Reactive Reserves & Unit Testing

PJM Initial Training Program

Student Guide

Prepared by:
State & Member Training

Table of Contents

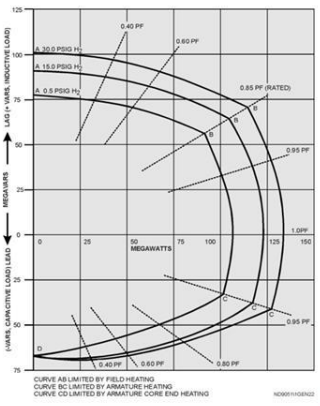
Objectives

- Identify the process for monitoring and maintaining reactive reserves
- Identify the reactive capability testing process and requirements

Capability Curve/Limitations

Reactive Capability

Capability Curve/Limitations



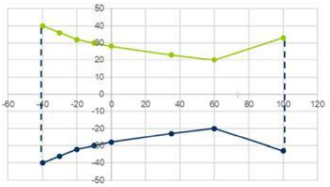


Exhibit 15: Example of inverter-based AC-coupled open-loop Hybrid Resource with solar and 40 MW battery.

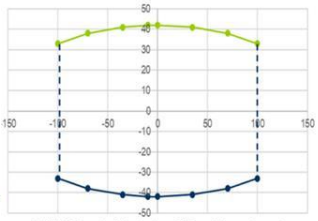
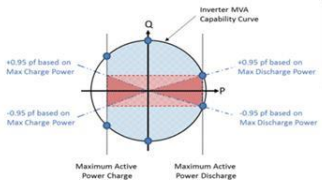


Exhibit 16: Example of inverter-based DC-coupled open-loop solar-storage Hybrid Resource with 100 MW solar and 100 MW battery.



2

Reporting Reactive Capability Data to PJM

Reporting Reactive Capability Data to PJM

Dispatchable Unit

Unit Info	MW	Min MVAR	Max MVAR	Comment
Point 1	50	-80	250	Typical net ECO Min
Point 2	100	-75	240	
Point 3	150	-70	230	
Point 4	200	-65	220	
Point 5	250	-60	210	
Point 6	300	-55	190	
Point 7	350	-50	180	Typical net ECO Max
Point 8	375	-45	170	*

*Max possible unit net output considering ideal operating conditions such as winter ambient temperatures, low cooling water temps, optimum fuel conditions, etc.

3

Reporting Reactive Capability Data to PJM

Unit that can also operate as a synchronous condenser

Unit Info	MW	Min MVAR	Max MVAR	Comment
Point 1	0	-50	150	Synchronous Condensing operating point
Point 2	70	-25	240	Typical net ECO Min
Point 3	75	-22	230	
Point 4	80	-20	220	
Point 5	85	-18	210	
Point 6	90	-15	190	
Point 7	95	-12	180	Typical net ECO Max
Point 8	100	-10	170	*

*Max possible unit net output considering ideal operating conditions such as winter ambient temperatures, low cooling water temps, optimum fuel conditions, etc.

4

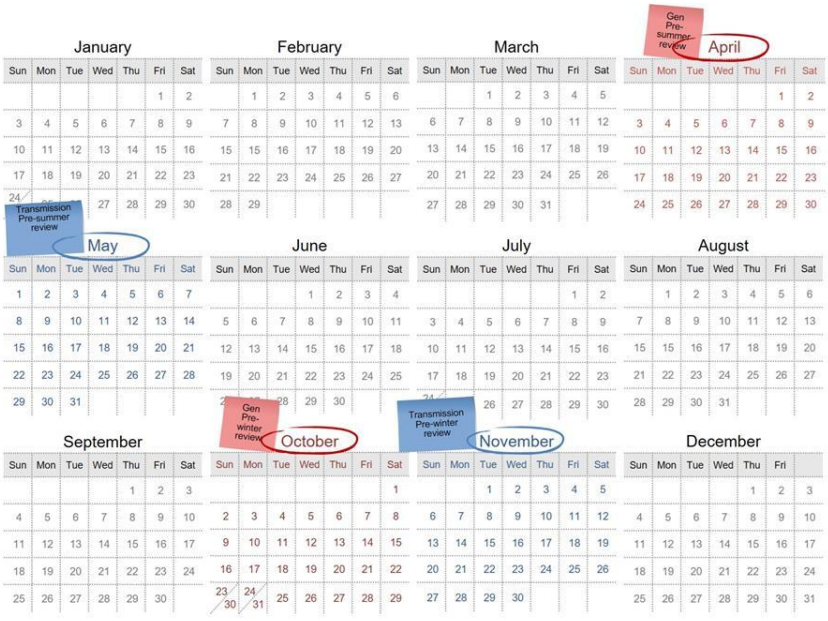
Reporting Reactive Capability Data to PJM

Inverter-based Energy Storage Resource

Unit Info	MW	Min MVAR	Max MVAR	Comment
Point 1	-20	-22	22	Max Active Power Charging (Min MW)
Point 2	-14	-26	26	
Point 3	-7	-29	29	
Point 4	0	-30	30	Inverter MVA Capability Curve Rating
Point 5	6	-29	29	
Point 6	12	-27	27	
Point 7	18	-24	24	
Point 8	25	-17	17	Max Active Power Discharging (Max MW)

5

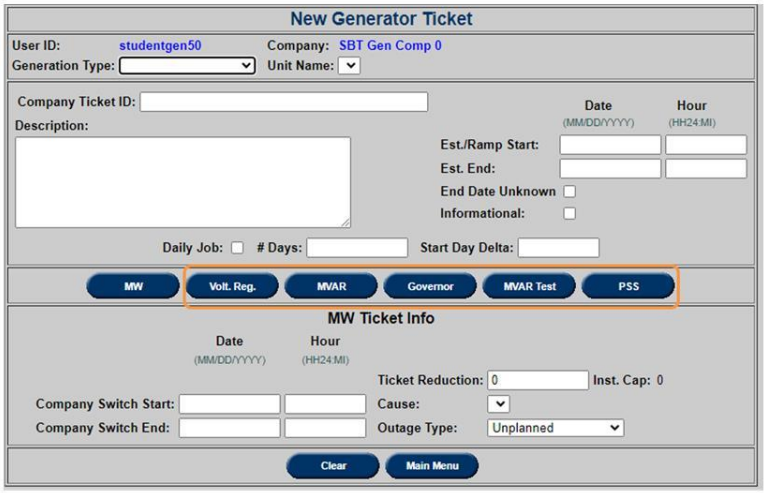
Reactive Capability Seasonal Review



6

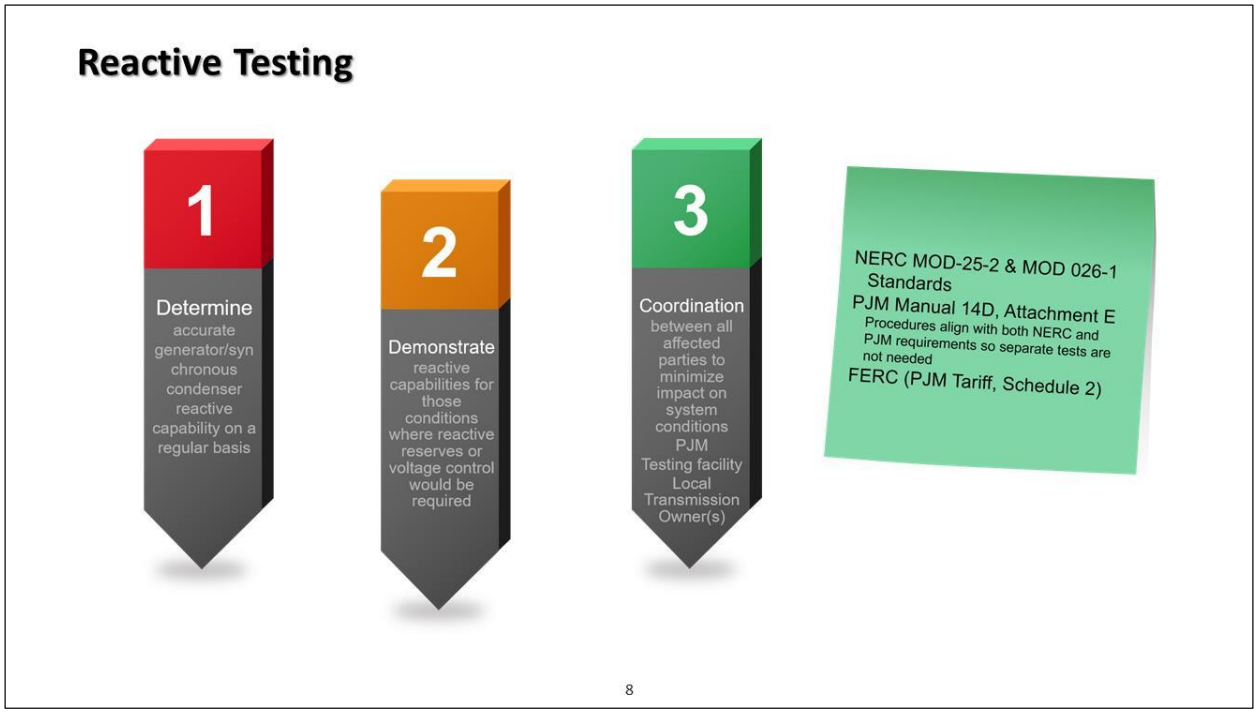
What Reactive Information is Reported?

What Reactive Information is Reported?

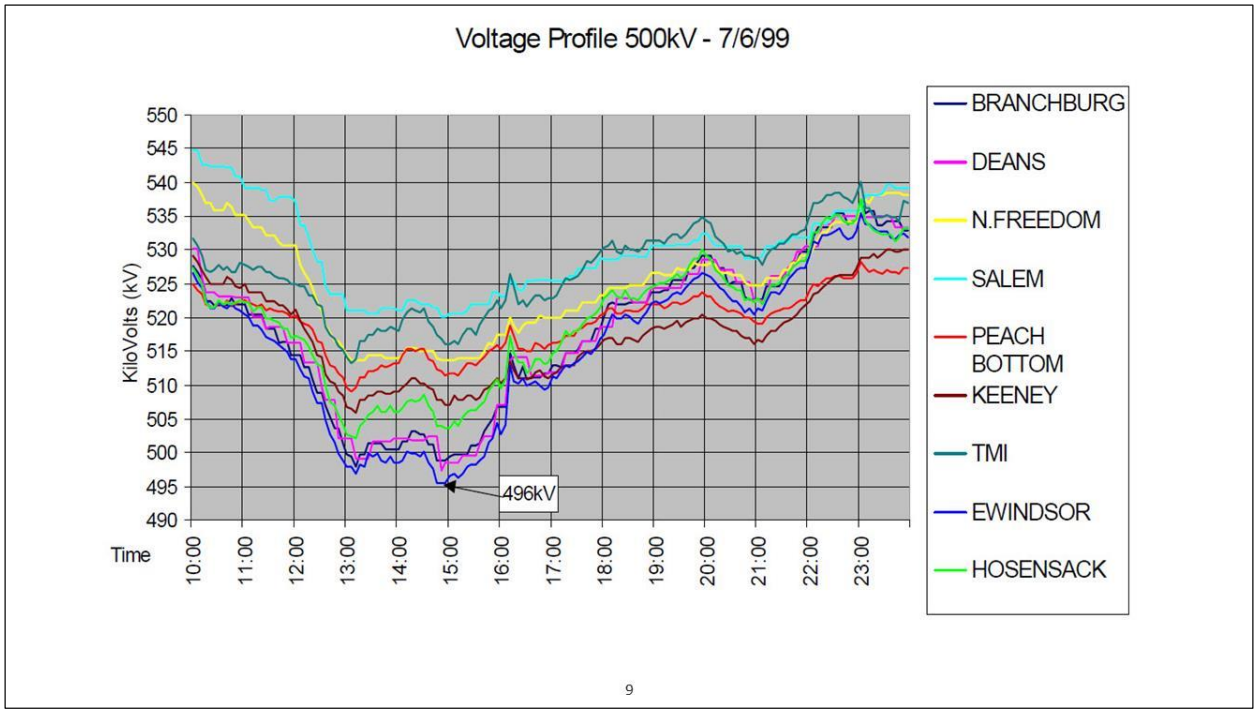


7

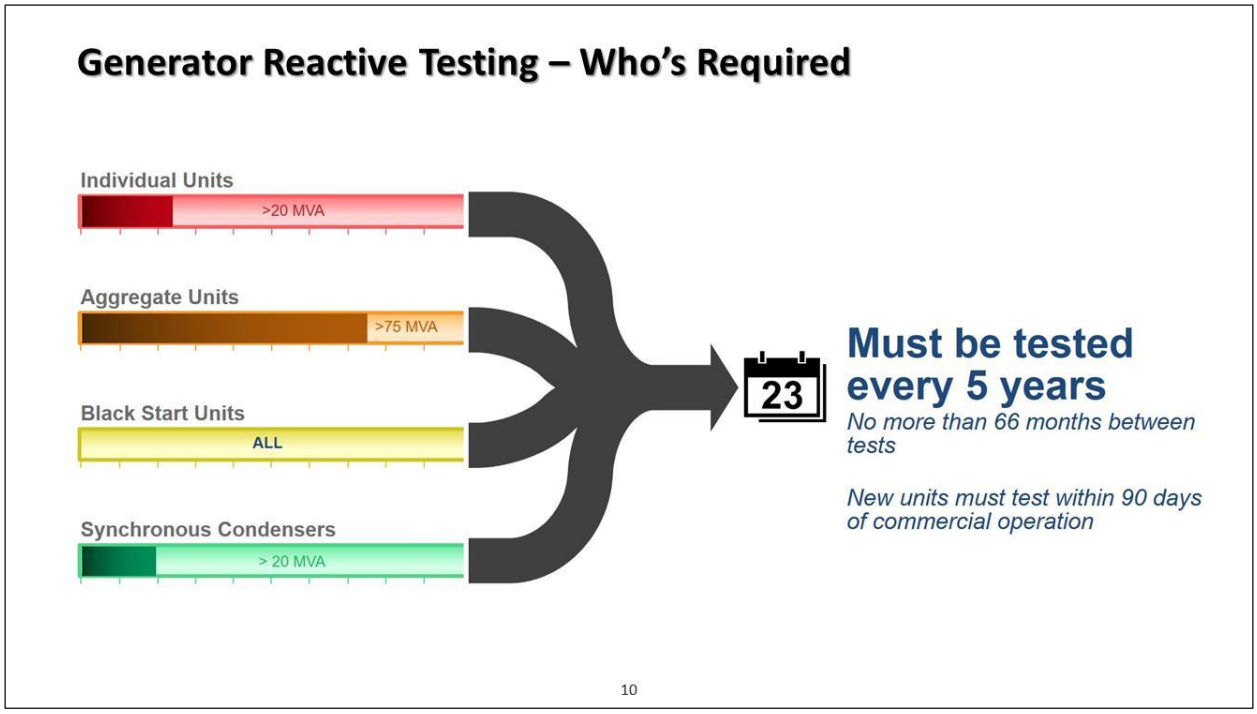
Reactive Testing



Voltage Profile 500kV - 7/6/99



Generator Reactive Testing - Who's Required



Unit Types

Unit Type	MW Output	MVAR Output	Test Duration
Fossil, Hydroelectric & Blackstart	Max	Max Lag	One Hour
	Max	Max Lead	When limit reached
	Min	Max Lag	When limit reached
	Min	Max Lead	When limit reached
Synchronous Condenser or Generator that operates in the condensing mode to provide reactive support	-	Max Lag	One Hour
	-	Max Lead	When limit reached
Nuclear	Max	Max Lag	One Hour
	Max	Max Lead	When limit reached
Variable (e.g. Wind and Solar) (Testing done with at least 90% of turbines or inverters on line)	Variable	Max Lag	When limit reached
	Variable	Max Lead	When limit reached
Inverter based energy storage resources	Max	Max Lag	When limit reached
	Max	Max Lead	When limit reached
Max MW Output = fully discharging	Zero	Max Lag	When limit reached
	Zero	Max Lead	When limit reached
Min MW Output = fully charging	Min	Max Lag	When limit reached
	Min	Max Lead	When limit reached

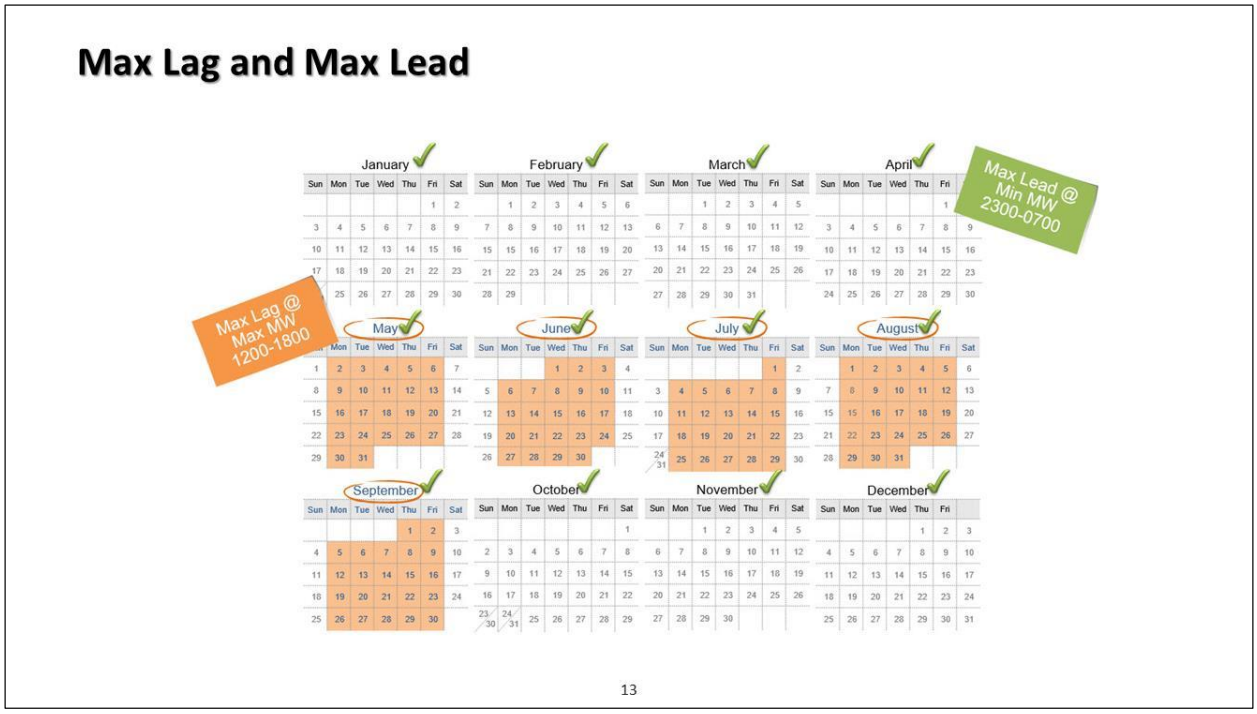
11

Unit Types

Unit Type	MW Output	MVAR Output	Test Duration
DC-Coupled Inverter Based Hybrid Resource	Max	Max Lag	When limit reached
	Max	Max Lead	When limit reached
	Zero	Max Lag	When limit reached
	Zero	Max Lead	When limit reached
	Min	Max Lag	When limit reached
	Min	Max Lead	When limit reached
AC-Coupled Inverter Based Hybrid Resource	Max	Max Lag	When limit reached
	Max	Max Lead	When limit reached
	Max Inverter Operating Point	Max Lag	When limit reached
	Max Inverter Operating Point	Max Lead	When limit reached
	Zero	Max Lag	When limit reached
	Zero	Max Lead	When limit reached
	Min	Max Lag	When limit reached
	Min	Max Lead	When limit reached

12

Max Lag and Max Lead



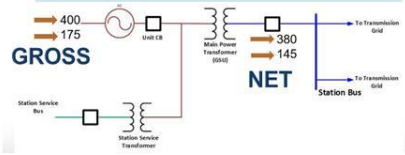
Testing Process

3 Business Days Prior to testing

MOC submits "MVAR Test" Ticket via eDART no later 12:00 PM EPT

Ticket must include:

- MW & MVAR values unit will be at during the testing
- Whether values are gross or net
- Will the unit be operating in the LAG or LEAD



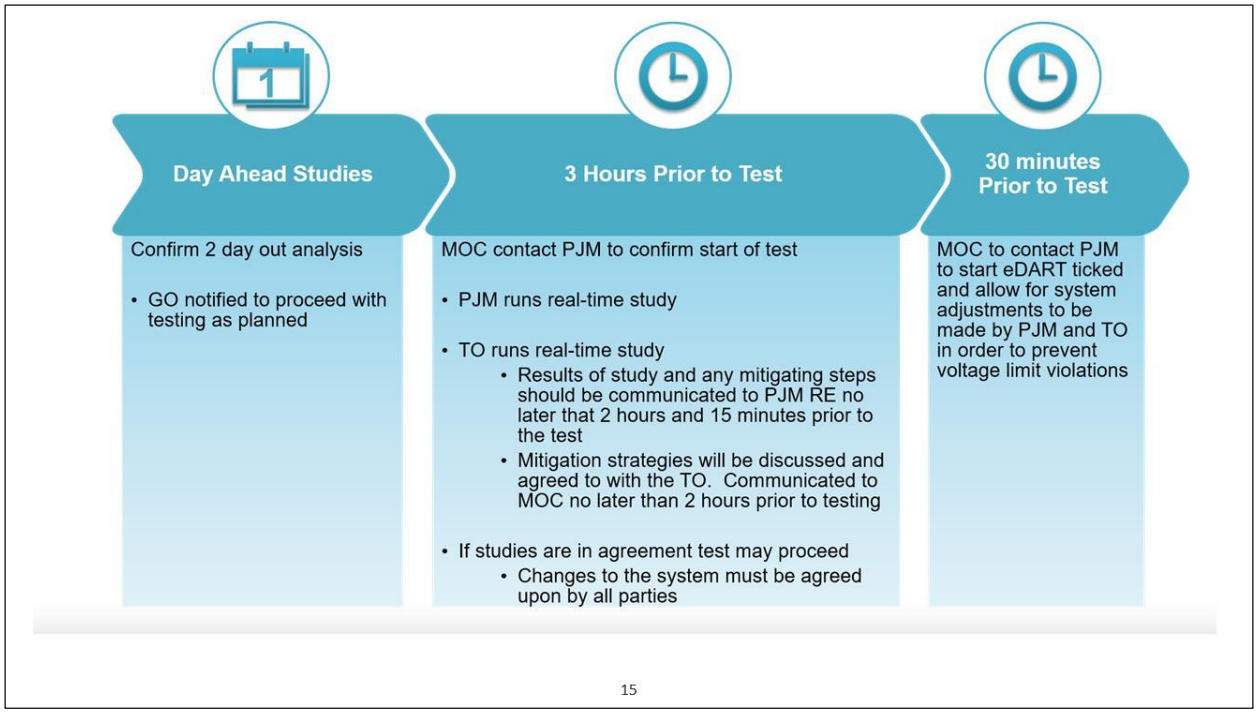
2 Day Out Analysis

Studies performed to determine feasibility of the reactive test based on reliability

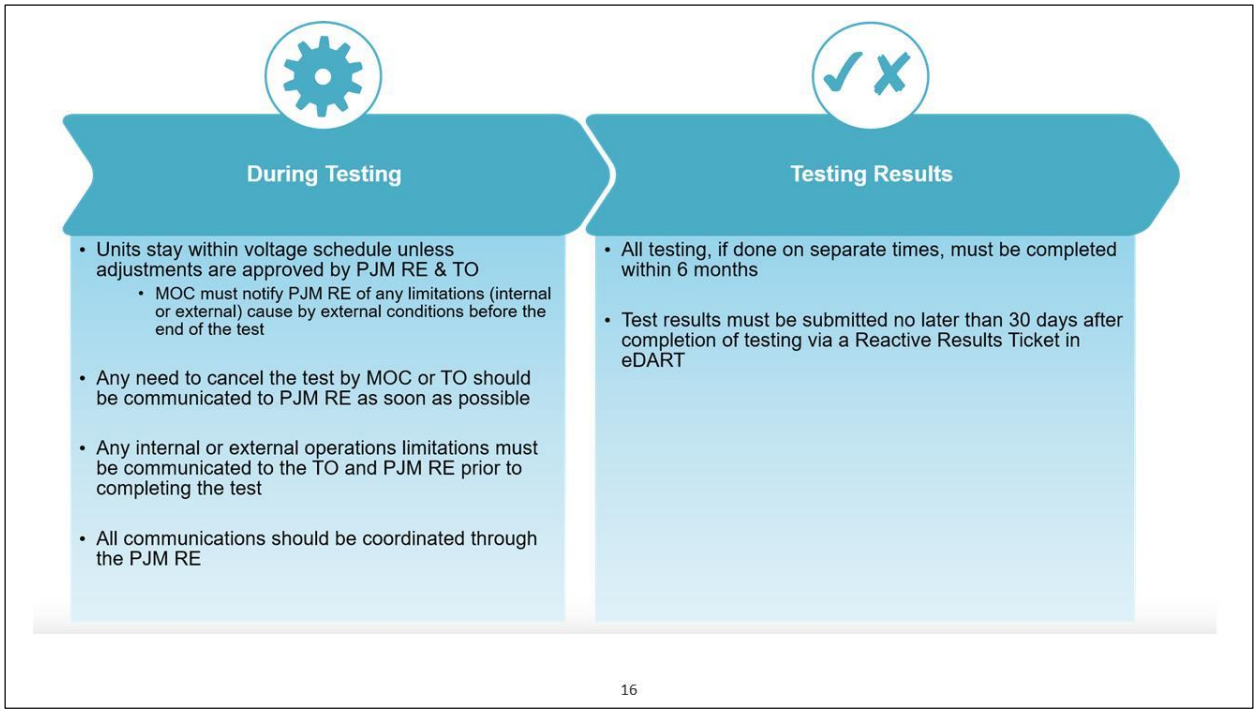
- Coordination with TO on mitigating actions (i.e. Capacitors in/out of service, voltage schedule changes)
  - TO must agree to changes
- For reliability concerns – Ticket will be denied
  - Note made on reason for cancellation
  - GO notified of cancellation (reschedule to another time period or date)
- If no reliability concerns
  - Verify company's telemetry testing point is modeled and data is accurate
  - If unit is not online, re-verify prior to the test
  - Verify data is not stale
  - Verify current Reactive Capability Curve Data
- If telemetry does not match – ticket will be denied

14

Testing Process



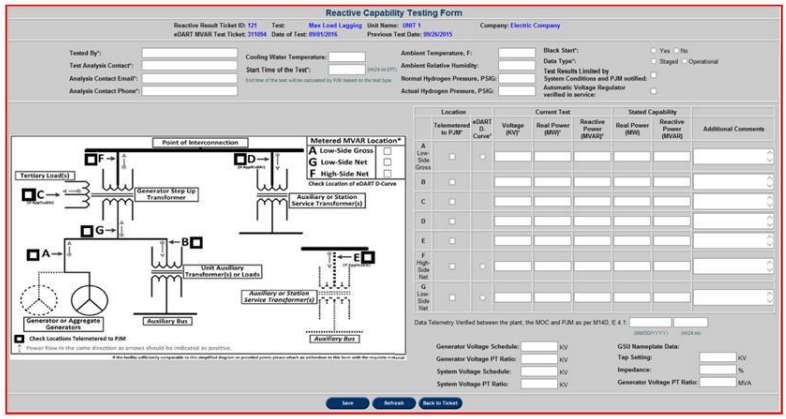
Testing Process



Reactive Capability Testing - Reporting Results

Reactive Capability Testing – Reporting Results

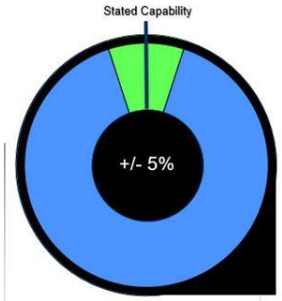
- Generator Owner shall complete the Reactive Capability Testing Form within 30 calendar days from the test date



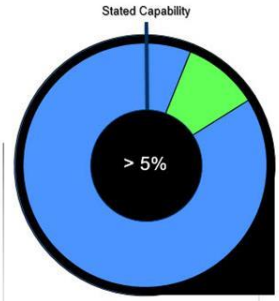
17

Test Results

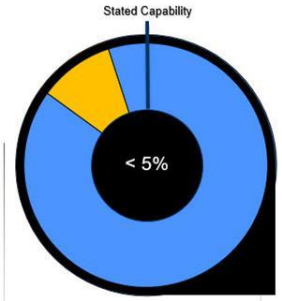
Test Results



- Fully demonstrated capability
- PJM will notify MOC or TO units achieved their reactive capability and no further action is required



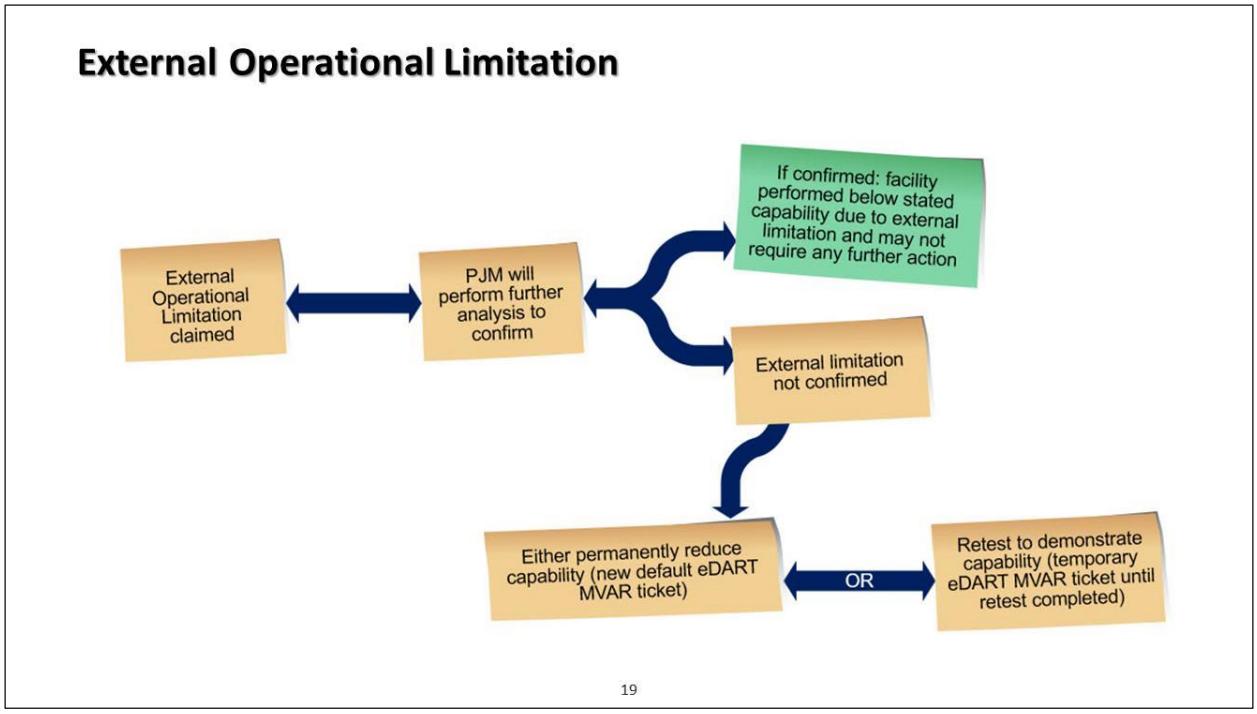
- Fully demonstrated capability
- PJM will notify MOC or TO units exceeded their reactive capability and request increase the capability modeled within the PJM EMS by entering new default eDART MVAR ticket



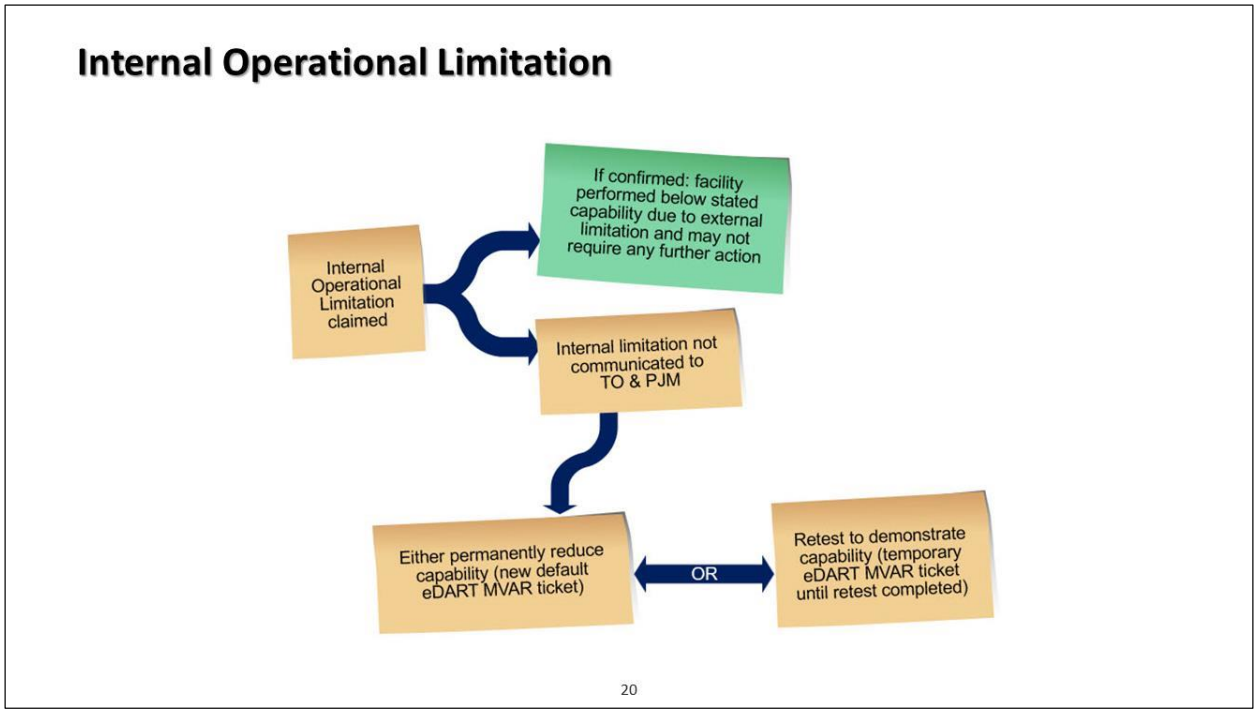
- Not demonstrated capability
- PJM will determine which units were affected by internal or external operational limitations based on reasons documented in the submitted test results

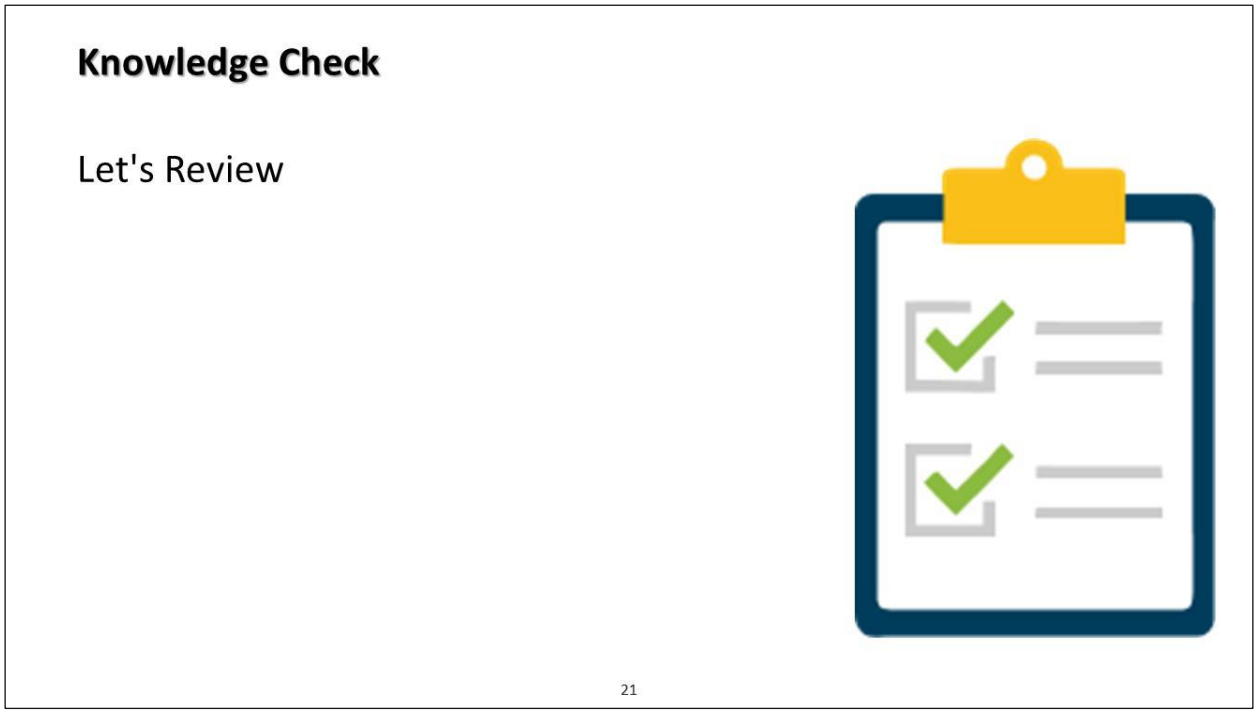
18

External Operational Limitation



Internal Operational Limitation





1. All test results must be submitted to PJM within what time frame?

a. 30 days

b. 60 days

c. 3 months

d. 6 months

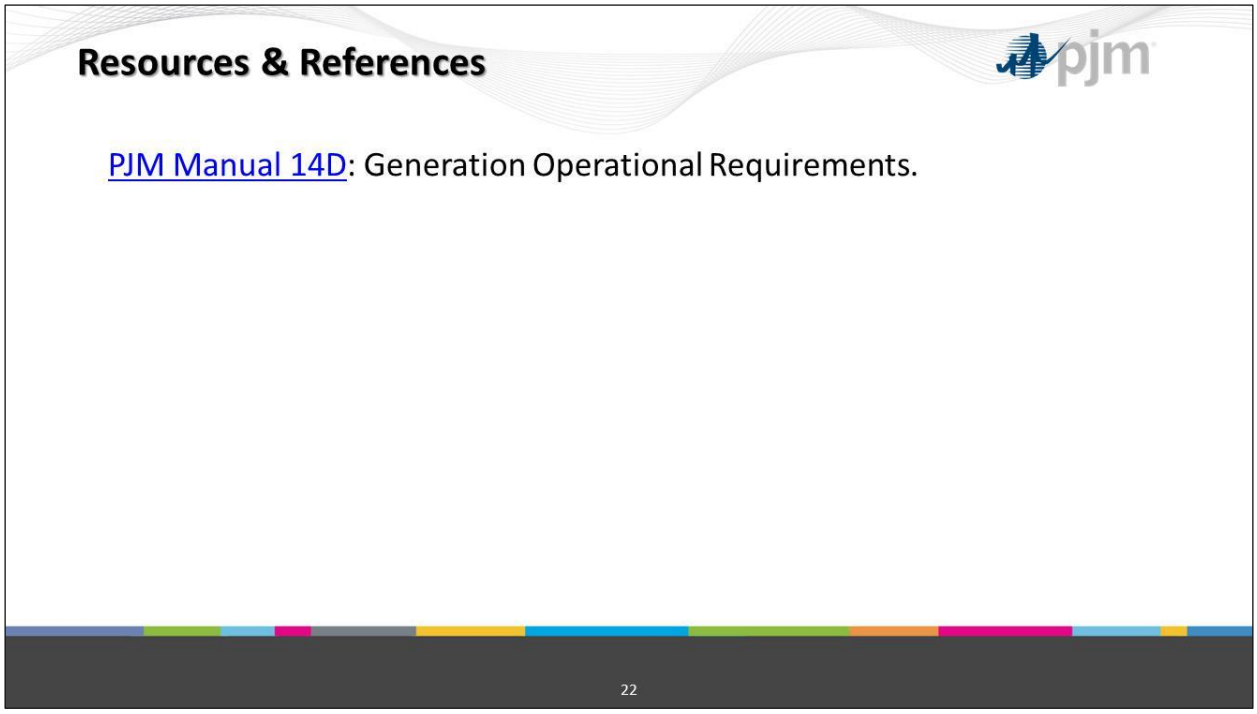
2. A facility will be considered as passing its reactive capability test if it meets what criteria? (Select all that apply)

a. Within 5% of stated limits

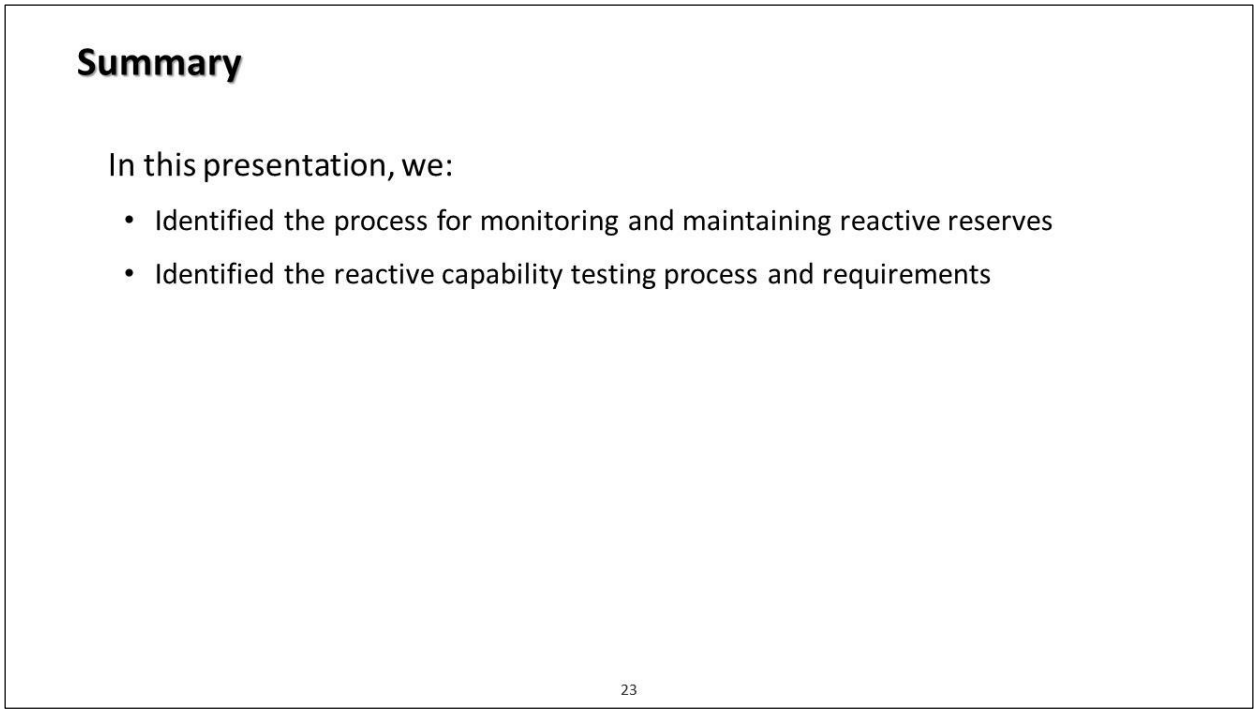
b. Greater than 5% of stated limits

c. Below 5% of stated limits

Resources & References



Summary


Summary
In this presentation, we:
• Identified the process for monitoring and maintaining reactive reserves
• Identified the reactive capability testing process and requirements
23

Questions

Questions

PJM Client Management & Services	
Telephone:	(610) 666-8980
Toll Free Telephone:	(866) 400-8980
Website:	www.PJM.com
Email:	trainingsupport@pjm.com

24