Emergency Procedures: Voltage Emergencies

With Reactive Reserve Checks (RRCs)

Student Guide

Prepared by:
State & Member Training

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Objectives

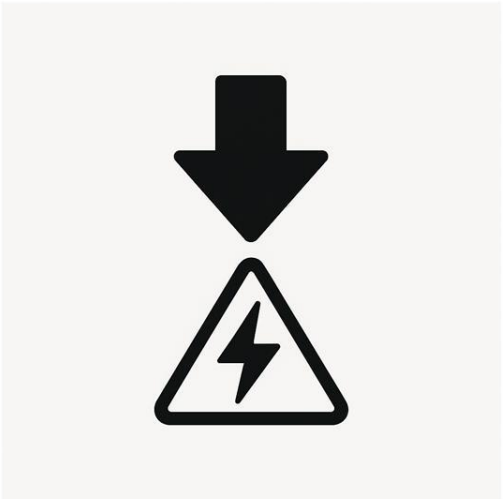
- Identify PJM and Member actions that will be taken once PJM initiates Voltage Control Emergency Procedures

Voltage Emergencies

Voltage Emergencies

Low Voltage Alert

Purpose: Heighten awareness, increase planning, analysis and preparation efforts when heavy loads and low voltages are anticipated in an upcoming period



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PJM Actions - Low Voltage Alert

Notifications

- Request Reactive Reserve Check
- Enhance communications

Operations

- Conduct power flow analysis of future load and transfer increases
- Review generation and transmission outages and their impact on voltage
- Assess the impact of transfers, be prepared to curtail transactions impacting reactive transfer limits
- Using the NERC Interchange Distribution Calculator, assess the impact of parallel flows

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PJM Actions - Low Voltage Alert

- Power Flow Analysis:
  - Evaluate and plan using the analysis, to include:
    - Ensuring necessary off-cost generation is ready to respond to transfer constraints
    - Consider changing the Reactive Transfer back off limit from 50 MW to 300 MW

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Member Actions - Low Voltage Alert

Notifications

- Notify management, all stations, and key personnel
- Respond to the Reactive Reserve Check

Operations

- Defer maintenance or testing affecting capacity or critical transmission

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Heavy Load Voltage Schedule Warning

Purpose: Prepare for maximum support of voltages on the BES

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PJM Actions - Heavy Load Voltage Schedule Warning

Notifications

- *Issue* the Heavy Load Voltage Schedule Warning **four hours prior** to requesting actual implementation of the HLVS; *Cancel* when appropriate

Operations

- Request that Members verify all actions have been taken on the distribution and sub-transmission systems to support voltages at the EHV level

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Member Actions - Heavy Load Voltage Schedule Warning

Operations

- Ensure, while still observing established limits:
  - Underlying reactors are **out** of service
  - Underlying capacitors are **in** service
  - Transformer taps are adjusted to ensure all distribution capacitors are **in** service
  - AVRs are **in** service on generating units

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Heavy Load Voltage Schedule Action

Purpose: Issued at peak load periods to request maximum support of voltage on the bulk power system and to increase reactive reserves at the EHV level

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PJM Actions - Heavy Load Voltage Schedule Action

Notifications

- *Issue* the Heavy Load Voltage Schedule Action; *Cancel* when appropriate

Operations

- Request all companies implement the Heavy Load Voltage Schedule

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Member Actions - Heavy Load Voltage Schedule Action

Notifications

- Inform PJM of any units approaching max MVAR output, unit MVAR restrictions, or AVRs out of service

Operations

- Ensure, while still observing established limits:
  - Underlying reactors are **out** of service
  - Underlying capacitors are **in** service
  - Capacitors on the 500 kV system with PLCs are in service
  - AVRs are **in** service on generating units

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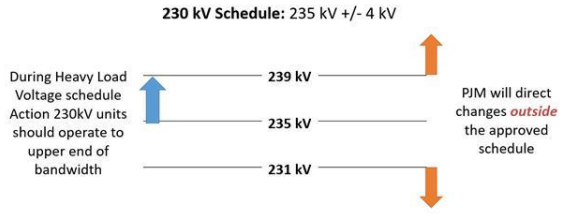
Member Actions - Heavy Load Voltage Schedule Action

Generating Unit Operation

- Units on the 230 kV system and below:
  - Increase MVAR output as necessary to maintain bus voltages or nominal voltages, whichever is greater
  - Voltage levels should be maintained within predetermined limits at all times
- Units on the 500 kV system and above:
  - Operated to maintain a reasonable MVAR reserve
  - Reactive moves on these units should be coordinated with PJM



During a HLVS Action, units on the 230 kV system should operated to the upper bandwidth setting.

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High System Voltage

Purpose: Prepare the system for expected high voltages

- Coordinate with TOs to take steps to control high voltage prior to entering a light load period
- Take actions in real time when portions of the PJM RTO are experiencing a low load/high voltage condition

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PJM Actions - High System Voltage

Notifications

- *Issue* the High System Voltage message, directing companies to take action to control high system voltage; *Cancel* when appropriate

Operations

- Coordinate with TOs/GOs to direct generators to be operated outside their voltage schedule bandwidth on a case-by-case basis

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Member Actions - High System Voltage

Notifications

- GDs communicate with PJM and TOs any restrictions on unit ability to absorb MVARs if it varies from reported capability
- TOs communicate with PJM all LTC and voltage schedule adjustments

Operations

- Transmission Owners
  - Ensure all switchable capacitors are out of service and SVCs are operating in the lead
  - Ensure all available shunt reactors are in service
  - Review and adjust LTC settings as appropriate
  - Review and adjust generator voltage schedules to have generators absorb reactive power
- Generation Owners
  - Operate generators at the lower bandwidth of their voltage schedule when possible

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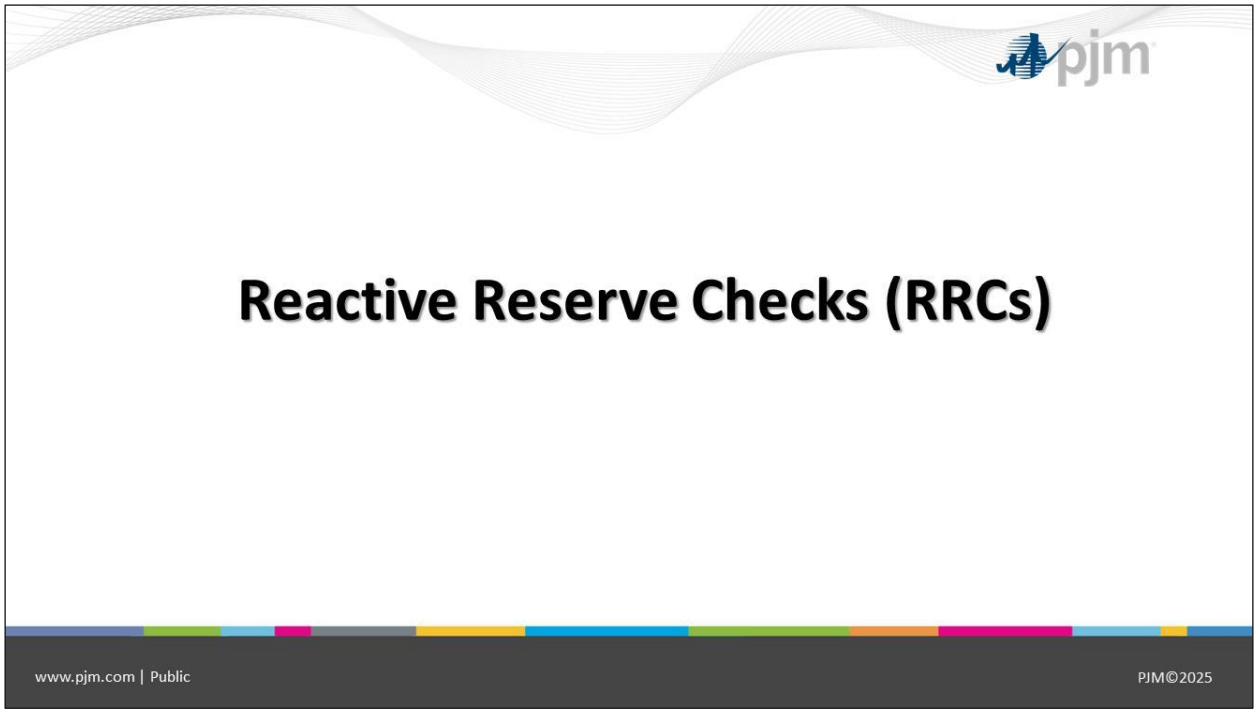
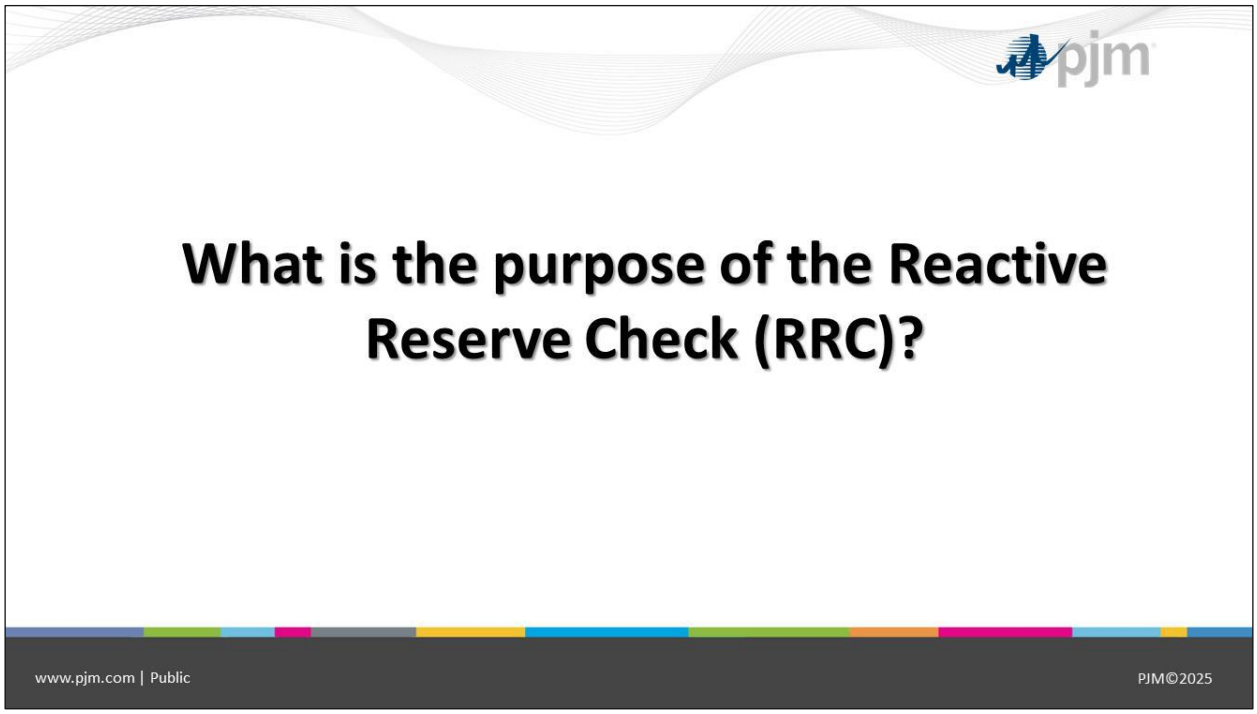
Reactive Reserve Checks





PJM Actions - RRC

Notifications

- Initiate RRC within eDART, requesting response for entire RTO or on a Control Zone basis
- Announce RRC via the ALL-CALL

Operations

- Take snapshot of reactive reserves from the PJM EMS for comparison purposes
- Work with members to:
  - Resolve discrepancies in reported reserves
  - Correct capability data as needed to ensure accurate Contingency Analysis results

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Member Actions - RRC

Generation Owners

- Outside of an RRC
  - Report capability, status and/or availability of reactive equipment per normal procedures
  - Notify TO/PJM regarding unit reactive performance issues and update eDART as appropriate
- During an RRC
  - No action required, unless directly requested by PJM/TO

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Member Actions - RRC

Transmission Owners

- Outside of an RRC
  - Report capability, status and/or availability of reactive equipment per normal procedures
  - Review eDART Reactive Capability Curves for units within their zone
    - If discrepancies are found, update EMS or reconcile with PJM/GO
  - Compare company EMS information on equipment-level basis to PJM EMS data via the *RRC Self-Check* form
- During an RRC
  - Enter required data in eDART via the eDART RRC form

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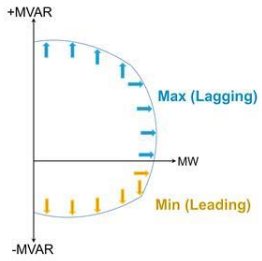
Calculating Capability Values - RRC

Units & Condensers: *Using its current MW value & LAGGING or LEADING value*	**Capacitors:** *Online = In-Service*
LAGGING: Current MWs MVAR Max – Current MVAR value LEADING: Current MWs MVAR Min – Current MVAR Value	LAGGING: Total Available Offline MVARs (Can be Added) LEADING: Total Available Online MVARs (Can be Removed)
SVCs & STATCOMS:	**Reactors:**
LAGGING: Unit's MVAR Max – Current MVAR value LEADING: Unit's MVAR Min – Current MVAR value	LAGGING: Total Available Online MVARs (Can be Removed) LEADING: Total Available Offline MVARs (Can be Added)



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Example - Steam Unit

RRC Example 1

- A steam unit is online at 380 MW
- Its current MVAR output is at 62 MVAR lagging
- What is the LAGGING and LEADING MVAR reserve for this unit?

Unit/Condenser		
MW Point	MVAR Min	MVAR Max
135	-12	121
350	-12	145
360	-12	150
370	-12	155
375	-12	150
380	-12	147
390	-12	73
400	-12	0

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Example - Condenser

RRC Example 2

- A Condenser is online and its current output is 45 MVARs lagging
- What is the LAGGING and LEADING MVAR reserve for this unit?

Unit/Condenser		
MW Point	MVAR Min	MVAR Max
0	-16	50
20	-15	50
25	-14	40
30	-13	35
35	-12	35
40	-11.5	30
45	-11	35
50	-10.5	25
55	0	0
60	0	0

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Example - SVC/STATCOMs

SVC/STATCOM Example

- A SVC is online and is currently at -12 MVARs leading
- What is the LAGGING and LEADING MVAR reserve for this facility?

SVC		
MW Point	MVAR Min	MVAR Max
NA	-50	175

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Example - Capacitor/Reactor

Capacitor/Reactor Example

- What are the LAGGING and LEADING MVAR reserves based on the status of these devices?

Capacitors		
Station Equipment Name	SE Status	Rated or Actual MVAR
Station 1 Cap 1	Offline	85
Station 1 Cap 2	Offline	85
Station 2 Cap A	In-Service	50
Station 3 Cap 1	In-Service	30

Reactors		
Station Equipment Name	SE Status	Rated or Actual MVAR
Station 1 Reactor 1	In-Service	50
Station 1 Reactor 2	Offline	50
Station 5 Reactor A	In-Service	40

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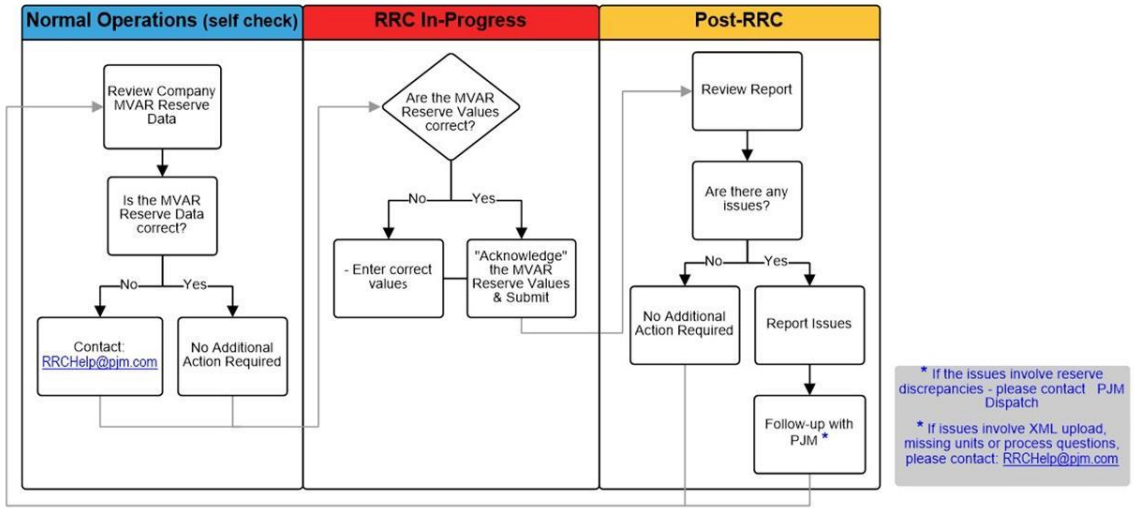
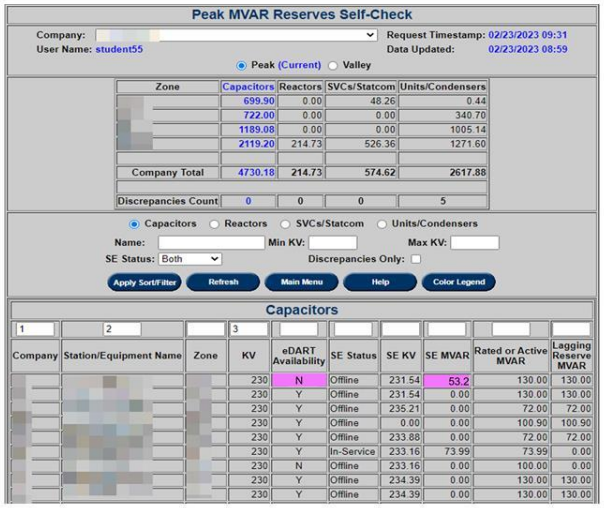
RRC Flow Chart



Peak Capacitor Reactive Reserve Self-Check



Peak MVAR Reserves Self-Check

Company: [redacted] Request Timestamp: 02/23/2023 09:31
User Name: student55 Data Updated: 02/23/2023 08:59

Peak (Current) Valley

Zone	Capacitors	Reactors	SVCs/Statcom	Units/Condensers
[redacted]	699.90	0.00	48.26	0.44
[redacted]	722.00	0.00	0.00	340.70
[redacted]	1189.08	0.00	0.00	1005.14
[redacted]	2119.20	214.73	526.36	1271.60
Company Total	4730.18	214.73	574.62	2617.88
Discrepancies Count	0	0	0	5

Capacitors Reactors SVCs/Statcom Units/Condensers

Name: Min KV: Max KV:

SE Status: Both Discrepancies Only:

Apply Sort/Filter Refresh Main Menu Help Color Legend

Capacitors

Company	Station/Equipment Name	Zone	KV	eDART Availability	SE Status	SE KV	SE MVAR	Rated or Active MVAR	Lagging Reserve MVAR
[redacted]	[redacted]	[redacted]	230	N	Offline	231.54	53.2	130.00	130.00
[redacted]	[redacted]	[redacted]	230	Y	Offline	231.54	0.00	130.00	130.00
[redacted]	[redacted]	[redacted]	230	Y	Offline	235.21	0.00	72.00	72.00
[redacted]	[redacted]	[redacted]	230	Y	Offline	0.00	0.00	100.90	100.90
[redacted]	[redacted]	[redacted]	230	Y	Offline	233.88	0.00	72.00	72.00
[redacted]	[redacted]	[redacted]	230	Y	In-Service	233.16	73.99	73.99	0.00
[redacted]	[redacted]	[redacted]	230	N	Offline	233.16	0.00	100.00	0.00
[redacted]	[redacted]	[redacted]	230	Y	Offline	234.39	0.00	130.00	130.00
[redacted]	[redacted]	[redacted]	230	Y	Offline	234.39	0.00	130.00	130.00

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Peak Reactor Reactive Reserve Self-Check

Peak MVAR Reserves Self-Check

Company: [redacted] Request Timestamp: 02/23/2023 09:31
User Name: student55 Data Updated: 02/23/2023 08:59

Peak (Current) Valley

Zone	Capacitors	Reactors	SVCs/Statcom	Units/Condensers
[redacted]	699.90	0.00	48.26	0.44
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Company Total	4730.18	214.73	574.62	2617.88
Discrepancies Count	0	0	0	5

Capacitors Reactors SVCs/Statcom Units/Condensers

Name: Min KV: Max KV:

SE Status: Both Discrepancies Only:

Apply Sort/Filter Refresh Main Menu Help Color Legend

Reactors

Company	Station/Equipment Name	Zone	KV	eDART Availability	SE Status	SE KV	SE MVAR	Rated or Active MVAR	Lagging Reserve MVAR
[redacted]	[redacted]	[redacted]	345	Y	Offline	353.64	0.00	-80.00	0.00
[redacted]	[redacted]	[redacted]	345	Y	In-Service	353.64	-84.06	-84.06	84.06
[redacted]	[redacted]	[redacted]	345	Y	In-Service	352.74	-130.67	-130.67	130.67

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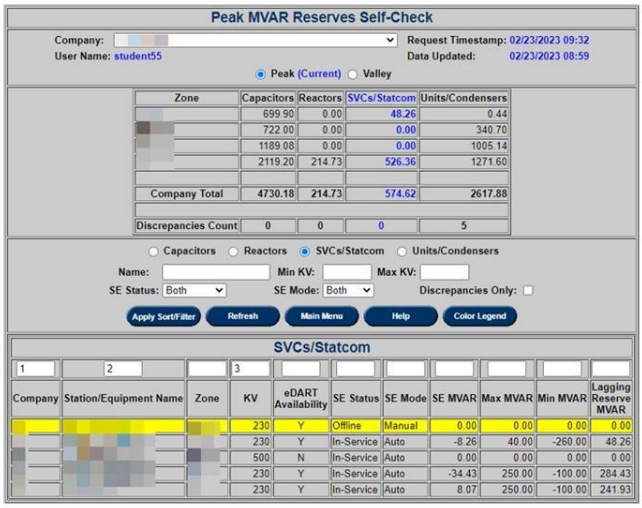
Peak SVC/Statcom Reactive Reserve Self-Check



Peak MVAR Reserves Self-Check

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User Name: student55 Data Updated: 02/23/2023 08:59
Peak (Current) Valley

Zone	Capacitors	Reactors	SVCs/Statcom	Units/Condensers
[redacted]	699.90	0.00	48.26	0.44
[redacted]	722.00	0.00	0.00	340.70
[redacted]	1189.08	0.00	0.00	1005.14
[redacted]	2119.20	214.73	526.36	1271.60
Company Total	4730.18	214.73	574.62	2617.88
Discrepancies Count	0	0	0	5

Capacitors Reactors SVCs/Statcom Units/Condensers
Name: Min KV: Max KV:
SE Status: Both SE Mode: Both Discrepancies Only:
Apply Sort/Filter Refresh Main Menu Help Color Legend

SVCs/Statcom

Company	Station/Equipment Name	Zone	KV	eDART Availability	SE Status	SE Mode	SE MVAR	Max MVAR	Min MVAR	Lagging Reserve MVAR
[redacted]	[redacted]	[redacted]	230	Y	Offline	Manual	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	230	Y	In-Service	Auto	-8.26	40.00	-260.00	48.26
[redacted]	[redacted]	[redacted]	500	N	In-Service	Auto	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	230	Y	In-Service	Auto	-34.43	250.00	-100.00	284.43
[redacted]	[redacted]	[redacted]	230	Y	In-Service	Auto	8.07	250.00	-100.00	241.93

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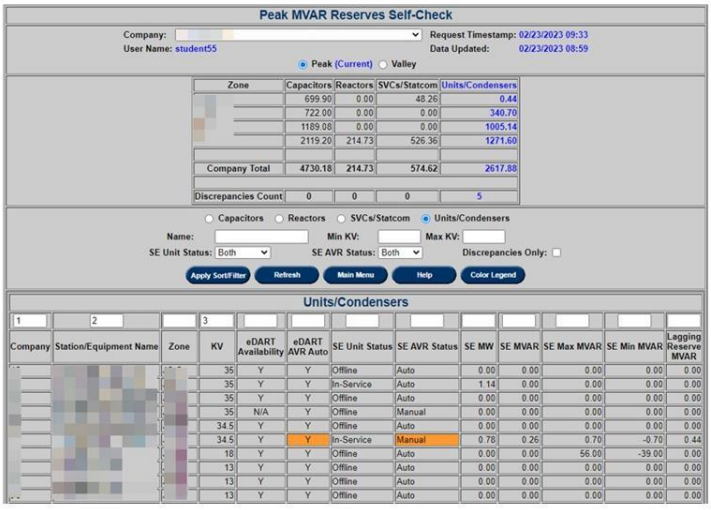
Peak Units/Condensers Reactive Reserve Self-Check



Peak MVAR Reserves Self-Check

Company: [redacted] Request Timestamp: 02/23/2023 09:33
User Name: student55 Data Updated: 02/23/2023 08:59
Peak (Current) Valley

Zone	Capacitors	Reactors	SVCs/Statcom	Units/Condensers
[redacted]	699.90	0.00	48.26	0.44
[redacted]	722.00	0.00	0.00	340.70
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Capacitors Reactors SVCs/Statcom Units/Condensers
Name: Min KV: Max KV:
SE Unit Status: Both SE AVR Status: Both Discrepancies Only:
Apply Sort/Filter Refresh Main Menu Help Color Legend

Units/Condensers

Company	Station/Equipment Name	Zone	KV	eDART Availability	eDART AVR Auto	SE Unit Status	SE AVR Status	SE MW	SE MVAR	SE Max MVAR	SE Min MVAR	Lagging Reserve MVAR
[redacted]	[redacted]	[redacted]	35	Y	Y	Offline	Auto	0.00	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	35	Y	Y	In-Service	Auto	1.14	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	35	Y	Y	Offline	Auto	0.00	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	35	N/A	Y	Offline	Manual	0.00	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	34.5	Y	Y	Offline	Auto	0.00	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	34.5	Y	Y	In-Service	Manual	0.78	0.26	0.70	-0.70	0.44
[redacted]	[redacted]	[redacted]	18	Y	Y	Offline	Auto	0.00	0.00	56.00	-39.00	0.00
[redacted]	[redacted]	[redacted]	13	Y	Y	Offline	Auto	0.00	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	13	Y	Y	Offline	Auto	0.00	0.00	0.00	0.00	0.00
[redacted]	[redacted]	[redacted]	13	Y	Y	Offline	Auto	0.00	0.00	0.00	0.00	0.00

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Potential Flags

eDART ticket listed as Unavailable and SE MVAR is not 0

Condition:

- Whenever eDART identifies a facility as unavailable, but the PJM EMS SE MVAR output which would indicate that the facility is in-service.

Mismatch between eDART AVR and EMS AVR

Conditions:

- Whenever an eDART AVR ticket exists, but the PJM EMS has the AVR in AUTO (automatic) mode.
- Whenever no eDART AVR ticket exists, but the PJM EMS has the AVR in Manual mode.

Retired Equipment

Future Equipment

Conditions:

- Whenever a facility is marked as retired in the eDART database.
- Whenever a facility is marked as future in the eDART database.

Reactive Reserve Check Exercise

Let's Review!

1. **Calculate the LEADING and LAGGING Reactive Reserves for this Steam generating unit. PJM wants to know this Steam Unit's Lagging and Leading Reserve MVAR value. The current MW output of the unit is 420 MWs, with a reactive output of 56 MVAR Lagging . Use the Reactive Capability Curve to determine the reserve values.**

Reactive Capability Curve

MW Point	MVAR Min	MVAR Max
100	-15	100
200	-15	109
300	-15	128
400	-14	135
420	-14	133
480	-13	111
510	-13	8
540	-10	0

a. *Lagging: 77 MVARS, and Leading: -70 MVARS.*

b. *Lagging: 135 MVARS, and Leading: -15 MVARS.*

c. Lagging: 28 MVARS, and Leading: -135 MVARS.

d. Lagging: 133 MVARS, and Leading: -14 MVARS.

2. You also have a Condenser available that is ONLINE and currently at 26 MVAR Lagging. Using the Reactive Capability Curve for this resource to determine its Lagging and Leading reactive reserves. PJM wants to know this condenser's Lagging and Leading Reserve MVAR value.

MW Point	MVAR Min	MVAR Max
0	-15	60
70	-14	60
145	-13	55
165	-11.5	45
190	-11	35
250	-10	24
285	-9.5	10
300	0	0

a. Lagging: 34 MVARS, and Leading: -41 MVARS.

b. Lagging: 60 MVARS, and Leading: -15 MVARS.

c. Lagging: 60 MVARS, and Leading: 0 MVARS.

d. Lagging: 18 MVARS, and Leading: -11.5 MVARS.

e. Lagging: 0 MVARS, and Leading: 0 MVARS.

3. PJM is also going to want to know the reserve capability of system capacitors and reactors. Using the capability chart below, what are the Capacitor Lagging and Leading Reserve values? And, what are the Reactor Lagging and Leading Reserve values? There are two answers to this question.

Unit Name	Resource Type	Status	Rated/Actual MVAR
Alpha 1	Capacitor	✓Online	50
Beta 2	Reactor	**X** Offline	30
Gamma 3	Capacitor	✓Online	100
Delta 4	Reactor	✓Online	45
Epsilon 5	Capacitor	**X** Offline	75
Zeta 6	Reactor	✓Online	60
Eta 7	Capacitor	✓Online	120
Theta 8	Reactor	**X** Offline	35
Iota 9	Capacitor	✓Online	90
Kappa 10	Reactor	✓Online	55

a. *The Capacitor Lagging Reserve value is 75 MVARs, while the Capacitor Leading Reserve value is 360 MVARs.*

b. *The Capacitor Lagging Reserve value is 412 MVARs, while the Capacitor Leading Reserve value is 65 MVARs.*

c. *The Reactor Lagging Reserve value is 160 MVARs, while the Reactor Leading Reserve value is 65 MVARs.*

d. *The Reactor Lagging Reserve value is 8 MVARs, while the Reactor Leading Reserve value is 37 MVARs.*

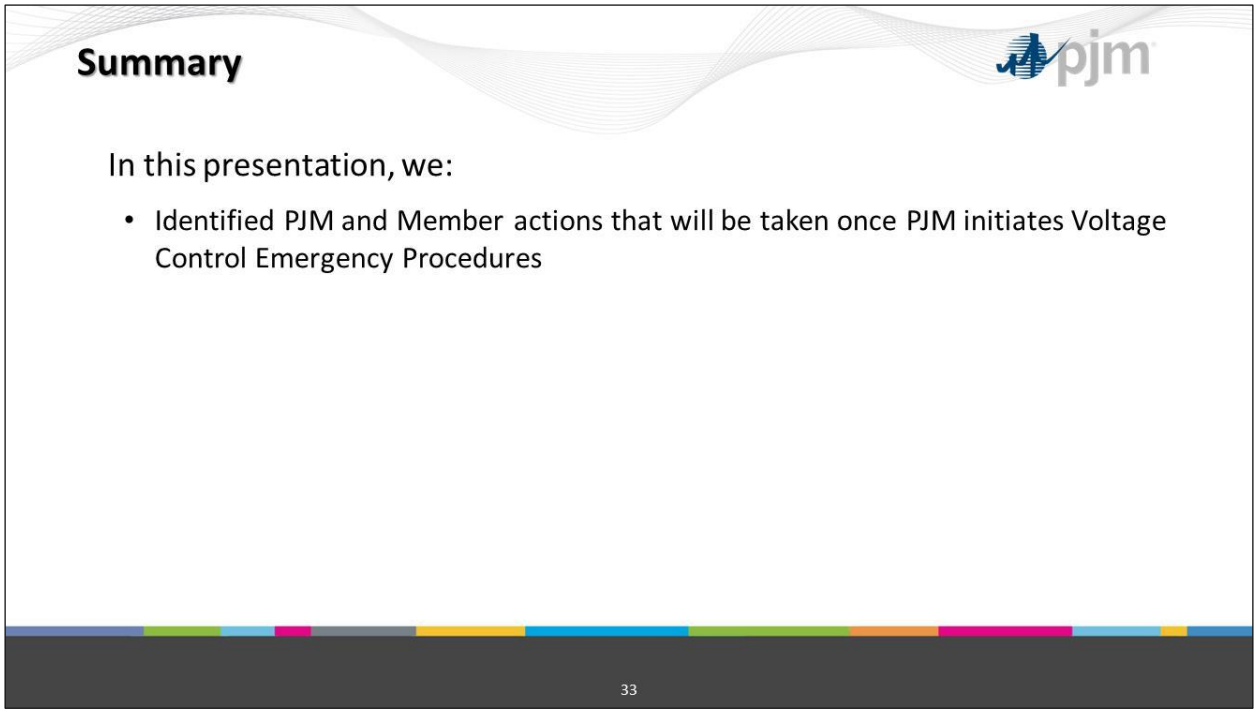
e. *The Capacitor Lagging Reserve value is 360 MVARs, while the Capacitor Leading Reserve value is 75 MVARs.*

f. *The Capacitor Lagging Reserve value is 220 MVARs, while the Capacitor Leading Reserve value is 8 MVARs.*

g. *The Reactor Lagging Reserve value is 65 MVARs, while the Reactor Leading Reserve value is 220 MVARs.*

h. *The Reactor Lagging Reserve value is 360 MVARs, while the Reactor Leading Reserve value is 0 MVARs.*

Summary



Questions?

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Member Community

The Member Community is PJM's self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services