FERC Order No. 881 – Managing Transmission Line Ratings

Phase 2

Technical White Paper

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1. Introduction

FERC Order No. 881 is designed to enhance the efficiency of transmission service and improve transparency of transmission line ratings. The order requires transmission providers, including ISOs/RTOs to implement ambient adjusted ratings (AAR's) on the transmission lines over which they provide transmission service unless otherwise subject to an exception. AARs apply to both normal and emergency ratings. FERC Order No. 881 requires implementation of these reforms by July 12, 2025.

FERC Order No. 881 requires ISO's/RTO's to utilize ambient adjusted ratings in their:

- Real time congestion management process
- Real time and look ahead market commitment process and look ahead reliability studies.
- Evaluation and curtailment of near term (10 days or less) transmission service.

Generally, transmission line rating represents the maximum transfer capability of a transmission line calculated as per the transmission line rating methodology of each transmission owner. The rating accounts for technical limitations on conductors and relevant transmission equipment (such as circuit breakers, disconnect switches, line traps, current transformers, voltage transformers and other substation equipment) thermal limitations and also accounts for any associated stability issues (voltage and transient stability) in the transmission system. Transmission line rating of a transmission line is impacted by current flowing in the conductor, type of conductor and resistance in the conductor. Along with that the rating is impacted by ambient weather conditions (Temperature, Solar radiation, wind speed and direction).

Static ratings are determined based on pre -determined conservative ambient conditions such as full sun in the afternoon with max solar radiation impacting the line, low wind speeds and historic max ambient temperature in the region. IEEE/CIGRE standards provide methods to calculate ratings for overhead transmission lines. IEEE 738 steady state heat balance equations could be used to calculate normal continuous ratings. Both ambient adjusted temperature changes and solar heating changes could be accounted in these equations.

FERC Order No. 881 establishes the following parameters for AARs:

- Applies to a time period of not greater than one hour
- Reflects up-to-date forecast of ambient air temperature across the time period to which the rating applies
- Reflects the absence of solar heating during night time, i.e. accounts daytime/nighttime solar heating changes
- Calculated at least once for each hour
- Reflects updates to sunrise and sunset times used to calculate at least monthly
- Updating ambient adjusted ratings with every five degree Fahrenheit increment of temperature change
- Addressing how ambient adjusted ratings for transmission lines interact with system voltage and stability limits, remedial action schemes and system operating limits

Ambient adjusted ratings (AAR's) must reflect the temperature at which there is sufficient confidence that the actual temperature will not be greater than that temperature (expected temperature and an appropriate forecast margin). FERC Order No. 881 also requires that the ratings to be calculated for at least historical range of temperatures +/- a margin of 10 degrees Fahrenheit.

If transmission owners choose to develop rating look up tables for their equipment, the table should have rating available for every 5 degree Fahrenheit change of temperature.

Seasonal ratings are utilized in the longer term reliability studies/availability transfer capability studies (ATC) and seasonal congestion revenue rights calculations. FERC Order No. 881 also requires transmission owners to utilize at-minimum four seasons and associated seasonal ratings. Transmission owners are responsible for defining season start and end times in their transmission line rating methodologies. CAISO/RCWEST expects to work with all TOP's through stakeholder forums and achieve consistency on seasonal definitions and rating methodologies.

2. How CAISO/RCWEST Utilize Ratings Today

NERC FAC-008-3 standard requires transmission owners to determine facility ratings based on technically sound principles documented in their transmission line rating methodologies. The transmission owner has the responsibility to establish rating based on their rating methodology and communicate the rating to CAISO/RCWEST. FERC Order No. 881 does not trump the already approved NERC standards. The transmission owner still has the responsibility to calculate AAR ratings based on the established rating methodology and communicate ratings to CAISO/RCWEST.

Under the existing process, CAISO's participating transmission owners (PTOs) send in their ratings to CAISO utilizing Transmission Register interface. Transmission Register is a secure web-enabled database environment for CAISO internal users and specific participating transmission owners (PTO) to access transmission equipment ratings. PTO's can enter transmission ratings either in MVA or ampere's (ampere ratings converted to appropriate MVA on the basis of base voltage designations for the transmission equipment) and gets transmitted into CAISO's/RCWESTs model management system. RCWEST TOP's utilize CIM data exchange process to submit appropriate normal and emergency ratings to RCWEST. These MVA ratings gets transmitted into CAISO's model management system as well. Some RCWEST TOP's utilize excel templates to send in their ratings.

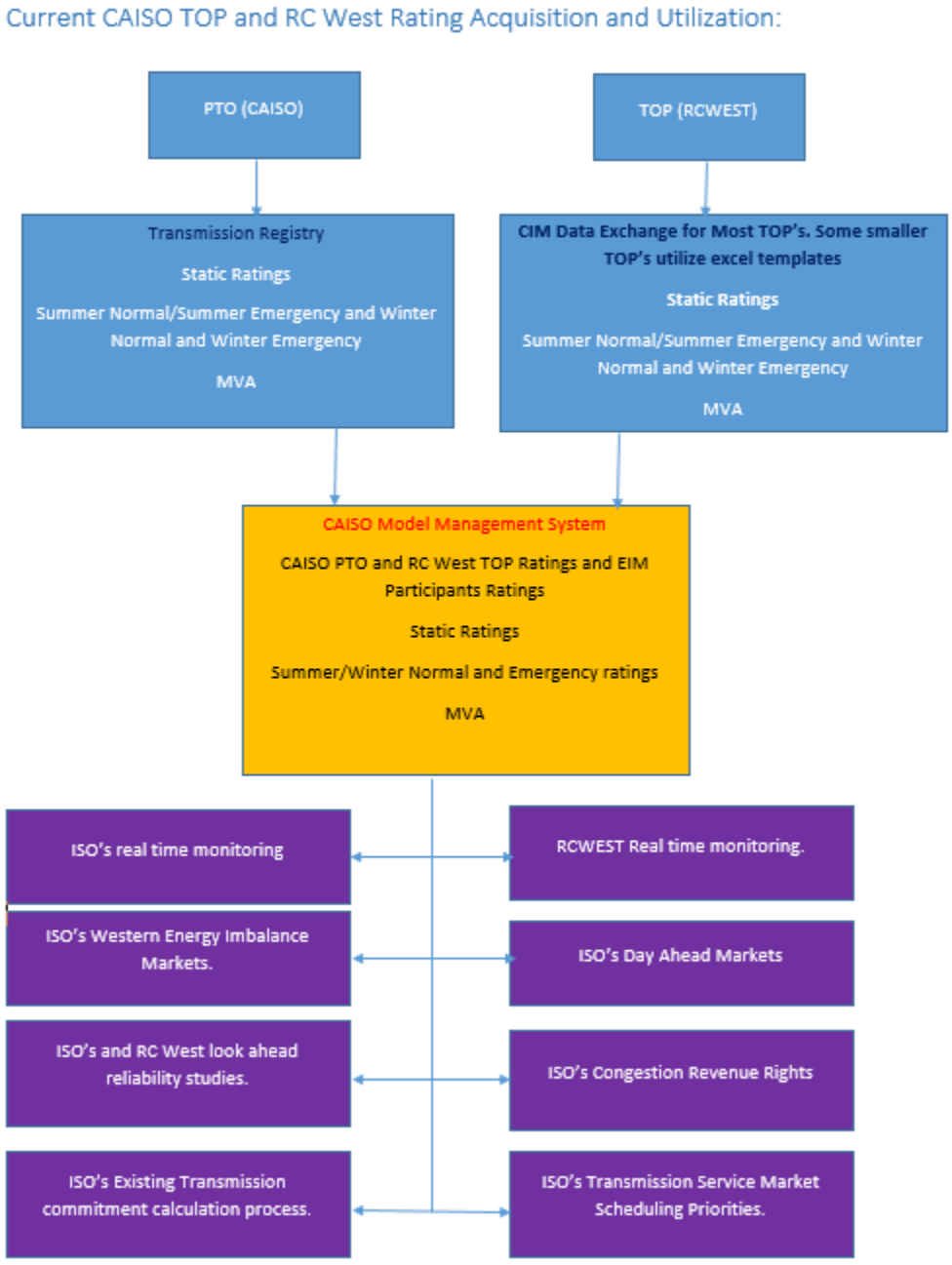
The ratings from the model management system feed into CAISOs/RCWESTs downstream reliability and market applications. All these ratings are static in the nature and change seasonally based on CAISO's full network modeling schedules. CAISO PTO/RCWEST TOPs communicate when they change ratings from one season to another. Each TOP can only have one season start and end dates for their entire system.

There is an established emergency rating change process where any temporary updates to the static seasonal ratings can be processed through CAISO's outage management system (OMS).

CAISO's look ahead markets in day-ahead time frame and look ahead reliability study processes utilize seasonal ratings acquired from CAISO's model management system. (One normal and one emergency

rating). CAISO's near real time markets utilize seasonal ratings as well. CAISO's planning study process utilize the seasonal ratings from transmission registry and update ratings as needed to reflect the system conditions that they are performing studies. CAISO's congestion revenue rights (CRR) calculation process utilize seasonal ratings from transmission registry in their calculation process. (One normal and one emergency rating).

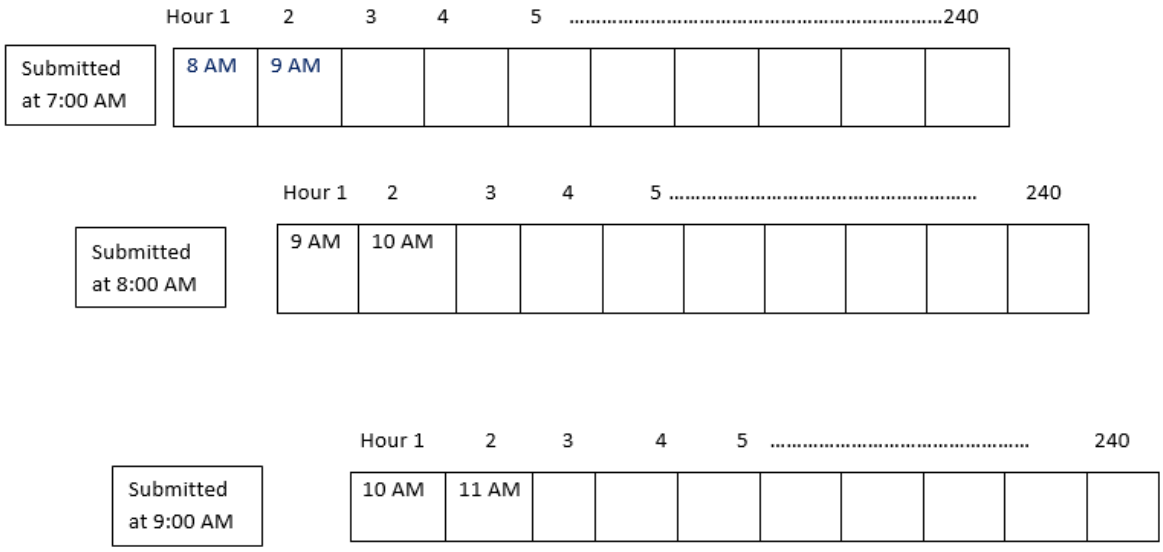
The chart below illustrates the current CAISO/RCWEST rating consumption process.



3. Key FERC Order No. 881 Requirements for Transmission Owners and ISO's.

Transmission owners are responsible for updating their rating methodologies to be compliant with FERC Order No. 881 and the currently approved NERC FAC standards. They need to update their rating methodologies to include not fewer than four seasonal ratings in each year. These seasonal ratings should be updated annually. Transmission owners need to define the seasons and their start and end times and provide those ratings to ISO/RTO's. AAR requirements are applicable to all transmission lines whose ratings are impacted by ambient air temperature as well as solar radiance. Transmission owners are required to calculate both instantaneous AAR and 240 hours (10 days) of look ahead AAR. These AAR ratings needs to be updated at least hourly.

As shown in the picture below, calculated look ahead ambient adjusted ratings for transmission lines should reflect 240 hours of hourly granularity submitted each hour valid for the next 240 hours on a rolling basis.



These requirements apply to both normal and emergency ratings on the transmission equipment as defined in transmission owner's transmission line rating methodologies. Exceptions for lines whose ratings are not impacted by ambient air temperature or solar heating needs to be documented in the transmission line rating methodologies. If a transmission line rating is limited wither voltage stability or transient stability limited those lines could also be put under exception list.

FERC Order No. 881 also require transmission owners to share the line ratings methodologies with ISOs/RTOs and other transmission providers upon request in a timely manner. ISO/RTO's need to maintain database of transmission owners transmission line rating methodologies on open access same time

information system (OASIS) site or other password protected websites. Any exceptions as documented in the transmission line rating methodologies need to be posted in these sites as well.

4. CAISO/RCWEST Plan to be Compliant with FERC Order No. 881

CAISO/RCWEST has launched efforts to develop technology and business processes to comply with FERC Order No. 881, including business requirements specifications for new interfaces to acquire and utilize ratings in CAISO/RCWEST processes, by providing a user interface, as well as a web service interface for the transmission owners to submit the data programmatically. We have identified three project tracks:

- **Track 1: Real Time Reliability Applications**
    - This track is intended to develop our processes/tools to receive real time ambient adjusted ratings from Transmission owners. These ratings will be utilized in our real time reliability monitoring processes.
    - We plan to receive AAR via Inter-Control Center Communications Protocol (ICCP)
    - Target capability will be ready in Q4 2023 and CAISO/RCWEST will work with transmission owners as they are ready to send the data to us.
    - CAISO/RCWEST will include training and testing sessions after tool development and our current expectations are that these sessions will be scheduled in Q12024.
- **Track 2: Operational/EMS Model Data and Applications**
    - This track is intended to develop our tools and processes to receive look ahead AAR (240 hours AAR) from transmission owners.
    - Target capability ready in 2024
    - CAISO/RCWEST will share the data formats and process details with stakeholders after our business requirements and technology is finalized before the actual implementation. We expect the business requirements and finalization of technology to complete in Q2 2023.
    - Our current expectations are that these tools will be developed internally. CAISO/RCWEST is planning to enhance existing Transmission Register tools interface. This new enhanced Transmission Register interface will be utilized to interface with both CAISO PTO's and RCWEST TOP's and acquire look ahead AAR.
    - CAISO/RCWEST will include training and testing sessions after tool developments are complete.
- **Track 3: Market Applications and Look Ahead Applications**
    - This track is intended to develop our tools and processes to utilize the look ahead AAR in CAISO's real-time and day-ahead markets and RCWEST's look ahead reliability studies.

- Develop reporting and data posting requirements that are mandated by FERC Order No. 881.
- Target earlier than July 2025 to meet compliance deadline.
- CAISO/RCWEST will include training and testing sessions after tool developments are complete.

The CAISO/RC West has also initiated a public stakeholder process to keep stakeholders informed of the progress on this effort. We have created two working groups to foster the stakeholder discussion and collaboration. These working group meetings are expected to be hosted monthly.

Data submission working group

- Coordinate and share the templates and data formats that CASIO/RCWEST will utilize to acquire seasonal ratings/real time AAR and Look ahead AAR.
- Detailed training and testing plans will be shared with the stakeholders through this group.

Methodologies working group

- Coordinate and collaborate with transmission owners on developing processes/tools/rating methodologies. Share best practices of implementation.
- Ensure consistency among TOP's in the development of transmission line rating methodologies.

CAISO/RCWEST also intends to collaborate with transmission owners to achieve consistency among the transmission rating methodologies in defining seasonal ratings on season start end times and also emergency rating and duration definitions. Consistency is key to make sure we are always operating to the right limit across tie-lines.

5. CAISO/RCWEST Implementation Plan

This section provides details on the CAISO/RCWEST implementation plan to acquire seasonal ratings/real-time AAR, and Look ahead AAR.

FERC Order No. 881 requires transmission owners to utilize four seasonal ratings at minimum. Transmission owners are responsible to update their transmission ratings methodologies with the definition and start and end times of the seasons. CAISO/RCWEST will work with transmission owners to achieve consistency on transmission line rating methodologies. Once transmission owners have updated their transmission line rating methodologies they can work with CAISO/RCWEST to send us their seasonal ratings.

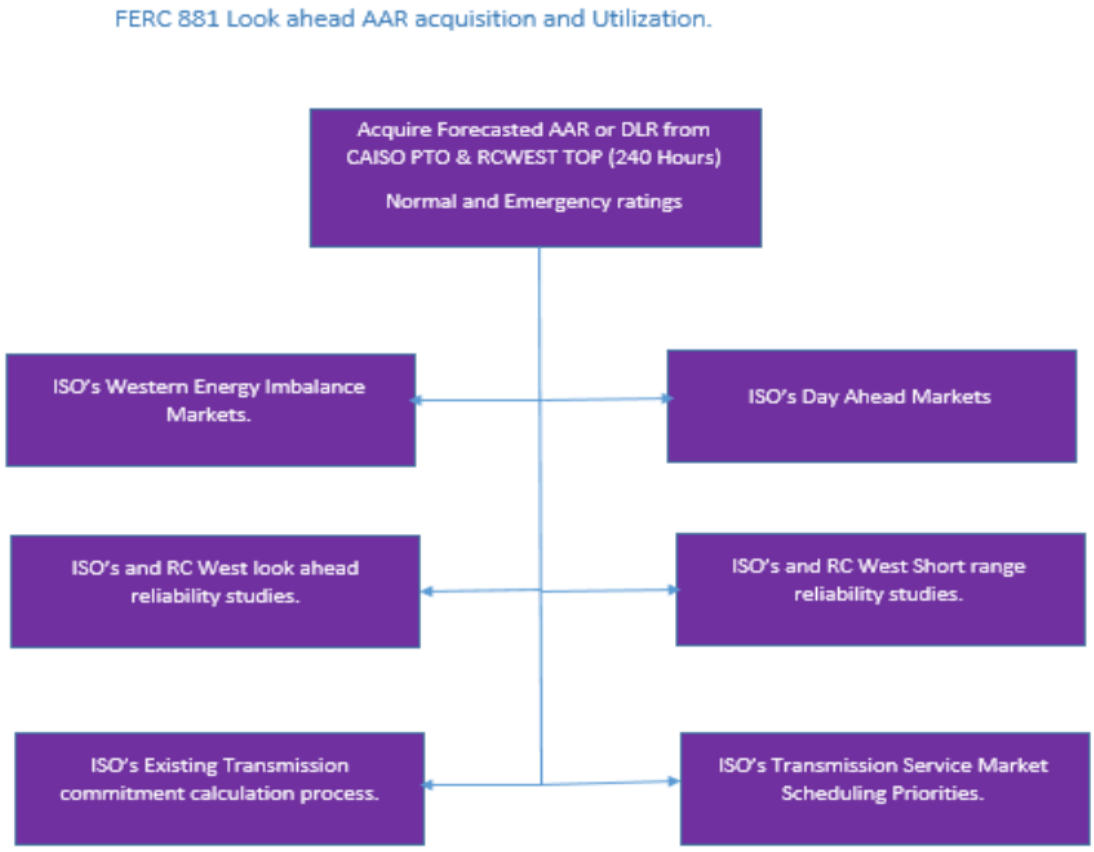
- ISO PTOs will need to follow the ISO transmission registry process to utilize four seasonal ratings.
- RC West TOPs will need to follow the RC West IRO-010 data specification process to utilize four seasonal ratings. The new interface will also allow for submission of the seasonal ratings.

FERC Order No. 881 requires transmission owners to calculate real time and Look ahead ambient adjusted ratings.

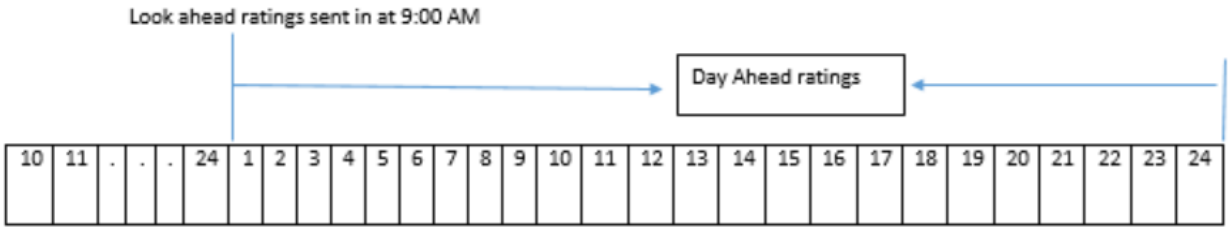
- Real time AAR from both ISO PTOs and RC West TOPs will be acquired through Inter-Control Center Communications Protocol (ICCP) protocol. These real time ratings will be utilized in CAISO/RCWEST real time reliability monitoring tools.
- We will provide an interface, both UI and API, by enhancing the existing Transmission Registry, to acquire hourly look ahead ambient adjusted ratings (240 hours). The CAISO will utilize these look ahead hourly ratings in the CAISO's day-ahead market and real-time market processes and other RCWEST look ahead reliability studies.

CAISO/RCWEST expects transmission owners perform rating validations before sending the ratings to CAISO/RCWEST. We are also looking into developing basic data checks such as hierarchy checks (emergency ratings > normal ratings) and reasonability checks (min/max) checks on incoming ratings. We will coordinate with TOP's on the reasonability checks. We will also be performing validations against the mandatory attributes that are needed for data submission.

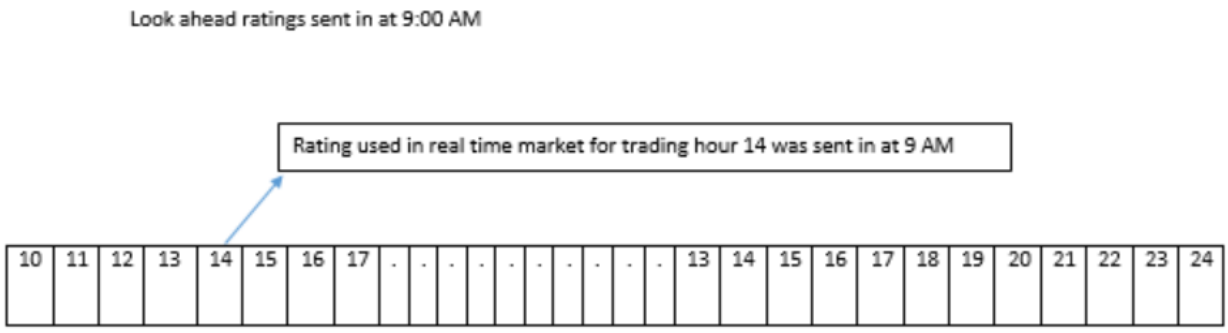
The below chart details how look ahead AAR will flow into CAISO reliability and market tools and RCWEST reliability tools.



As part of CAISO's compliance filing, we have proposed on below timelines for look ahead ratings that would be utilized in the day-ahead and real-time markets. Look ahead ratings that are submitted no later than 9 a.m. on the day before the applicable trading day will be utilized in the day-ahead market processes.



Look ahead ratings that are submitted 5 hours before the applicable trading hour will be utilized in the real time market processes.



6. Proposed Technical Solution - High Level Overview

The high level data flow for the FERC Order No. 881 project solution is as follows:

- Network model data will be available in Transmission Register
- TOPs will use the key attributes from the network model dataset, as defined in the data specification, to submit the normal, emergency, highest emergency and ambient adjusted ratings and the corresponding durations
- Data submitted to TR will be used in the market and reliability processes
- Real time ratings can be submitted directly to EMS using ICCP
- New report on CMRI to display the real time ratings and ratings used in the market runs

As part of the FERC Order No. 881 implementation plan, CAISO is proposing to enhance the TR application with the following changes:

- New user interface to submit and/or retrieve transmission line ratings
- New web services interface to programmatically submit and/or retrieve ratings
- Data validations, including reasonability checks, will be enforced
- Standard certificate-based authorization and authentication protocol

The diagram below represents a high level overview of the proposed solution: