Approach: The Real Time Thermal Rating System for Strategic Overhead Conductor Transmission Lines, Part I," IEEE Transactions on Power Apparatus and Systems, 1977.

[8] Neher, J.H. and M. H. McGrath, "The calculation of the temperature rise and load capability of cable systems," in Transactions of the American Institute of Electrical Engineers. Part III: Power Apparatus and Systems, vol. 76, no. 3, pp. 752-764, April 1957.

[9] IEC 60287-1-1:2023, Electric cables — Calculation of the current rating — Part 1-1: Current rating equations (100 % load factor) and calculation of losses — General., 2023

[10] IEC 60853-1:1985, Calculation of the cyclic and emergency current rating of cables — Part 1: Cyclic rating factor for cables up to and including 18/30 (36) kV, 1985

[11] IEC 60853-2:1989, Calculation of the cyclic and emergency current rating of cables — Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages, 1989

[12] IEC 60853-3:2002, Calculation of the cyclic and emergency current rating of cables — Part 3: Cyclic rating factor for cables of all voltages, with partial drying of the soil, 2002.

[13] IEEE Std 835-1994, IEEE Standard Power Cable Ampacity Tables, 1994.

[14] IEEE Std 835a-2012, IEEE Standard Power Cable Ampacity Tables Amendment 1, 2012.

[15] IEEE Std 7382023: Standard for Calculating the CurrentTemperature Relationship of Bare Overhead Conductors, 2023.

[16] IEC/TR 61597:2021, Overhead electrical conductors — Calculation methods for stranded bare conductors, 2021

[17] CIGRE Working Group 22.12, Thermal Behaviour of Overhead Conductors, CIGRE Technical Brochure 207, 2002.

[18] CIGRE Working Group B2.12 Guide for Selection Of Weather Parameters For Bare Overhead Conductor Ratings, CIGRE Technical Brochure 299, 2006.

[19] CIGRE Working Group B2.36, Guide for Application of Direct Real-Time Monitoring Systems, CIGRE Technical Brochure 498, 2012.

[20] CIGRE Working Group B2.42, Guide for Thermal Rating Calculations of Overhead Lines, CIGRE Technical Brochure 601, 2014.

[21] CIGRE Working Group B2.59, Forecasting Dynamic Thermal Line Ratings, CIGRE Technical Brochure 969, 2025

[22] IEEE C57.91-2025: IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators," 2025.

[23] IEC 60076-7:2018 Loading guide for mineral-oil-immersed power transformers, 2018

[24] BC Hydro, Bulk Electric System Facility Rating Methodology, Transmission Maintenance Standard 80.10-08-00, Rev. 8, 25 November 2020.

[25] Lupandina, I., Gawlik, W., Schrammel, M., Ilgevicius, A., Kürten, M., Viereck, K., "Evaluation of dynamic loading capability for optimal loading strategies of power transformers," Elektrotechnik & Informationstechnik, vol. 137, no. 8, pp. 515–522, 2020.

[26] PJM Interconnection, "VI-B Power Transformer Rating Procedures," 1999.

[27] Electric Power Research Institute (EPRI), "PTLOAD 6.2 User Manual," EPRI.

[28] North American Electric Reliability Corporation (NERC), "Reliability Standard FAC-008-5 – Facility Ratings Methodology," 2005.

[29] Wallach, D., "A Review of Present-Day Transformer Loading Practices at Duke Energy," TechCon, 2022.

[30] Federal Energy Regulatory Commission, "Order No. 881: Managing Transmission Line Ratings," Docket No. RM20-16-000, 2021.

[31] Federal Energy Regulatory Commission, "Notice of Inquiry: Dynamic Line Ratings," Docket No. AD22-5-000, 2022.

[32] Federal Energy Regulatory Commission, "Advance Notice of Proposed Rulemaking: Implementation of Dynamic Line Ratings," Docket No. RM24-6-000, 2024.

Author



Dr. Oleg Roizman is the founder and managing director of Intellpower Pty. Ltd. in Australia, an engineering consulting and services company with an emphasis on the continuous online monitoring, diagnostics, and life management of power transformers.
He holds a Ph.D. in Electrical Engineering and a Bachelor of Science in Electrical Engineering and Economics (Hons.).
Dr. Roizman is an inventor, a sought-after speaker and educator, a member of the IEEE Transformer Committee, and an active participant in various CIGRE working groups. He has authored over 30 technical papers.