PJM TO Connection User Guide

For PJM Member Transmission Operations Personnel

26 Sept 2023

For Public Use

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Contents

TO Connection application

TO Connection purpose

The *TO Connection* application serves as a tool suite for a select set of PJM sub-applications which PJM and its member Transmission Owners utilize in coordination with, or provides as awareness to, its member Transmission Owners.

TO Connection location

Homepage:

- breadcrumb path: pjm.com ► Markets & Operations ► PJM Tools ► TO Connection
- url: https://www.pjm.com/markets-and-operations/etools/to-connection.aspx
- release notes: https://www.pjm.com/markets-and-operations/etools/to-connection/to-connection-release-notes.aspx

Production Environment Login: https://toconnection.pjm.com

TO Connection user base

The *TO Connection* application intended audience is transmission system operations / dispatcher focused, including internal PJM Dispatchers / Reliability Engineers, tool administrators, and PJM member Transmission Owner system operator staff directly involved in the underlying tool.

TO Connection history

In 2014, the *Post Contingency Local Load Relief Warning* [PCLLRW] tool release provided a common tool designed to streamline the need, development and communication of Load Shed Plans between PJM Dispatch and its member Transmission Owners in relation to PJM System Operating Limits [SOL]. At that time, the tool only provided load impact distribution factors related to thermally impacted SOL.

In 2018, the *PCLLRW* tool was further expanded to provide Voltage Distribution Factors [VDFax] and thus allowing Load Shed Plans around low voltage impacted SOL to be shared in a common manner to that of thermal SOL.

In 2021, the *PCLLRW* tool was incorporated into a new *TO Connection* tool suite along with a new *Stability Viewer* tool.

In 2022, the *PCLLRW* tool was further expanded to dynamically identify deficient load shed plans, rather just during the load shed plan submittal process, along with the PJM ability to leverage an optional projected post-contingency condition for use in determining necessary load shed.

In 2023, the *PCLLRW* tool was once again expanded to include a tracker for switching solutions. In this section of the tool, users are able to track switching solutions across the entire RTO from the past year.

Current plans around *TO Connection* development include views around PJM's *Intelligent Event Processor* to enhance TO member situational awareness and PJM - TO coordination.

TO Connection features

Framework

The *TO Connection,* application leverages a common framework with that of other PJM Tools, allowing users the ability to:

- Link to the PJM Tools Homepage;
- Transfer between PJM Tools using Single Sign On (SSO);
- Move to PJM.com;
- Sign Out of the application, with visibility to their individual connection timeout via a Session Expiration countdown;
- Adjust the application between a Light & Dark Theme.

Banner messaging

TO Connection's applications have the capability of sharing information across the sub-applications leveraging Banner messages to direct a user to critical input failures and event status changes. Banner messages are intended to be both informative and yet unobtrusive to the end user's experience.

Banner messages trigger conditionally and are not omnipresent within the tool.

The set of potential Banner messages, by sub-application type, within TO Connection are as follows:

- PCLLRW
  - Status Change: "NEW: <MessageType> for <Area> to control <B1> <B2>. Click here to go to PCLLRW."
  - Status Change: "UPDATED: <MessageType>for <Area> to control <B1> <B2>. Click here to go to PCLLRW."
  - Status Change: "CANCELED: <MessageType> for <Area> to control <B1> <B2>. Click here to go to PCLLRW."
  - Load Shed Plan: "A valid load shed plan has been submitted for <AREA>. Click here to go to PCLLRW."
  - Load Shed Plan: "A deficient load shed plan has been submitted for <AREA>. Click here to go to PCLLRW."
  - PJM EMS SA: "SA Exceedances are stale. Click here to go to PCLLRW."
  - PJM EMS SA: "SA Exceedances are up to date. Click here to go to PCLLRW."
  - PJM VDFAX: "VDFAX is unavailable. Click here to go to PCLLRW."
  - PJM VDFAX: "VDFAX is available. Click here to go to PCLLRW."
- Stability Viewer

- New Limit: "A new Stability Limit has been issued for <Area Name>. Click here to go to Stability Viewer."
- Edited Limit: "Stability limit for <Area Name> has been modified. Click here to go to Stability Viewer."
- Closed Limit: "Stability limit for <Area Name> has been closed. Click here to go to Stability Viewer."

Figure 1. Sample Banner message (standalone, orange) showing a PCLLRW status change, and directing user to the PCLLRW tool.

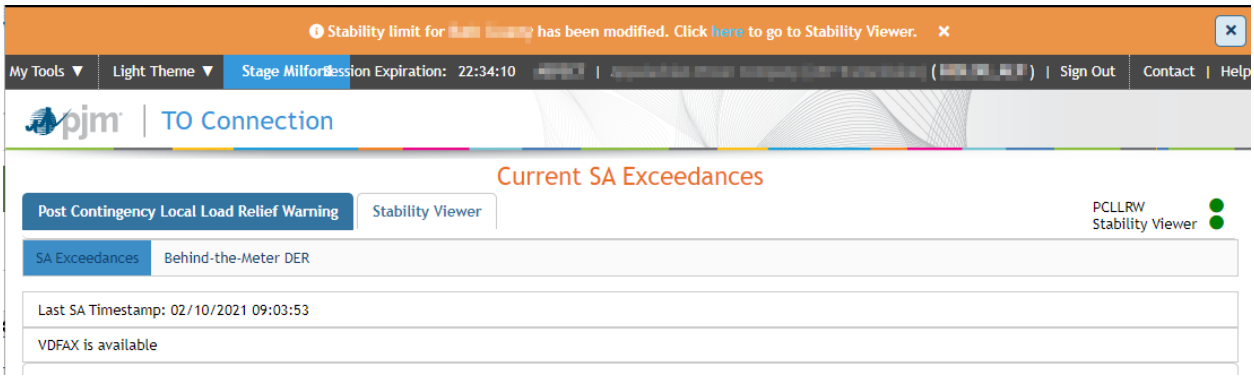


Figure 2. Sample Banner message (top, orange) showing a stability limit edit, and directing user to the Stability Viewer tool.

Heartbeat

The heartbeat area provides status information around input to a given sub-application of *TO Connection*. The *TO Connection* heartbeat area is continuously displayed regardless of the user's location within a given Application or Sub-application tab.

On "mouse over", the individual heartbeat will provide tooltip timestamp information relative to the given area.

Red heartbeats are an indication of a system failure. Green heartbeats are an indication of a system operating within appropriate time parameters.

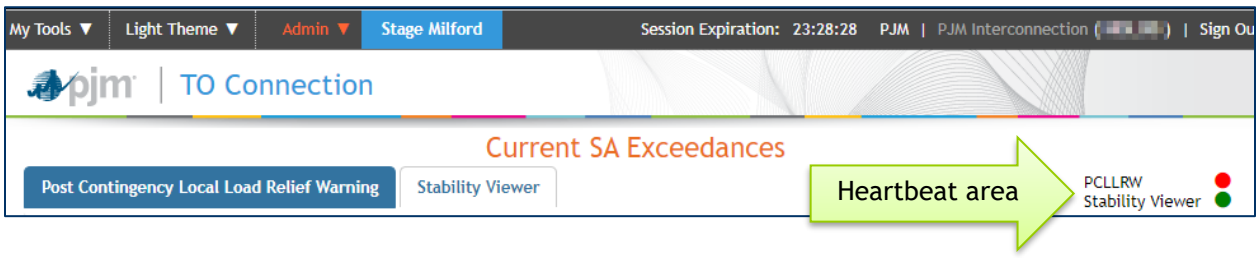


Figure 3. Sample heartbeat showing a *PCLLRW* system in a failed state (red) and *Stability Viewer* as operational (green).

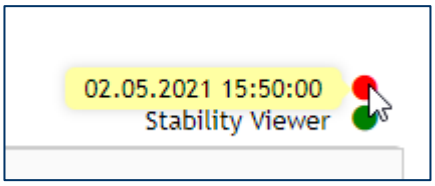


Figure 4. Tooltip ("mouse over") showing timestamp related to an individual Heartbeat message.

Application areas

The *TO Connection* suite opens by default into the *SA Exceedances* tab of the *Post Contingency Local Load Relief Warning* sub-tool.

Navigation within the *TO Connection* application suite is done by [See Figure 4 below for visual references] :

- Either selecting [left mouse-click] another sub-tool tab:
  - Options shown below include *Post Contingency Local Load Relief Warning* and *Stability Viewer* sub-tools;
    - Designated as area A.
  - The highlighting of the sub-tool tab denotes which sub-tool the user is within presently;
  - Selecting a non-highlighted sub-tool, such as *Stability Viewer* in area A, will change the available functional area tabs, designated as area B.
- Or, selecting [left mouse-click] another sub-tool functional area within the existing tool;
  - Options shown below include the "SA Exceedances" and "Behind the Meter DER" tabs (functional areas) within the *Post Contingency Local Load Relief Warning* tool.
    - Designated as area B.
  - The highlighting of the sub-tool area tab denotes which sub-tool functional area the user is within presently;
  - Selecting a non-highlighted sub-tool area in area B will change the functional area title, designated as C, as well as changing the main application body of the sub-tool functional area, designated as D.

Selecting a sub-tool dynamically drives changes to availability of functional areas.

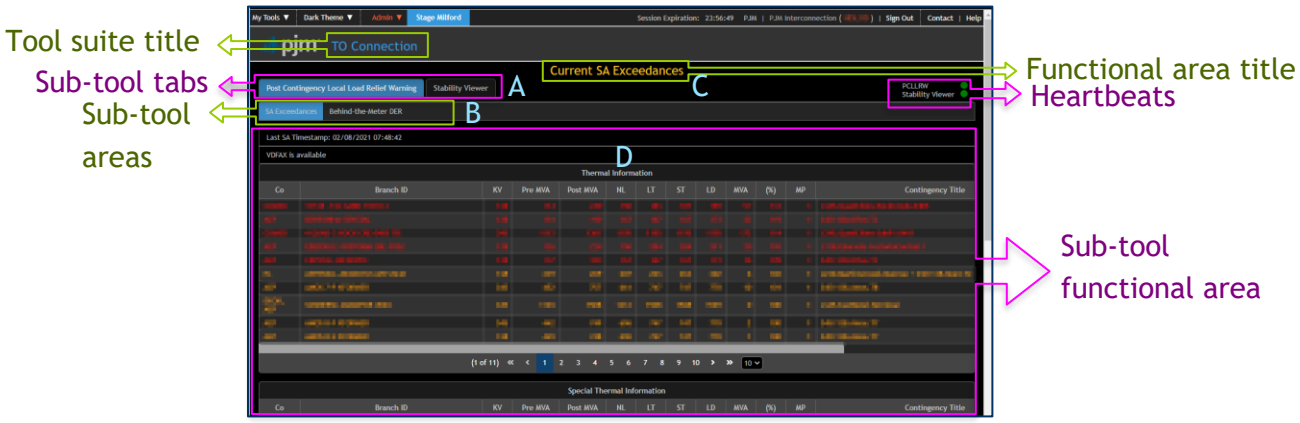


Figure 5. Application area layout with callouts for descriptions and dynamic area reference designations (A-D).

Post Contingency Local Load Relief Warning sub-tool

PCLLRW purpose

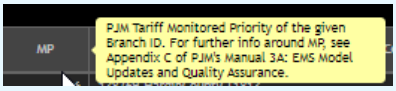
PJM Dispatch and impacted (as monitored element owner(s) OR with load at risk) Transmission Owners utilize the *Post Contingency Local Load Relief Warning* [*PCLLRW*] sub-tool within the *TO Connection* application in the development and coordination of load shed plans in mitigating thermal and voltage contingency-based (N-1) SOL exceedances.

PCLLRW features

SA Exceedances

SA Exceedances tab reflects the PJM Security Analysis (aka, Contingency Analysis) results related to thermal and voltage related trends and exceedances. This includes the PJM default active contingency analysis, as well as "Special" contingencies for both thermal and voltage, used for monitoring conditions such as sectionalizing scheme failures.

For further information around various column data in the SA Exceedances tables, tooltip information is provided upon table header mouse-over.



The tab serves as a secondary method (primary being direct operator to operator communication) for PJM Operators to receive notice around PCLLRW issuances, and begin to develop post-contingency Load Shed plans for those conditions.

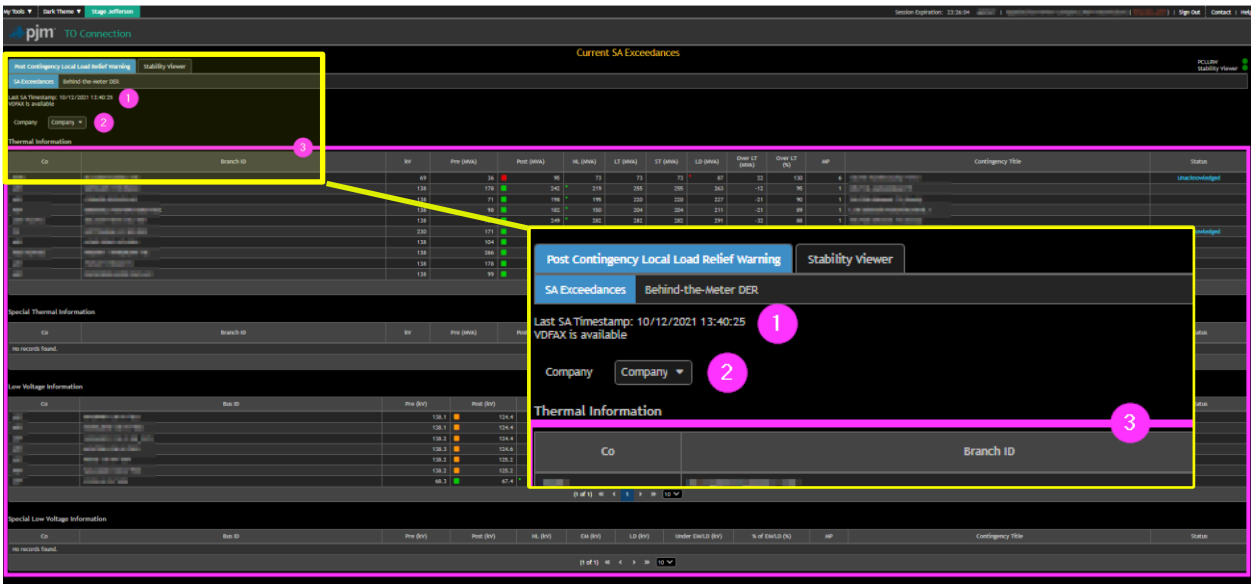


Figure 6. Post Contingency Local Load Relief Warning overview of default *SA Exceedances* tab, with callout for areas identified.

SA Exceedances Area Callout	*Description*
1	**Last SA Timestamp**: PJM's EMS Security Analysis timestamp, as last communicated to PCLLRW; **VDFAX state**: PJM's Voltage Distribution Factor (VDFAX) tool available/unavailable state.
2	**Company:** For those companies with access to TO Connection across a PCLLRW admin-defined set of PJM Account Manager accounts/organizations, a dropdown **Company filter** allows for adjusting the USER's view on TO zonal basis to one or more companies. • When adjusted, the user's view is impacted. Other user's views are NOT impacted. • When adjusted, the user is provided adjacent awareness of their filtered list, via a comma separated set, next to the filter of the applied filter. 
3	**Current SA Exceedances Tables:** Provide PJM trending/exceedances for monitored element + contingency pair coordination between PJM and impacted branch/bus and load owners. • *Thermal Information* & *Special Thermal Information* tables are related to element thermal rating trends/exceedances and PCLLRW coordination efforts. • *Low Voltage Information* & *Special Low Voltage Information* tables are related to bus rating trends/exceedances and PCLLRW coordination efforts.

Table 1. SA Exceedances area callouts and descriptions as they relate to the preceding Figure.

PJM default/primary contingency analysis relevant to the PCLLRW process are captured within the Thermal Information & Low Voltage Information *tables. (PJM refers to this set as Group 1)*

PJM utilizes a Special contingency group, with results captured under Special Thermal Information & Special Low Voltage Information *tables, for unique situations related to equipment outage preparation, monitoring sectionalizing failure contingencies, as well as in preparation/awareness around operational events/emergencies unique to that of the default contingency set. (PJM refers to this set as Group 21)*

Current SA Exceedances table(s) constraint visibility

Provide awareness to the user of thermal/voltage constraint (i.e., monitored element/facility and contingent facility pair) trends, ratings exceedances, and PCLLRW coordination efforts between PJM and members. The PCLLRW sub-tool provides constraint visibility at the TO level by the following mechanisms:

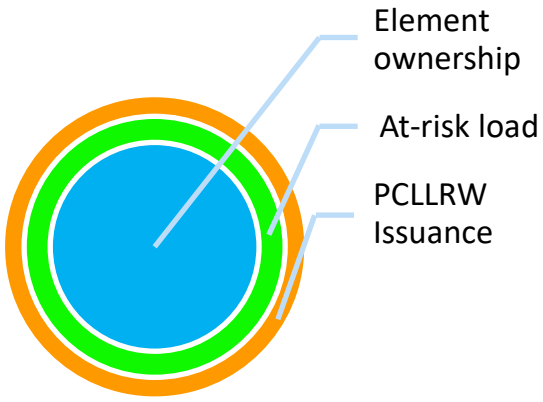
1 | Element ownership [default]: Either the branch owner(s) or the bus owner, as defined in PJM's EMS, will have visibility for constraints upon their facilities.

2 | At-risk load: TOs with load "at-risk" (i.e., mitigating load which exceeds a PJM admin-defined distribution factor threshold) are provided visibility to the constraint when BOTH the following conditions are TRUE:

(a) the appropriate PJM system (EMS for thermal, VDFAX for voltage) has derived distribution factor load calculations for the constraint;

(b) a TO has PJM EMS-defined load within those distribution factor calculations which exceed the threshold and potentially mitigate the constraint, even if they are not the constrained element's owner.

3 | PCLLRW issuance: Finally, TOs issued a PCLLRW for a given constraint gain visibility to the constraint if they failed to meet the Element ownership or At-risk load mechanisms prior to issuance.



Current SA Exceedances table(s) hierarchy

All constraints are displayed by severity order based upon:

- Over LT (%), in decending order;
- % of EM/LD (%), in ascending order;

Given the four defined SA Exceedances Information tables (Thermal, Special Thermal, Low Voltage & Special Low Voltage), trends & exceedances display in the following manner:

1 | Constraints exceeding the LD (i.e., Load Dump) rating for the given branch/bus constraint are identifiable via:

(a) a large RED icon in the appropriate Post(-contingency) calculated column/cell;

(b) a corresponding small RED icon in the LD column/cell .

2 | Constraints NOT exceeding LD, BUT exceeding the ST (i.e., Short Term) rating for thermals or EM (i.e. Emergency) rating for voltage for the given branch/bus constraint are identifiable via:

(a) a large ORANGE icon in the appropriate Post(-contingency) calculated column/cell;

(b) a corresponding small ORANGE icon in the ST (thermal) or EM (voltage) column/cell.

3 | Constraints NOT exceeding LD or ST or EM, BUT exceeding the LT (i.e., Long Term) rating for thermals or the given branch are identifiable via:

(a) a large YELLOW icon in the appropriate Post(-contingency) calculated column/cell;

(b) a corresponding small YELLOW icon in the LT (thermal) column/cell.

4 | Finally, constraints that are deemed to be trending (i.e., at or below for thermal; OR at or above for voltage) within appropriate Post-contingency emergency ratings (LT, ST or EM, and LD) for a given branch/bus constraint are identifiable via:

(a) a large GREEN icon in the appropriate Post(-contingency) calculated column/cell;

(b) a corresponding small GREEN icon in the NL (i.e., Normal) rating column.

(c) these trending constraint conditions will show the corresponding icons in the Post(-contingency) and NL columns regardless of if the value exceeds or is merely approaching the NL value.

Branch ID	kV	Pre (MVA)	Post (MVA)	NL (MVA)	LT (MVA)	ST (MVA)	LD (MVA)
	500	490	585	197	197	197	226
	765	424	500	205	205	205	236
	230	624	870	706	865	865	892
	138	424	500	205	205	205	236
	138	389	429	351	449	459	495
	230	572	773	697	826	826	950

Bus ID	Pre (kV)	Post (kV)	NL (kV)	EM (kV)	LD (kV)
	120.8	117.2	131.1	127.0	124.2
	121.1	117.6	131.1	127.0	124.2
	126.6	123.3	131.1	127.0	124.2
	129.0	125.8	131.1	127.0	124.2
	129.0	125.8	131.1	127.0	124.2
	129.6	126.5	131.1	127.0	124.2
	131.0	127.8	131.1	127.0	124.2

Figure 7. Post Contingency Local Load Relief Warning examples of LD, ST, LT, EM and NL ratings trends/exceedances.

Current SA Exceedances table(s) constraint Status

The Status column shows the coordination condition with respect to PCLLRW issuances.

1 | Default state is null or blank, which is equivalent to a condition that PJM is monitoring but not in a state of PCLLRW issuance.

2 | **Unacknowledged** is the initial state of PCLLRW receipt from PJM.

(a) Clicking the **Unacknowledged** hyperlink takes the user to the TO Load Shed Plan form.

3 | **Valid** is a state when a TO user has acknowledged the PCLLRW by providing PJM with a valid load shed plan to mitigate the constraint.

(a) By identifying enough post-contingency load shed to mitigate the given post-contingency thermal overload or post-contingency under-voltage condition;

(b) Or, unique to those TOs with coordinated and pre-identified FLS procedures in place with PJM, by identifying that an automated Facility Load Shed [FLS] TO EMS action will address the given post-contingency thermal overload or post-contingency under-voltage condition.

(c) Valid PCLLRWs can be further viewed/revised by clicking the **Valid** hyperlink in the row corresponding to the given constraint which takes the user to the TO Load Shed Plan.

(d) Valid PCLLRWs will be placed into a Deficient state if the TO Load Shed Plan does NOT mitigate the given post-contingency thermal overload or post-contingency under-voltage condition.

4 | **Deficient** is a state when a PJM TO user acknowledges the PCLLRW but has NOT provided a valid load shed plan to mitigate the constraint.

(a) By not identifying a satisfactory amount of post-contingency load shed to mitigate the given post-contingency thermal overload or post-contingency under-voltage condition.

(b) Deficient PCLLRWs can be further viewed/revised by clicking the **Deficient** hyperlink in the row corresponding to the given constraint which takes the user to the TO Load Shed Plan form.

(c) Deficient PCLLRWs should subsequently be placed into a Valid state by the TO revising the TO Load Shed Plan in such a manner which sufficiently mitigates the post-contingency condition.

Figure 8. The four potential PCLLRW states, as reflected in the TO's Status column by constraint row.

Load Shed Plan sessions

There are several considerations to finalizing a PCLLRW-driven Load Shed Plan between PJM and the TO within TO Connection's PCLLRW sub-tool. For detailed information around the PCLLRW Emergency Procedure event, including PJM and Member actions, please PJM's Emergency Operations manual, M-13.

Load Shed Plan – Session Timer

Load Shed Plan sessions begin with a 5 minute countdown to finalize the Load Shed Plan.

- A user can extend a given session by clicking the "**Reset**" button, which will restart the 5 minute countdown without losing the user's data entry.

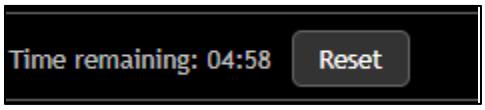


Figure 9. Session timer 5 minute shot clock and Reset option.

If session **Time remaining** reaches 00:00, a *Session Expired* popup message will inform the user of the need to reload the page.

- The user will have a fresh 5 minute clock, but will have lost their data entry progress within the form should the session expire.
- The user can **Click here to reload the page** hyperlink to begin a new form entry.

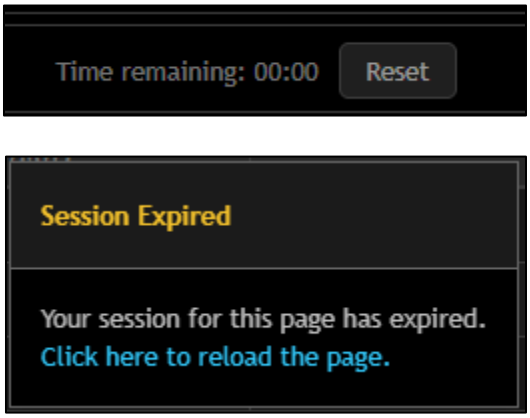


Figure 10. Session timer 5 minute shot clock expiration; and, Session Expired popup.

Load Shed Plan – Header

Load Shed Plans have an upper section just below the Session Timer which conveys detail around the given PCLLRW event. Variances exist between a thermal and that of a low voltage related PCLLRW. Breakdowns for each type follow with a Figure and Table by type..

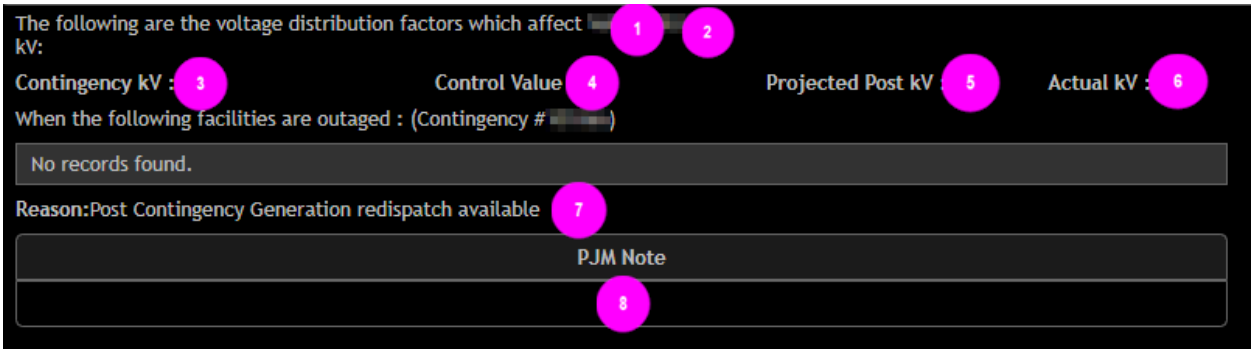


Figure 11. Header section of a low voltage PCLLRW, with callout areas identified.

Area	*Description*
1	**Substation** of the bus impacted by the post-contingency low voltage.
2	**kV Level** of the bus impacted by the post-contingency low voltage.
3	**Contingency kV:** The PJM state estimated post-contingency kV level for the bus identified by the PCLLRW in Areas #1 & #2 should the contingency occur. Equivalent to the Post (kV) column on the SA Exceedances tab.
4	**Control Value:** The PJM state estimated post-contingency kV level for the bus identified by the PCLLRW in Areas #1 & #2 should the contingency occur. Equivalent to the EM (kV) column on the SA Exceedances tab.
5	**Projected Post kV:** PJM Operator OPTIONAL field leveraged to estimate the most severe PJM state estimated post-contingency kV condition for the bus identified by the PCLLRW in Areas #1 & #2 should the contingency occur. When provided, the more severe of EITHER the Projected Post kV OR the Contingency kV field [i.e., the Post (kV) column on the SA Exceedances tab] is used in determining load shed plan validity.
6	**Actual kV:** At the time of PCLLRW issuance, the PJM state estimated pre-contingency kV level for the bus identified by the PCLLRW in Areas #1 & #2. Equivalent to the Pre (kV) column on the SA Exceedances tab.
7	**Reason:** PJM operator provided reason for PCLLRW issuance. Options include: • Post Contingency Switching available; • Post Contingency Generation redispatch available; • Load-No Generation or Switching available; • Generation – slow response; • BES 2 Facility; • Generation – called late; • Other **NOTE:** Reason field not shown if no PJM DFAX provided. Can be provided by PJM operator.

8	**PJM Note:** Provides an option for the PJM operator to provide further instruction, explanation to the impacted TO recipient. Default is "N/A".

Table 2. Low voltage Load Shed Plan Header section areas and descriptions as they relate to the preceding Figure.

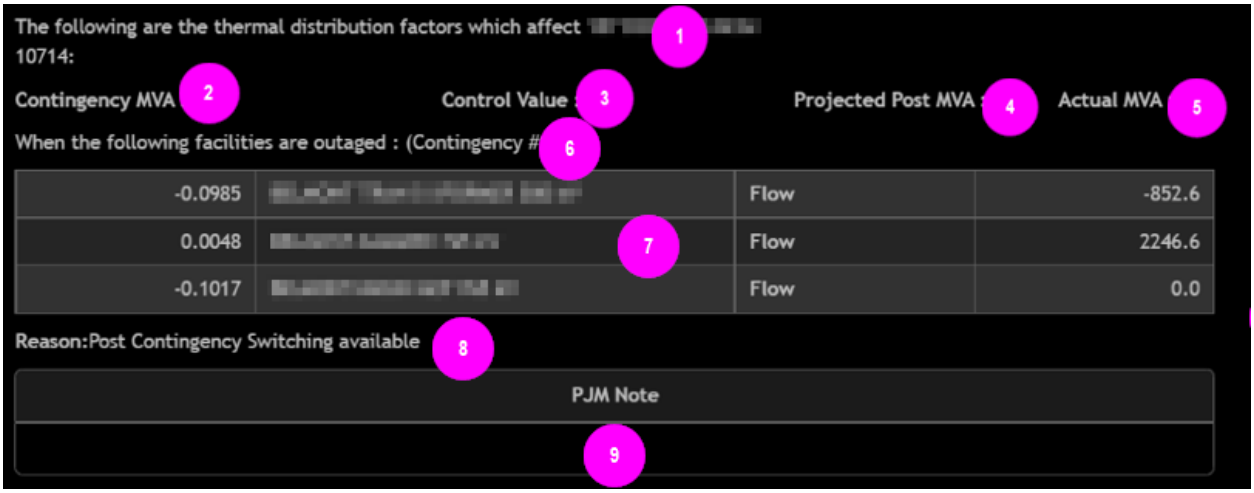


Figure 12. Header section of a thermal PCLLRW, with callout areas identified.

Area	*Description*
1	**Monitored equipment** name identifying the branch impacted by the post-contingency thermal condition.
2	**Contingency MVA:** At the time of PCLLRW issuance, the PJM state estimated post-contingency MVA for the branch identified by the PCLLRW in Area #1 should the contingency occur. Equivalent to the Post (MVA) column on the SA Exceedances tab.
3	**Control Value:** The PJM state estimated post-contingency MVA for the branch & contingency identified by the PCLLRW in Area #1. Equivalent to the LT (MVA) column on the SA Exceedances tab.
4	**Projected Post MVA:** PJM Operator OPTIONAL field leveraged to estimate the most severe PJM state estimated post-contingency kV condition for the branch identified by the PCLLRW in Area #1 should the contingency occur. When provided, the more severe of EITHER the Projected Post kV OR the Contingency kV field [i.e., the Post (MVA) column on the SA Exceedances tab] is used in determining load shed plan validity.
5	**Actual MVA:** At the time of PCLLRW issuance, the PJM state estimated pre-contingency MVA for the branch identified by the PCLLRW in Area #1. Equivalent to the Pre (MVA) column on the SA Exceedances tab.

6	**Contingency #:** The PJM EMS Contingency ID number associated with the contingency under which the PCLLRW is issued.
7	**Contingency tabular:** PJM's EMS breakdown of the contingency elements associated with the Contingency # field. PJM contingency analysis isolates each element, showing resultant distribution to the Monitored equipment in the 1st column, and result flow to the contingent element in the last column at various stages of the contingency execution. A contingency will always have at least one row, with additional rows depending on contingency definition complexity. Each switching element is not explicitly represented by a row within the given contingency definition, nor any load transfers, but the resulting impact of the full contingency definition is captured within the Contingency MVA field.
8	**Reason:** PJM operator provided reason for PCLLRW issuance. Options include: • Post Contingency Switching available; • Post Contingency Generation redispatch available; • Load-No Generation or Switching available; • Generation – slow response; • BES 2 Facility; • Generation – called late; • Other **NOTE:** Reason field not shown if no PJM DFAX provided. Can be provided by PJM operator
9	**PJM Note:** Provides an option for the PJM operator to provide further instruction, explanation to the impacted TO recipient. Default is "N/A".

Table 3. Thermal Load Shed Plan Header section areas and descriptions as they relate to the preceding Figure.

Load Shed Plan – DFAX Tabular

Figure 13. DFAX Tabular section of a **voltage** PCLLRW, with callout areas identified.

Area	*Description*
1	**Action buttons:** • Clicking **Confirm Load Plan** when the Cumulative Load Shed Relief field, identified as Area 11, is RED will result in a **Deficient** load shed plan **Status** for the individual PCLLRW. • Clicking **Confirm Load Plan** when the Cumulative Load Shed Relief field, identified as Area 11, is GREEN will result in a **Valid** load shed plan **Status** for the individual PCLLRW. • Clicking **Cancel** will return the user to the SA Exceedances tab.

2 **kV Relief Needed :** Represents the MINIMUM amount of load shed necessary to increase the post-contingency low voltage either above the EM emergency limit or above the Projected Post for the PCLLRW's monitored element.

3 **Zone:** Within a given row, represents the PJM EMS TO Zone affiliated with the **Station**, Area #4, AND **Name**, Area #5, load.

- This may include neighbors TO Zones adjacent to the user's TO Zone.
- Any load identified as being projected as part of the Load Shed Plan for a neighbors TO Zone by a given TO will be presumed to have been coordinated between the impacted parties involved.

4 **Station:** PJM EMS station name, aka, B1.

5 **Name:** PJM EMS equipment name, aka B3.

6 **Voltage Distribution Factor (kV/MW):** PJM Voltage DFAX package defined distribution factor, aka VDFAX, for the given equipment identified by the **Zone**, **Station** & **Name**.

- A VDFAX of 1.0000 indicates that load shed for the given equipment will alleviate flow and raise voltage on the Monitored bus that is the subject of the PCLLRW on a 1:1 ratio. 1:1 ratios are only present when the contingency sets up the load in a radial path post-contingency.
- A VDFAX of 0.2000 indicates that 20% of every MW shed on the given equipment will alleviate flow and raise voltage on the PCLLRW subject Monitored bus.

Unlike thermal DFAX, a VDFAX value may rise above a 1.0000 unity value due to the relief provided by the reactive, MVAR, component, Q, of the load in relation to the real power, MW component, P.

7 **PJM SE Station Load (MW):** At the time of PCLLRW issuance, provides the PJM stated estimated load for the given equipment identified by the **Zone**, **Station** & **Name**.

8

Transmission Owner Projected Load Shed (MW): TO utilizes this column to provide the post-contingency load to be shed in the event of a contingency in order to alleviate flow on the Monitored bus that is the subject of the PCLLRW.

- Multiple rows may be needed in order to provide the necessary relief.
- TO should ensure they are shedding non-critical load.

TO should project enough load shed to address the overload at the time of issuance, as well as any needed above that amount to address the overload throughout the lifecycle of the given PCLLRW event. (Typically, no longer than that peak period.)

9

Load Shed Relief (kV): PJM's PCLLRW sub-tool multiplies the **Voltage Distribution Factor (kV/MW)** column by the **Transmission Owner Projected Load Shed (MW)** column in order to determine the relief provided to the Monitored equipment that is the subject of the PCLLRW.

10

BTM: Identifies if PJM's EMS has identified Behind-the-Meter or Distributed Energy Resources affiliated with the **Station**, Area #4, AND **Name**, Area #5, load.

- When available, further information around BTM & DER related to the loads may be found in the **Behind-the-Meter DER in DFAX** and the **Matching Behind-the-Meter DER in PCLLRW** tables under the Load Shed Plan tabular fields.

11

Cumulative Load Shed Relief: This area provides a total amount of load shed as provided by the TO user based upon:

1 | The individual entries across the Transmission Owner Projected Load column;
2 | When applicable, any associated FLS automatic driven load shed relief amount.
3 | When applicable, any associated switching solution driven load shed relief amount.

- The cell field will show as GREEN when the total amount is greater than or equal to the kV Relief Needed (kV) field.
- The cell field will show as RED when the total amount is below the kV Relief Needed (kV) field.

TO should project enough load shed to address the overload at the time of issuance, as well as any needed above that amount to address the overload throughout the lifecycle of the given PCLLRW event. (Typically, no longer than that peak period.) If a Projected Post is provided by the PJM Operator, that is factored into the estimated load shed needed.

Table 4. **Voltage** Load Shed Plan Header section areas and descriptions as they relate to the preceding Figure.

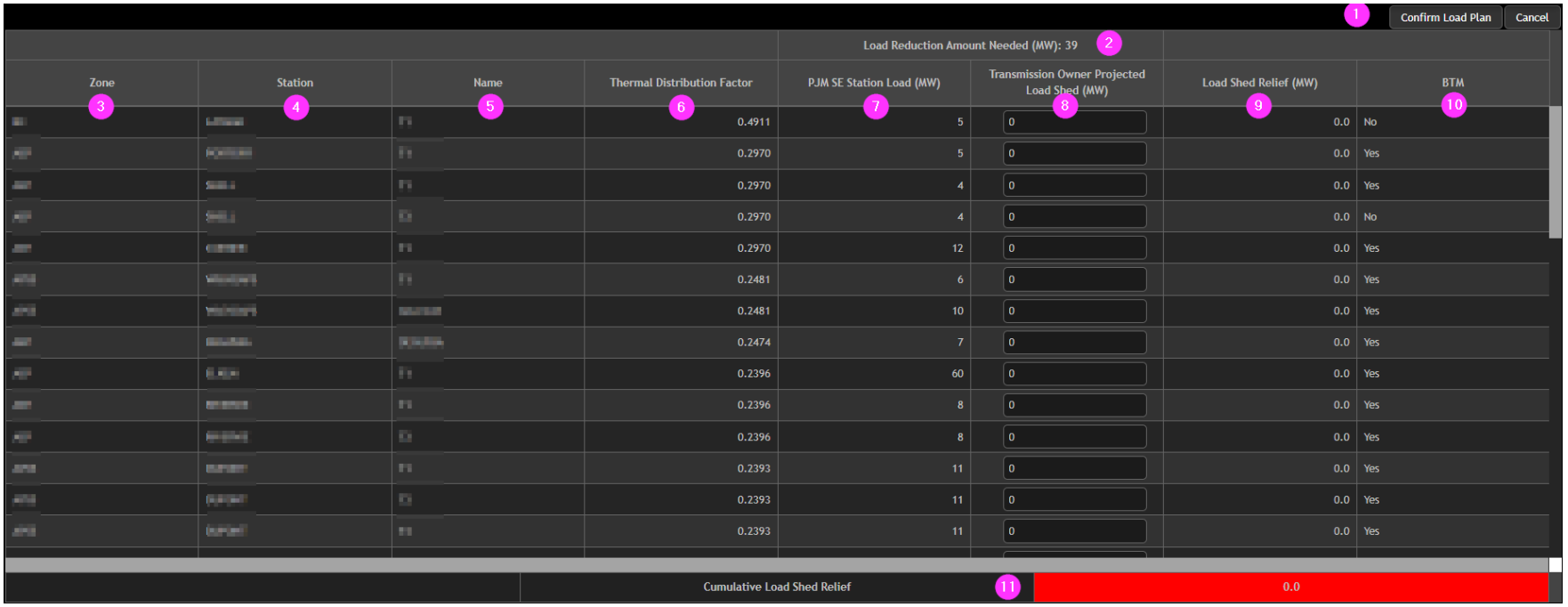


Figure 14. DFAX Tabular section of a **thermal** PCLLRW, with callout areas identified.

Area	*Description*
1	**Action buttons:** • Clicking **Confirm Load Plan** when the Cumulative Load Shed Relief field, identified as Area 11, is RED will result in a **Deficient** load shed plan **Status** for the individual PCLLRW. • Clicking **Confirm Load Plan** when the Cumulative Load Shed Relief field, identified as Area 11, is GREEN will result in a **Valid** load shed plan **Status** for the individual PCLLRW. • Clicking **Cancel** will return the user to the SA Exceedances tab.

2 **Load Reduction Amount Needed (MW):** Represents the MINIMUM amount of load shed necessary to reduce the post-contingency flow below the LT emergency limit or the Projected Post for the PCLLRW's monitored element.

3 **Zone:** Within a given row, represents the PJM EMS TO Zone affiliated with the **Station**, Area #4, AND **Name**, Area #5, load.

- This may include neighbors TO Zones adjacent to the user's TO Zone.
- Any load identified as being projected as part of the Load Shed Plan for a neighbors TO Zone by a given TO will be presumed to have been coordinated between the impacted parties involved.

4 **Station:** PJM EMS station name, aka, B1.

5 **Name:** .PJM EMS equipment name, aka B3.

6 **Thermal Distribution Factor:** PJM EMS contingency analysis package defined distribution factor, aka DFAX, for the given equipment identified by the **Zone**, **Station** & **Name**.

- A DFAX of 1.0000 indicates that load shed for the given equipment will alleviate flow on the Monitored equipment that is the subject of the PCLLRW on a 1:1 ratio. 1:1 ratios are only present when the contingency sets up the load in a radial path post-contingency.
- A DFAX of 0.2000 indicates that 20% of every MW shed on the given equipment will reduce flow on the PCLLRW subject Monitored equipment.

7 **PJM SE Station Load (MW):** At the time of PCLLRW issuance, provides the PJM stated estimated load for the given equipment identified by the **Zone**, **Station** & **Name**.

8 **Transmission Owner Projected Load (MW):** TO utilizes this column to provide the post-contingency load to be shed in the event of a contingency in order to alleviate flow on the Monitored equipment that is the subject of the PCLLRW.

- Multiple rows may be needed in order to provide the necessary relief.
- TO should ensure they are shedding non-critical load.

9	**Load Shed Relief (MW):** PJM's PCLLRW sub-tool multiplies the **Thermal Distribution Factor** column by the **Transmission Owner Projected Load (MW)** column in order to determine the relief provided to the Monitored equipment that is the subject of the PCLLRW.
10	**BTM:** Identifies if PJM's EMS has identified Behind-the-Meter or Distributed Energy Resources affiliated with the **Station**, Area #4, AND **Name**, Area #5, load. • When available, further information around BTM & DER related to the loads may be found in the **Behind-the-Meter DER in DFAX** and the **Matching Behind-the-Meter DER in PCLLRW** tables under the Load Shed Plan tabular fields.
11	**Cumulative Load Shed Relief:** This area provides a total amount of load shed as provided by the TO user based upon: **1 |** The individual entries across the Transmission Owner Projected Load column; **2 |** When applicable, any associated FLS automatic driven load shed relief amount. **3 |** When applicable, any associated switching solution driven load shed relief amount. • The cell field will show as GREEN when the total amount is greater than or equal to the Load Reduction Amount Needed (MW) field. • The cell field will show as RED when the total amount is below the Load Reduction Amount Needed (MW) field. *TO should project enough load shed to address the overload at the time of issuance, as well as any needed above that amount to address the overload throughout the lifecycle of the given PCLLRW event. (Typically, no longer than that peak period.) If a Projected Post is provided by the PJM Operator, that is factored into the estimated load shed needed.*

Table 5. **Thermal** Load Shed Plan Header section areas and descriptions as they relate to the preceding Figure.

Load Shed Plan – Facility Load Shed automation

The TO may enter the total amount of relief (MW for thermal or kV for voltage, as applicable) provided via an automated TO SCADA-controlled post-contingency switching, Facility Load Shed (FLS), option by:

- Selecting the **FLS** option in the lower portion of the form.
- Entering as an integer, in the **Amount** field, the total relief provided by the **FLS**.

Given the nature of the reliability concern involved, PJM recommends truncating, rather than rounding, during field entry. i.e., If a TO's FLS provides 2.9 MW or 2.9 kV of relief, that would equate to 2 MW or 2 kV.

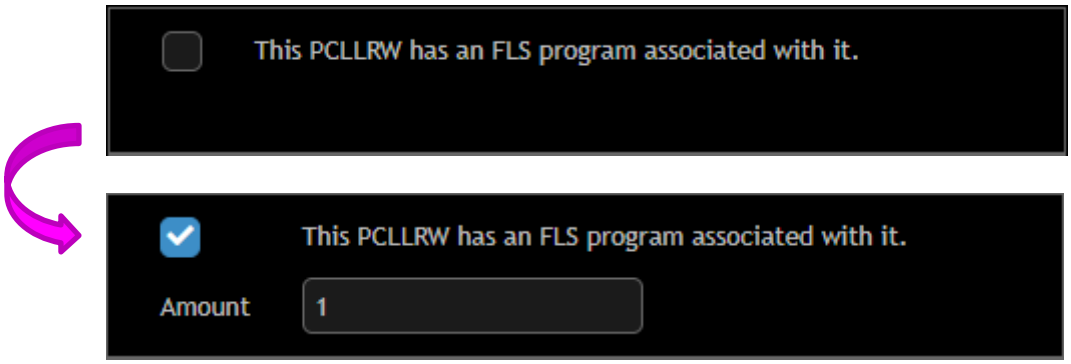


Figure 15. FLS option by default is unselected; and, as selected with a valid entry.

Load Shed Plan – Switching Solution

The TO may enter the total amount of relief (MW for thermal or kV for voltage, as applicable) provided via a TO SCADA-controlled post-contingency switching option by:

- Selecting the **switching solution** option in the lower portion of the form.
- Entering as an integer, in the **Amount** field, the total relief (MW or kV) provided by the post-contingency switching solution.

Given the nature of the reliability concern involved, PJM recommends truncating, rather than rounding, during field entry. i.e., If a TO's post-contingency switching solution provides 2.9 MW or 2.9 kV of relief, that would equate to 2 MW or 2 kV.

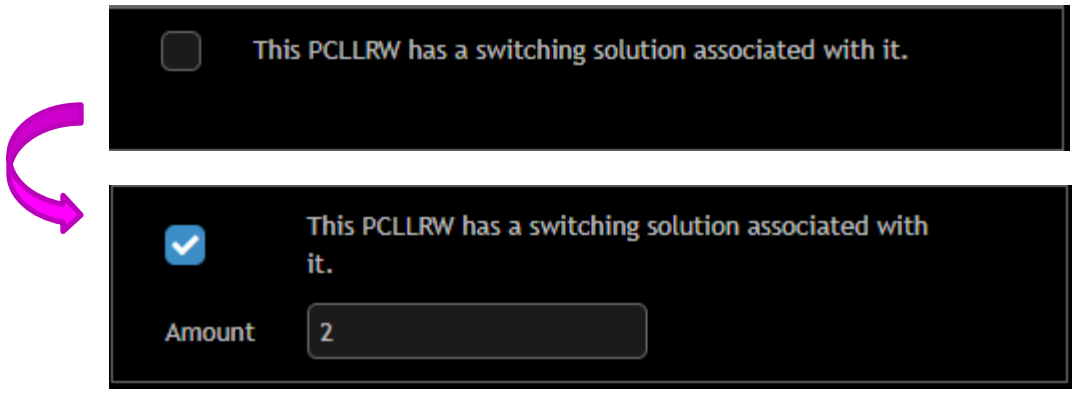


Figure 16. Switching Solution option by default is unselected; and, as selected with a valid entry.

PCLLRW Acknowledgement Only (No DFAX provided)

In the unlikely event PJM becomes unable to obtain DFAX for the constraint pair within the sub-tool, the tool will simply serve as a method for the TO to Acknowledge receipt, and the remainder of Load Shed Plan coordination will take place outside the tool between PJM operators and the impacted TO(s).

Figure 17. PCLLRW acknowledge screen with no associated DFAX provided by PJM.

Status	*Options*	*Description*
Unacknowledged	Acknowledge	When PJM initiates a PCLLRW with a TO, the PCLLRW sub-tool will show the constraint pair Status as **Unacknowledged**. Ack
	Go Back	Return to SA Exceedances tables; with PCLLRW remaining in **Unacknowledged** Status.

Table 6. Unacknowledged Options and Descriptions.

Relief Needed with Project Post Banners

Load Shed Plan is assessed and validated each time a new dataset is provided by EMS (Post MVA or Post KV or new DFAX) or user-provided Projected Post or a change in the external-provided Load Shed plan.

The Status of Valid or Deficient is updated in a banner at the top of the application. If the relief needed is more than the existing Load Shed Plan, the banner message will be updated to reflect that a deficient load shed plan has been submitted or has become deficient. If the relief needed is less than the existing Load Shed Plan, the banner message will be updated to show that a valid load shed plan has already been submitted.

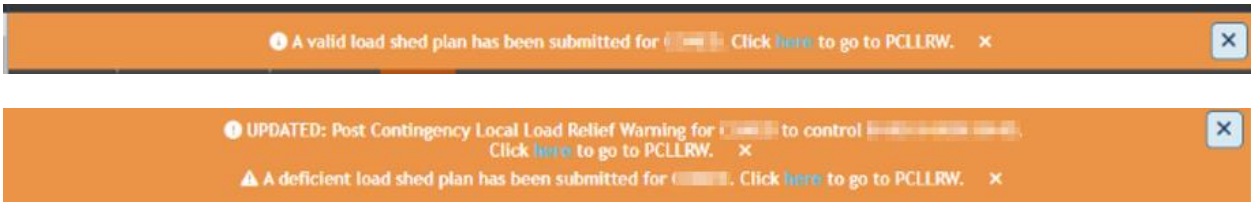


Figure 18. Examples of Valid and Deficient banners.

Behind-the-Meter DER

The Behind-the-Meter DER tab provides detail around all known Behind-the-Meter / Distributed Energy Resources [BtM / DER] within PJM, including the closest associated PJM Bulk Electric System [BES] substation. Additional information, where provided, related to an individual BtM / DER can be found by leveraging the Details dropdown icon .

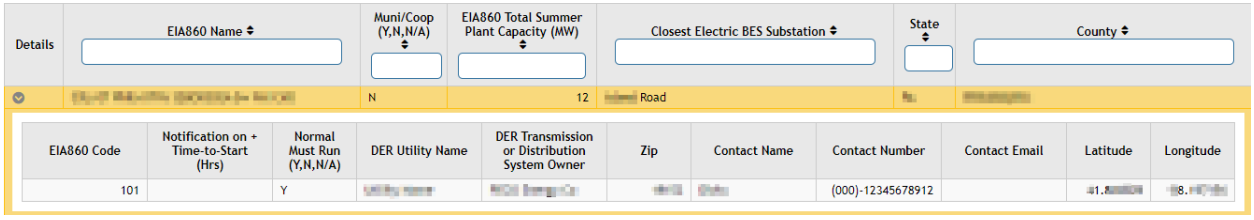


Figure 19. BtM / DER example image along with expanded Detail (collapsible by clicking the icon) showing additional fields.

PCLLRW Event Historian

The PCLLRW Event Historian displays previously issued Load Shed Plans in reverse chronological order. This historian is found by clicking the "Event Historian: button located under the Post Contingency Local Load Relief Warning header. The information displayed includes the following fields:

- Event
- Event Start and Event End
- User
- Company

- Branch/Bus ID
- kV
- Contingency Title
- Status
- TO Load Shed Plan: This is a hyperlink which will bring the user to the Load Shed Plan.

Expanding any given row will also display each event trigger for the given event such as the status changing between the following options: Issue, Reissue, Reissue with a change in Projected Post, and Cancelled. Once expanded, the following fields will be displayed:

- Event Start and End
- User
- Control Value
- SA Post
- Projected Post

The Event Historian shows a maximum of a 90 day date range and will default the start date to be yesterday and the end date to be today. The dates range can be changed by using the Occurring During Start and End date filters at the top of the display. These date ranges are inclusive and future dates are invalid.

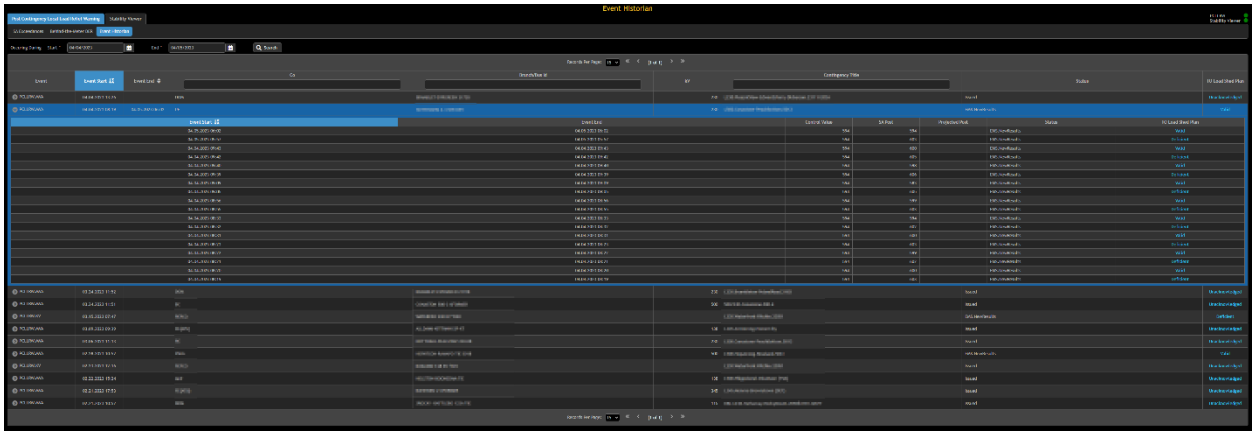


Figure 20. Event Historian with an expanded row.

Switching Solution Tracker

Located under the Post Contingency Local Load Relief Warning tab, the Switching Solution [S/S] Tracker provides default visibility to all active topology control solutions across the RTO. The Tracker can be further expanded via the dropdown below to include returned switching solutions across the RTO up to one year in the past.

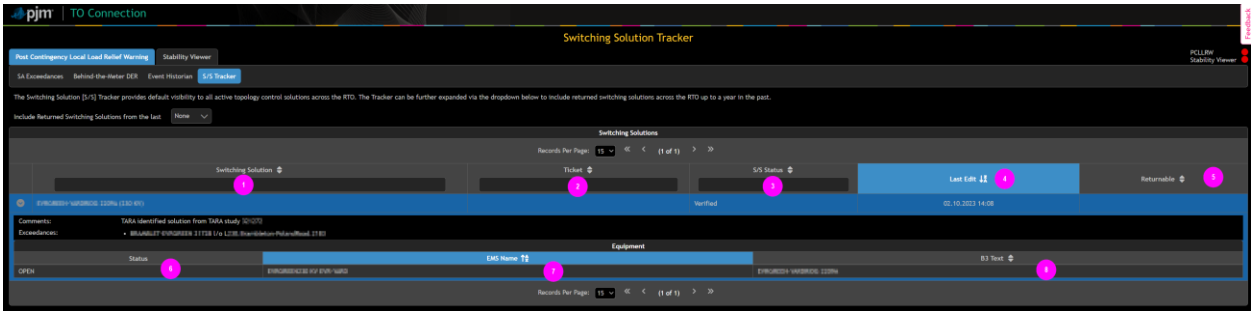


Figure 21. S/S Tracker with an expanded row.

Area	*Description*
1	**Switching Solution:** Name of switching solution.
2	**Ticket:** If the switching solution is associated with a specific eDART ticket, the ticket number will be displayed here. If no eDART ticket is associated with the switching solution, then the field will be blank.
3	**Status:** Switching solutions will have the following statuses: • Verified: This switching solution has been verified as a valid solution with the TO. • Implemented: This switching solution is currently implemented. • Returned: This switching solution has been returned and no longer implemented.
4	**Last Edit:** Timestamp of last edit to switching solution.
5	**Returnable:** Yes/No indicators to indicate whether or not an Implemented S/S is returnable.
6	**Status:** Indicates the status of the equipment within the switching solution
7	**EMS Name:** PJM EMS equipment name
8	**B3 Text:** B3 Text of equipment

Options for filtering the S/S Tracker include switching solutions from the last 1 day, 7 days, 30 days, 90 days, 6 months, and 12 months. By default, the page will not be filtered (None).

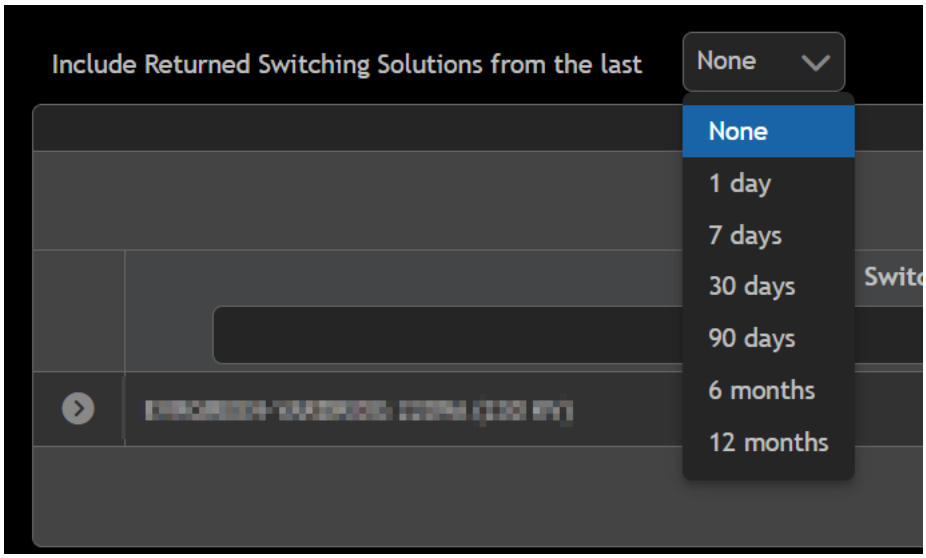


Figure 22. S/S Tracker filter

PCLLRW interfaces

For issuance via the PCLLRW tool writes direct to the following PJM tools:

- *SmartLogs* – PJM internal tool leveraged for logging PJM operator daily events.
- *Emergency Procedures* – PJM internal/external tool utilized in the sharing of PJM Emergency Procedure events covered within PJM's Emergency Procedures manual, M-13.

PCLLRW receives input from the following PJM tools:

- *EMS SA* – Provides contingency analysis (aka, Security Analysis or SA) results, as well as thermal distribution factors (DFAX) which determine load reduction benefit for a given thermal monitored element + contingency constraint pair.
- *VDFAX* – Tool which generates voltage distribution factors (VDFAX) used to determine load reduction benefit for a given voltage monitored element + contingency constraint pair.
- *Real Time Topology Control (RTTC)* – A tool which monitors RT SA Thermal results and proposes switching solutions which could be used in lieu of generation control to alleviate exceedances.

Stability Viewer sub-tool

Stability Viewer purpose

PJM Dispatchers utilize the *Stability Viewer* sub-tool as a logging and historian for unit or area stability restrictions throughout PJM. PJM member Transmission Owners are provided visibility around the *Stability Viewer* sub-tool within the *TO Connection* application as awareness around unit or area stability restrictions in the PJM footprint.

Known stability impacted areas with calculated limits are captured within PJM's Transmission Operating Procedures manual, M-03B. (PJM Manuals) In addition to the predefined area limitations, PJM has additional internal tools which allow for the study or Real-time adjustment to certain limits based upon the topology of the system for the given time space. PJM shares these limitations as they manifest themselves directly to impacted PJM Generation Owners. Stability Viewer provides additional visibility to PJM Transmission Owners.

Stability Viewer features

Stability Limits

Stability Limits are made up of three components:

Stability (Unit or Area) + Stability Type + Stability Value = Stability Limit

Stability Limits are either established against a single unit; Or, against a set of units grouped into a single Stability Area.

Stability Limits restriction *Types* are defined as follows:

Type	Units	Areas	Description
MW.Max	✓	✓	A megawatt (MW) maximum (Max), or real power, restriction for a given single unit or a defined unit group. Once established, the unit, or unit collective, is not to exceed that value until PJM lifts the restriction.
MVAR.Max	✓	✓	A megavar (MVAR) maximum (Max), or lagging reactive power, restriction for a given single unit or a defined unit group. Once established, the unit, or unit collective, is not to exceed that value until PJM lifts the restriction.
MVAR.Min	✓	✓	A megavar (MVAR) minimum (Min), or leading reactive power, restriction for a given single unit or a defined unit group. Once established, the unit, or unit collective, is not to exceed that value until PJM lifts the restriction.
Pumps.Max	✗	✓	A pumped storage facility restriction defined by a maximum number of units for a given area that can operate in a pumping mode. Established against a Stability Area, not against a single unit.

Gens.Max	✗	✓	Defines a maximum number of units for a given area that can operate in a generating mode. Established against a Stability Area, not against a single unit. Utilized for non-pumped storage facilities as well as pumped storage facilities.

Stability Limit restriction *Values* are expressed as a positive or negative integer. For both MVAR.Min and MVAR.Max restrictions, the value being negative would be an indication of a Leading reactive limit, and likewise a positive integer would indicate if the Min or Max restriction was a Lagging reactive limit.

Table 7. Stability Limit restriction Types.

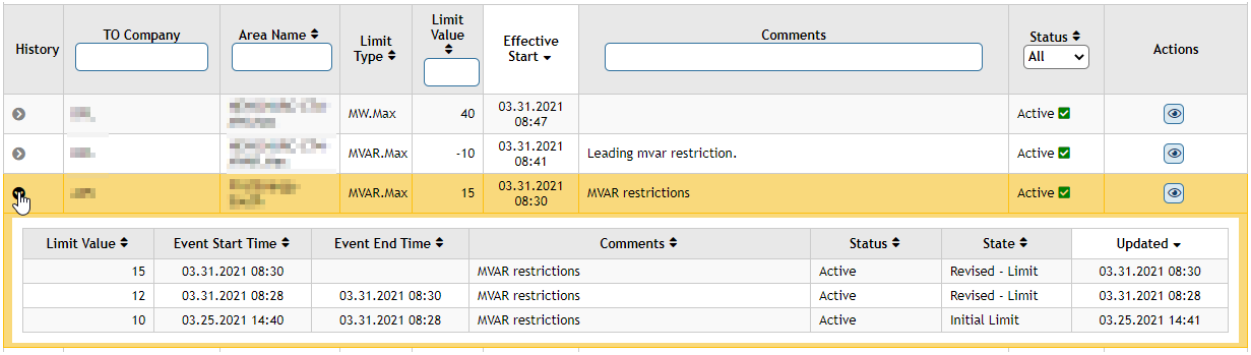
The Stability Limits tab/table shows the active stability limits in place across the PJM RTO. Columns represented for the TO member view include:

- **History**: A right arrow icon ( ) that when clicked, will convert ( ) and display a sub-table for the given Stability Limit event showing the evolution over time.
- **TO Company**: Represents a given TO transmission zone as reflected in PJM's EMS.
- **Area Name**: Defines the Stability Area name, which can either reflect a single unit, as a combination of the PJM EMS B1 & B3 names, or as a PJM defined Stability Area. Further information around the units that comprise either of these can be found via the "View Units" function in the Actions column.
- **Limit Type**: Stability limit restriction type as defined in Table 1 above.
- **Limit Value**: Either a positive integer reflecting a real or reactive power restriction, or a maximum number of units for a given area; Or, a negative (-) integer reflecting a reactive power restriction.
- **Effective Start**: Reflects the initial time associated with a given Stability Limit
- **Comments**: Any comments provided by PJM staff to help define the Limit/change.
- **Status**: Given that the main page only shows limits that have not reached an end state, *Active* or *Pending* statuses are the only options presented for the given limit. *Active* is in place. *Pending* is slated for a future date.
    - The Historian tab expands the options and includes *Closed* or *Cancelled* statuses. Active limits will reach a *Closed* end Status. Pending limits that never become Active may reach a *Cancelled* end Status.
- **Actions**: Selecting the eye icon ( ) allows the user to view further detail around the unit(s) that are associated with the given limit such as NA Name, B1 Name, B2 Name, B3 Name, B3 Text, Unit ID, Installed Capacity (MW), GO Name, Province/State, TO Name.

Fields reflected within Stability Limit's individual event history.

- **Limit Value**: Covered above.
- **Event Start Time**: Beginning timeframe for the given log.

- **Event End Time**: End timeframe for the given log. (NOTE: Pending limits effectively are provided with the identical Event Start Time and Event End Time. The limit is only proposed for a given start time. Active limits are expected to have a delta between their Event Start Time and Event End Time.)
- **Event Start Time**: Populates when the Stability Limit (Unit/Area + Type) ends.
- **Comments:** Covered above.
- **Status:** Covered above.
- **(Event) State:** Displays the state associated with an event. Options include:
    - *Pending* → A proposed limit for a future date. Associated with *Pending* Status only. Subsequent changes, prior to reaching an Active Status, are also marked as *Pending*.
    - *Cancelled* → A proposed *Pending* limit that never reached an *Active* state.
    - *Initial Limit* → The first activation for a given limit having reached an *Active* Status.
    - *Revised – Comment* →Any *Active* Status limit with an update to the Comment field ONLY and thus does not substantively change the limit.
    - *Revised – Limit* → Any *Active* Status limit with an update to the Limit field (may also include an update to the Comment field).
    - *Closed* → An Active Status limit which reaches end state.
- **Updated:** The timestamp associated with the event state update.



History	TO Company	Area Name	Limit Type	Limit Value	Effective Start	Comments	Status	Actions
			MW.Max	40	03.31.2021 08:47		Active	
			MVAR.Max	-10	03.31.2021 08:41	Leading mvar restriction.	Active	
			MVAR.Max	15	03.31.2021 08:30	MVAR restrictions	Active	

Limit Value	Event Start Time	Event End Time	Comments	Status	State	Updated
15	03.31.2021 08:30		MVAR restrictions	Active	Revised - Limit	03.31.2021 08:30
12	03.31.2021 08:28	03.31.2021 08:30	MVAR restrictions	Active	Revised - Limit	03.31.2021 08:28
10	03.25.2021 14:40	03.31.2021 08:28	MVAR restrictions	Active	Initial Limit	03.25.2021 14:41

Figure 23. Example showing event History changes for a MVAR.Max restriction starting at 10 MVAR (lagging) on 3/25 @ 14:40 and increasing to 12 MVAR on 3/31 @ 08:28, then increasing again on 3/31 to 15 MVAR lagging limit maximum restriction. (i.e., The unit must remain below 15 MVAR lagging.)

Stability Areas

Stability Areas are made up of two or more units and defined to be as one of two Types:

- **M03B** – Those areas that are predefined by operating procedure around stability within the PJM Transmission Operating Procedure manual, M-03B.
- **User** – Those areas that are defined by a PJM operator ad-hoc in order to alleviate a given system condition.

Stability Areas are defined by the following fields, as well as the units that they contain.

- **Name** – Unique name to capture the essence of the area.
- **Description** – Provides further clarity, as needed to help define the area.
- **Type** – Either *M03B* or *User*, as defined above.
- **Created** – Initial creation timestamp for the given area.
- **Active** – Indicates availability. If "true", the area remains available. If "false", the area is retired.
- **Actions** - Selecting the eye icon ( ) allows the user to view further detail around the units that are associated with the given Area such as NA Name, B1 Name, B2 Name, B3 Name, B3 Text, Unit ID, Installed Capacity (MW), GO Name, Province/State, TO Name.

Historian

Changes (events) over time that have an *Event End Time* are shown by default in a reverse chronologic order based on *Updated* timestamp and *Event End Time*. The *Historian* tab will thus provide a history over time of all the proposed and effective stability limits issued via the tool. *i.e., What has changed?*

The *Historian* leverages the same fields described in earlier sections.

Its presentation varies from the *Stability Limits* tab in that it shows a mix of what has transpired through time at PJM, including both *Closed* & *Cancelled* Statuses, whereas the *Stability Limits* tab focuses only on *Active* & *Pending* Statuses.

To narrow down the *Historian* to a single area/unit consideration, leveraging the *Area Name* and *Limit Type* while focusing the *Occurring During: Start* and/or *End* fields to the date(s) of your concern will help to hone in on a specific Stability Limit and its changes through time are portrayed in the remaining fields.

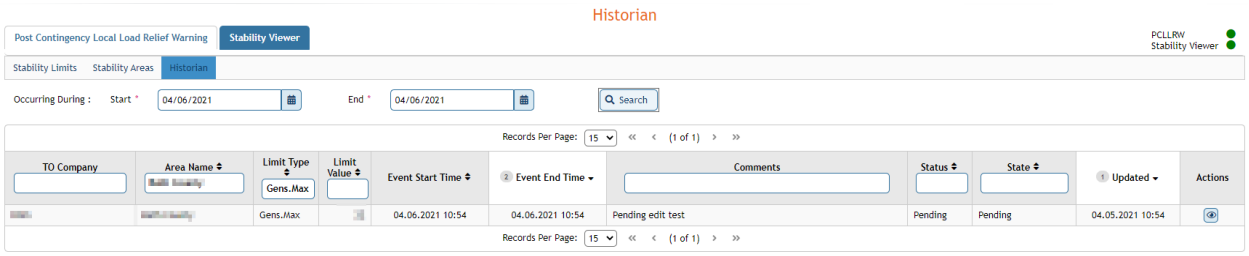


Figure 24. Example showing Historian honing in on a single Limit pair by leveraging the **Area Name** and **Limit Type** in concert with the **Occurring During***: **Start*** and ***End*** fields.

Stability Viewer interfaces

Issuance via the Stability Viewer tool writes direct to the following PJM tools:

- *SmartLogs* - PJM internal tool leveraged for logging PJM operator daily events.

Stability Viewer receives input from the following PJM tools:

- *Dart* – Dart (aka, eDART) provides unit detail information used in the identification of units and within Stability Area definitions.

Questions or Feedback

For questions or feedback around tool functionality, or suggested improvements to this guide, please utilize the following to direct your question:

TOConnection.Admin@pjm.com – Catch all, will reach the administrators of all tools within the TO Connection framework, including those listed below.

PCLLRW.Admin@pjm.com – For inquiries related to PCLLRW.

StabilityViewer.Admin@pjm.com – For inquiries related to Stability Viewer.

Version History

Version	Final Draft Date	Description
7	26 Sept 2023	Addition of Switching Solution Tracker
6	23 May 2023	Minor typos and clarifications.
5	18 Apr 2023	Updated to reflect Projected Post and Historian features.
4	25 Oct 2021	Corrected page numbering within Footers across sections.
3	20 Oct 2021	Publishing in alignment with PCLLRW visual improvement release (v1.1.0).
2	18 May 2021	Minor typos and clarifications.
1	13 May 2021	Inserted a new Figure 6, and expanded DER/BtM information.
0	05 May 2021	First publishing in alignment with Stability Viewer & TO Connection introduction.