Generation Initial Training Program

Reactive Reserves & Unit Testing

PJM State & Member Training Dept.

Objectives

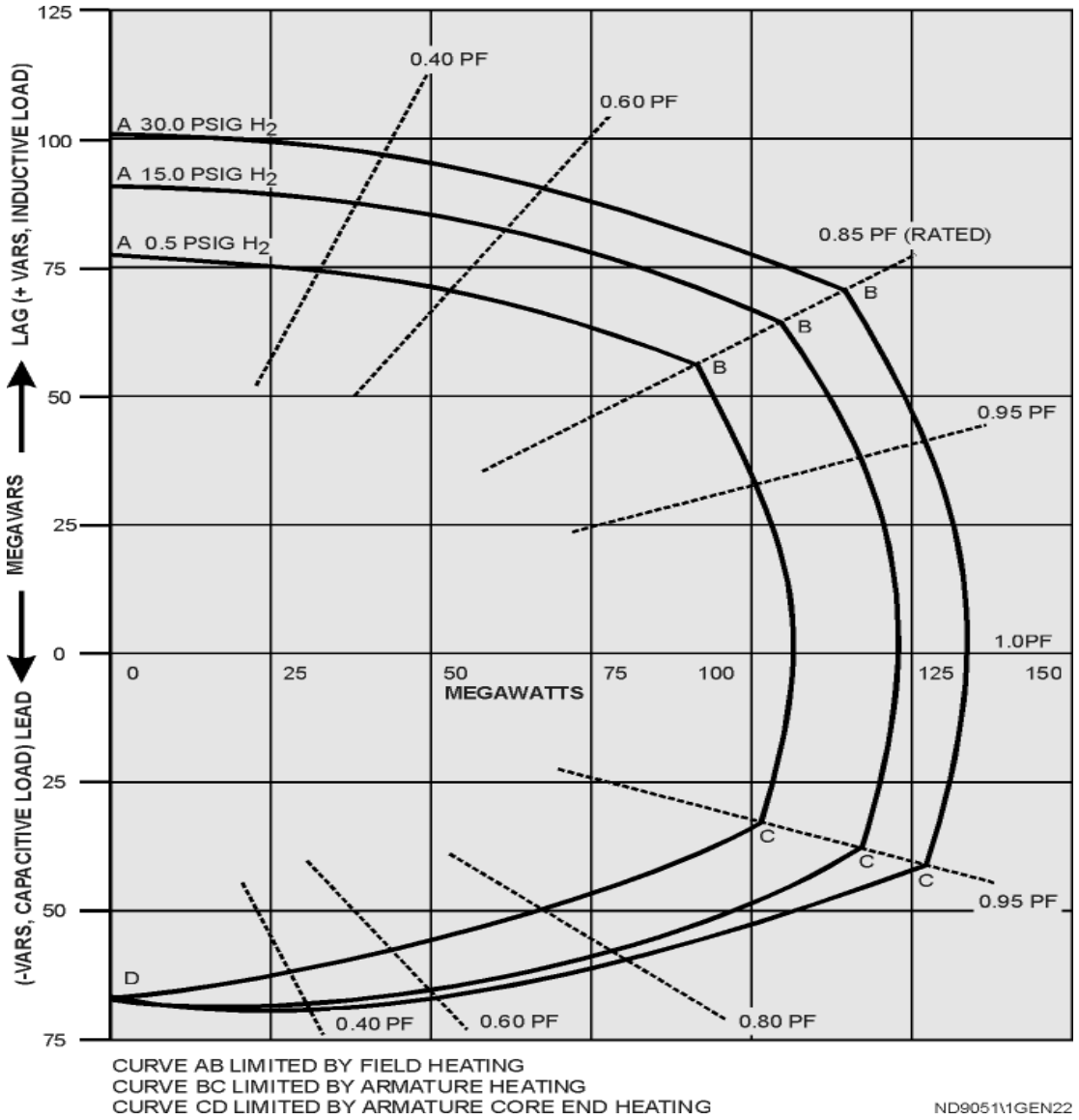
Students will be able to:

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

Reactive Capability Curve

- Generating Unit Reactive Capability is a measurement of the reactive power able to be delivered by a generating unit to the transmission system
- It is defined by the MW versus MVAR points of a generator capability curve
- For real-time changes, each Generation Owner should also notify PJM and the respective Transmission Owners via phone

Capability Curve



CURVE AB LIMITED BY FIELD HEATING
CURVE BC LIMITED BY ARMATURE HEATING
CURVE CD LIMITED BY ARMATURE CORE END HEATING

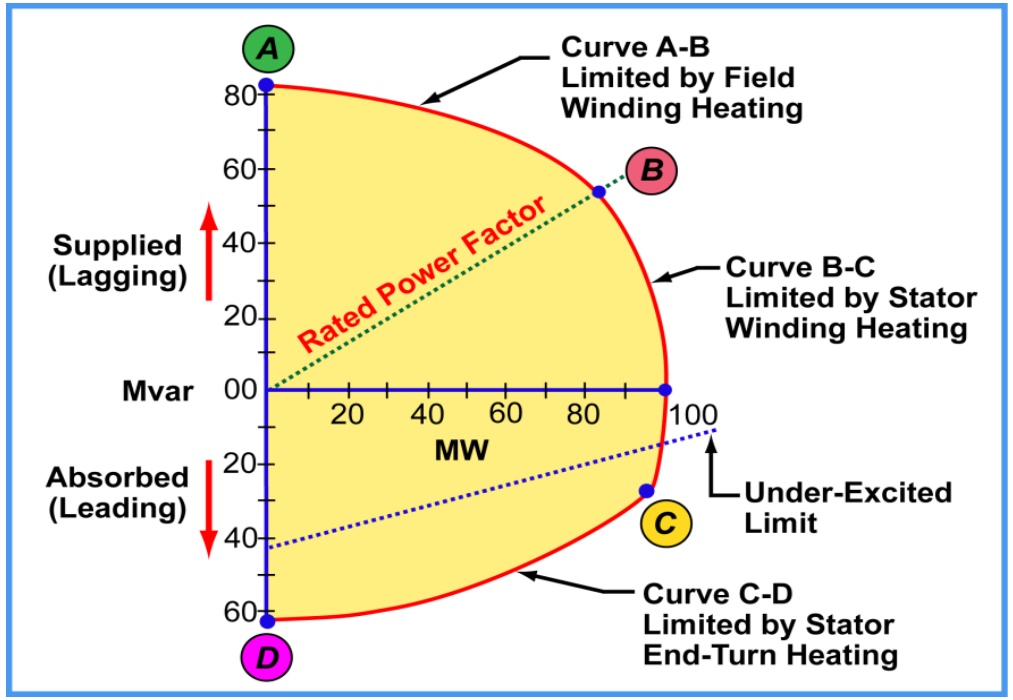
ND9051\1GEN22

Reactive Capability Curve

Reactive Capability (or “D”) Curves

- Generators Report "Continuous Unit Reactive Capability Curve"
  - Realistic usable capability sustainable during continuous unit operation
  - Based on actual operating experience

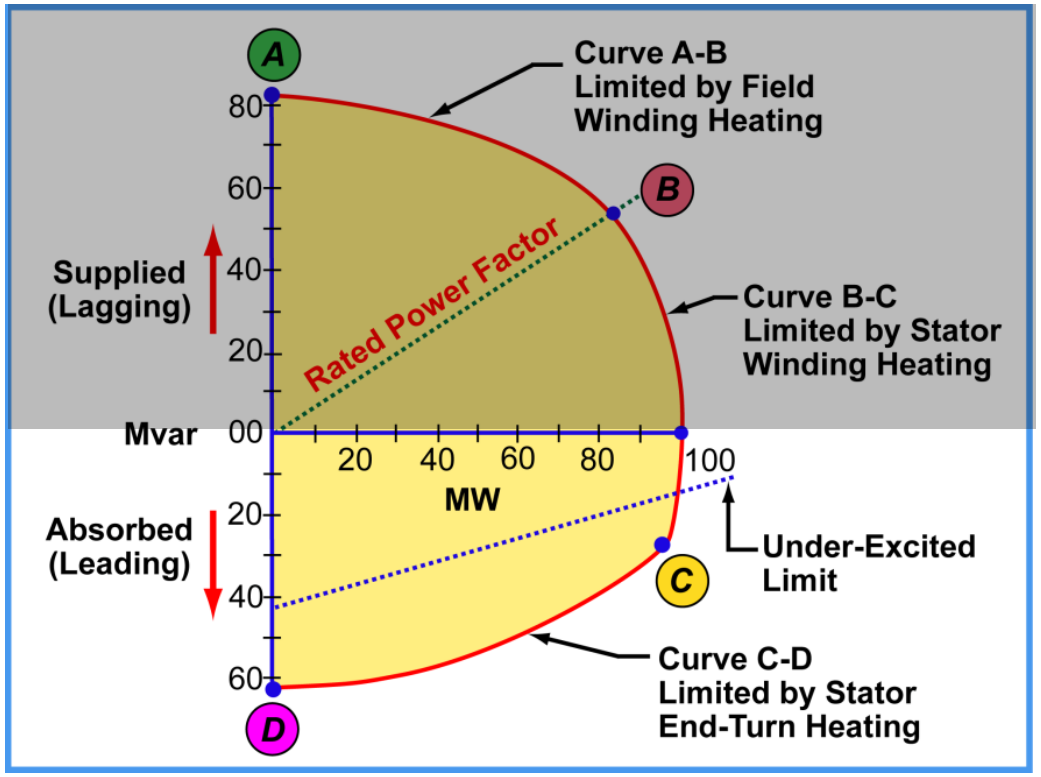
    (or testing)
  - Takes into consideration any normal unit or plant restrictions at 95˚ F ambient or above



Reactive Capability Curve

Generating Unit

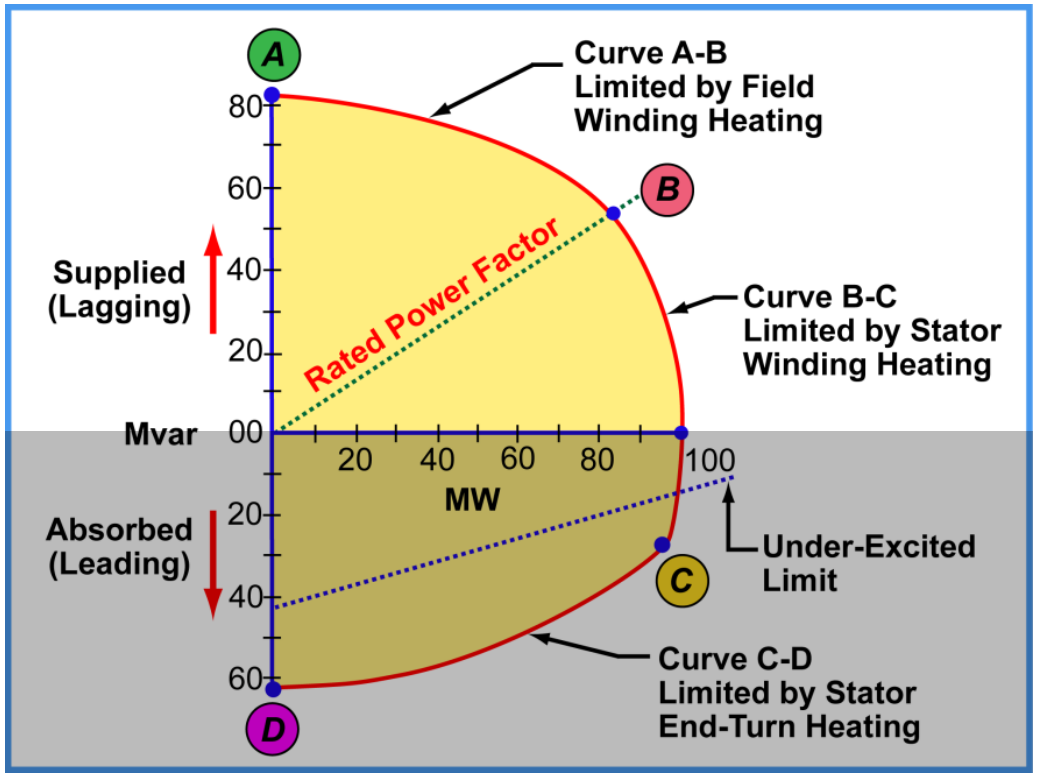
- Unit Over-Excitation
  - Limit on field heating, limits MVAR generation
  - Rotor overheating is I^2R heating caused by DC current over-excitation



Reactive Capability Curve

Generating Unit

- Unit Under-excitation
  - Limit on end turn heating
  - Unit instability
    - Field strength too weak, unit goes unstable
    - Area Stability concerns
      - Salem
      - PS South



Reactive Capability Curve

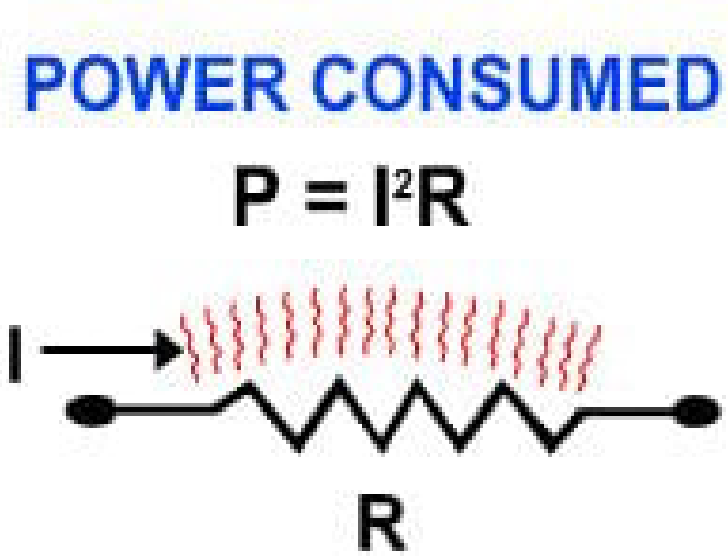
- To help maintain a reliable transmission system, each Generation Owner/Operator must provide initial or updated capability curve information to PJM via eDART as soon as the information is available
  - The Transmission Owner for the Transmission Zone where the unit is located will be automatically notified via eDART, as well as any other Transmission Owners with eDART authority to receive automatic notification for the unit

Generator Characteristics

- Generator limitation factors
  - Power capability of the prime mover
  - Heating of generator components (I^2R losses)
  - Necessity to maintain a strong enough magnetic field to transfer power from the rotor to the generator output

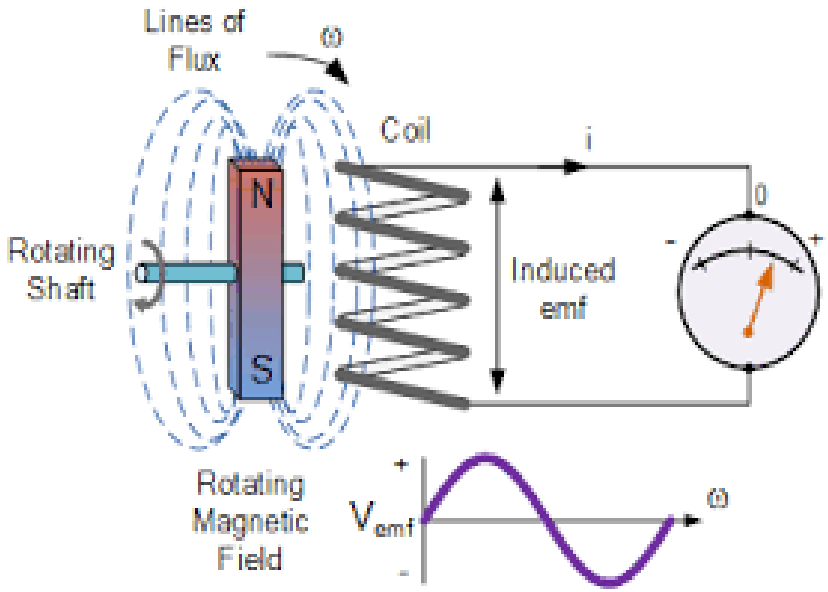
Generator Characteristics

Heating of Generator Components



Generator Characteristics

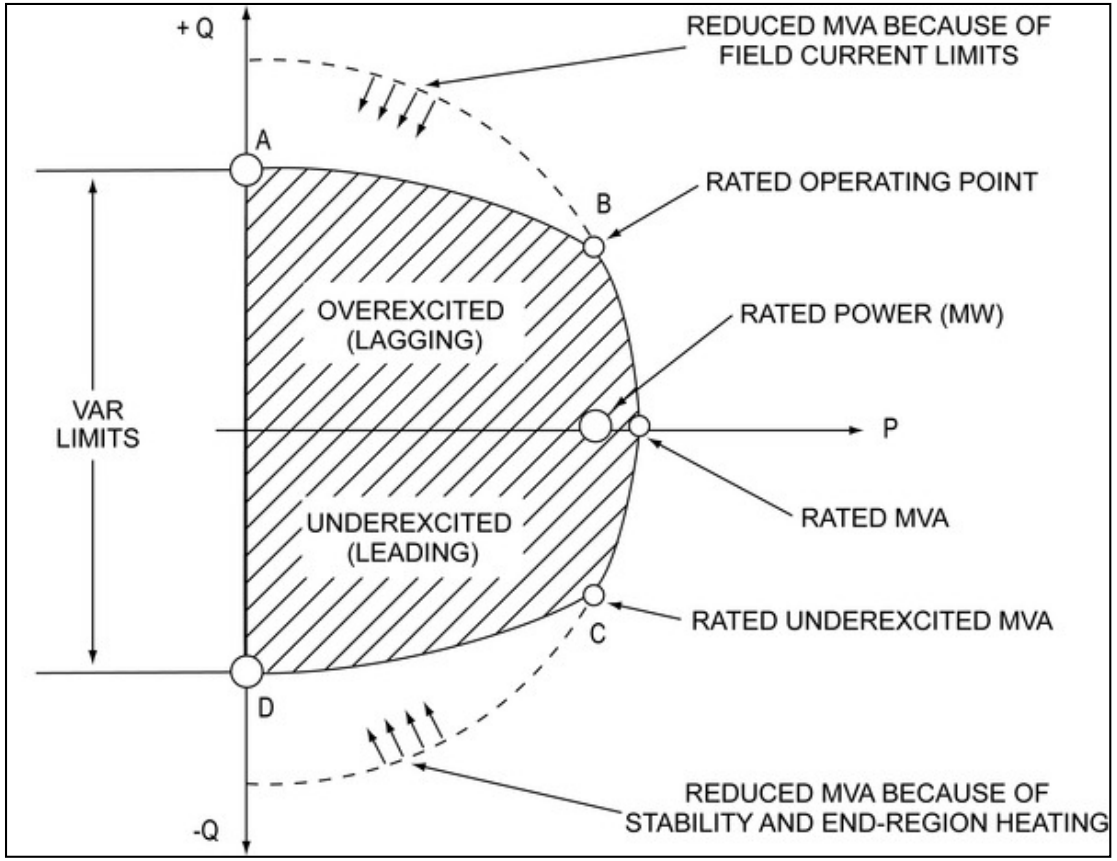
Magnetic Field Strength



Reactive Capability Limitations

Generating Unit

- MVAR output limited by D-curve
- Voltage regulator limits
  - Voltage regulator operates only within designed voltage limits
  - Designed to limit amount of MVARs that can be generated
- Power factor limits
  - Units are limited to operating within certain pf limits



Restrictions and Limitations

- Affects on the surrounding Power System:
  - Must coordinate shifts in generation to obtain desired MVAR flows and voltage adjustments
  - Should coordinate generation voltage adjustments with switchable sources (capacitors and reactors)
  - Do not remove all VAR reserve from a generating unit

Generator Reactive Testing

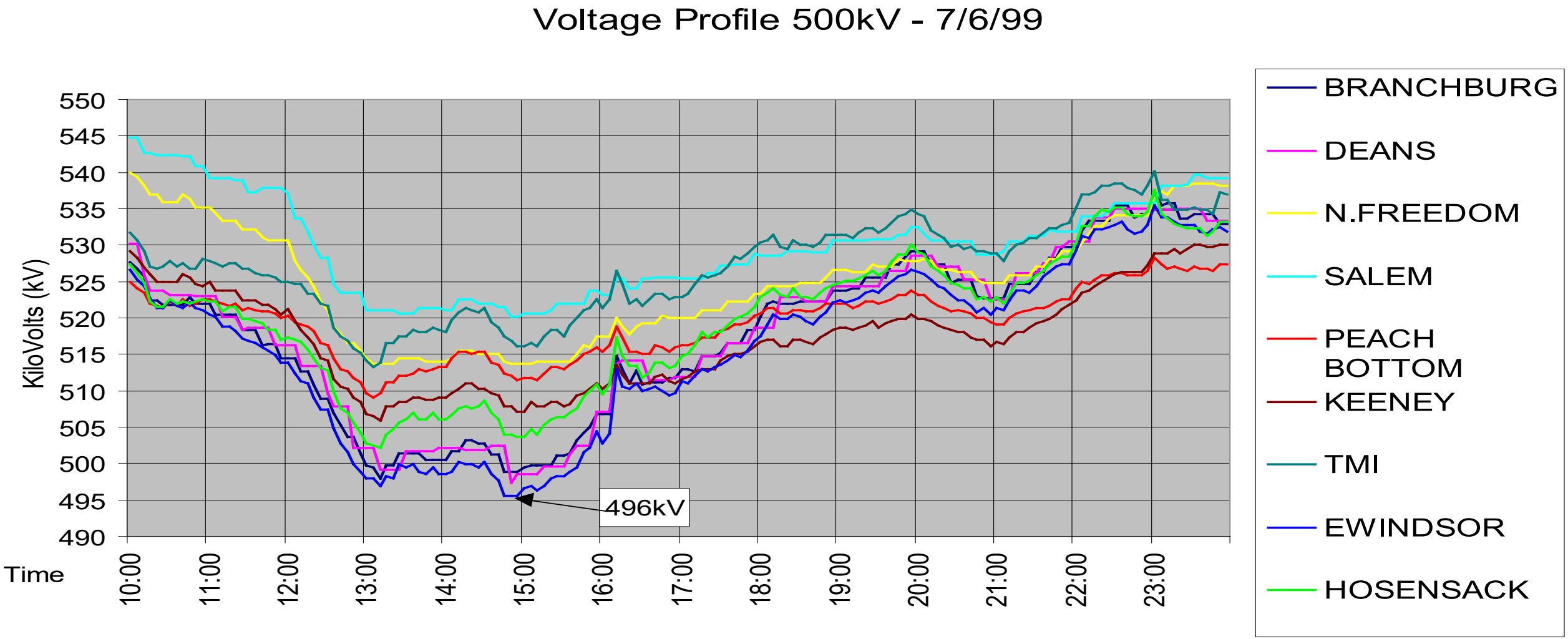
- Reactive capability testing:
  - The objective of reactive capability testing is to improve transmission system reliability by accurately determining generator/synchronous condenser reactive capability on a regular basis
  - Demonstrates reactive capabilities for those conditions where reactive reserves or voltage control would be required
  - Coordinated between all affected parties to minimize impact on system conditions
    - PJM
    - Testing facility
    - Local Transmission Owner(s)

Generator Reactive Testing: Why the Emphasis?

- The 1999 Mid-Atlantic Voltage Sag
  - Inaccurate MVAR ranges ⟶ Inaccurate voltage results
- D-Curves are basis for analysis of generator voltage performance
- The drivers behind the requirements include:
  - NERC MOD-25-2 and MOD 026-1 Standards
  - PJM Manual 14D, Attachment D
    - Procedures align with both NERC and PJM requirements so separate tests are not needed
  - FERC (PJM Tariff, Schedule 2)

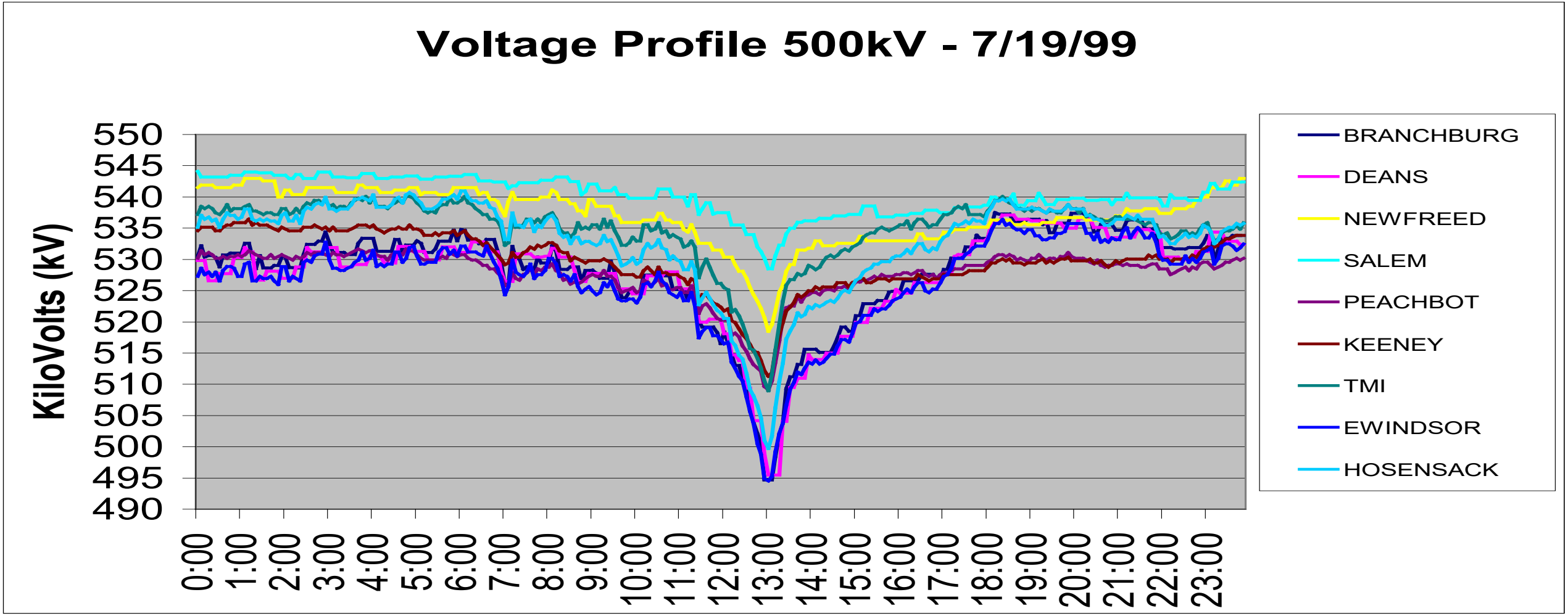
1999 Mid-Atlantic Voltage Sag

- 500 kV Voltages



1999 Mid-Atlantic Voltage Sag

- 500 kV Voltages



NERC MOD 025-2/MOD 026-1 Standards

- MOD 025-2

  To ensure that accurate information on generator gross and net Real and Reactive Power capability and synchronous condenser Reactive Power capability is available for planning models used to assess Bulk Electric System reliability

  Verify auxiliary equipment needed for expected normal operation is in service for both the Real Power and Reactive Power capability

  Perform verification with the automatic voltage regulator in service for the Reactive Power capability

NERC MOD 025-2/MOD 026-1 Standards

- MOD 026-1
  - To verify that the generator excitation control system or plant volt/var control function model (including the power system stabilizer model and the impedance compensator model) and the model parameters used in dynamic simulations accurately represent the generator excitation control system or plant volt/var control function behavior when assessing Bulk Electric System (BES) reliability.

PJM Manual 14D, Attachment D

- The attachment provides further explanation of the PJM Generating Unit Reactive Capability Curve Specification and Reporting Procedures that are discussed in this manual Section 7: Generator Operations. This section also applies to Synchronous Condensers.
  - The requirements are applicable only for units physically located within the PJM RTO footprint or Reliability Coordinator area, or to energy storage installations such as batteries and flywheels

Generator Reactive Testing

- PJM Generator Reactive Capability Testing
  - All individual units ≥ 20 MW, and all aggregate units ≥75 MW, which are connected to the BES must complete testing
    - This includes Wind and Solar units meeting the criteria
  - All units designated as Black-Start must complete testing
  - All Synchronous Condensers ≥ 20 MW which are connected to the BES must complete testing
  - Testing is required once very 5 years
    - No more than 66 months between consecutive tests

Generator Reactive Testing

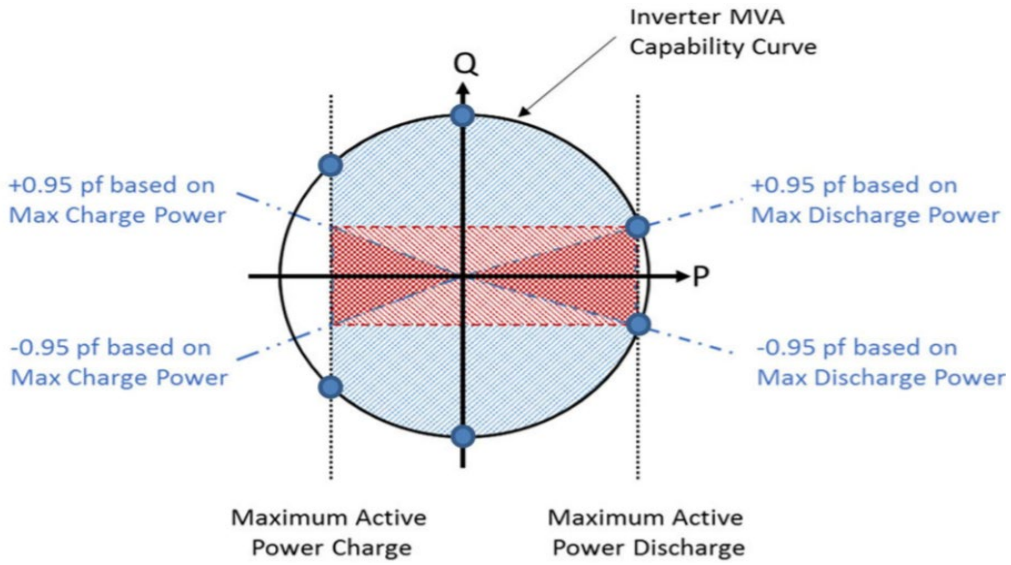
UNIT TYPE	MW OUTPUT	MVAR OUTPUT	TEST DURATION
FOSSIL, HYDROELECTRIC & BLACKSTART	MAX	MAX LAG	ONE HOUR
	MAX	MAX LEAD	WHEN LIMIT REACHED
	MIN	MAX LAG	WHEN LIMIT REACHED
	MIN	MAX LEAD	WHEN LIMIT REACHED
SYNCHRONOUS CONDENSER or GENERATOR THAT OPERATES IN THE SYNCHRONOUS CONDENSING MODE TO PROVIDE REACTIVE SUPPORT	-	MAX LAG	ONE HOUR
	-	MAX LEAD	WHEN LIMIT REACHED
NUCLEAR	MAX	MAX LAG	ONE HOUR

Generator Reactive Testing

UNIT TYPE	MW OUTPUT	MVAR OUTPUT	TEST DURATION
	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 VARIABLE	MAX LAG MAX LEAD	WHEN LIMIT REACHED WHEN LIMIT REACHED
INVERTER-BASED ENERGY STORAGE RESOURCES Max MW Output = fully discharging Min MW Output = fully charging	MAX MAX ZERO ZERO MIN MIN	MAX LAG MAX LEAD MAX LAG MAX LEAD MAX LAG MAX LEAD	WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED

Reporting Reactive Capability Data to PJM

1. For an inverter-based Energy Storage Resource, a minimum of three points is required: One for maximum MW injection to the grid for discharging, zero MW, and one for maximum MW withdrawal from the grid for charging
2. For inverter-based Energy Storage Resources, the reactive capability should be based on Inverter MVA Capability Curve



Reporting Reactive Capability Data to PJM

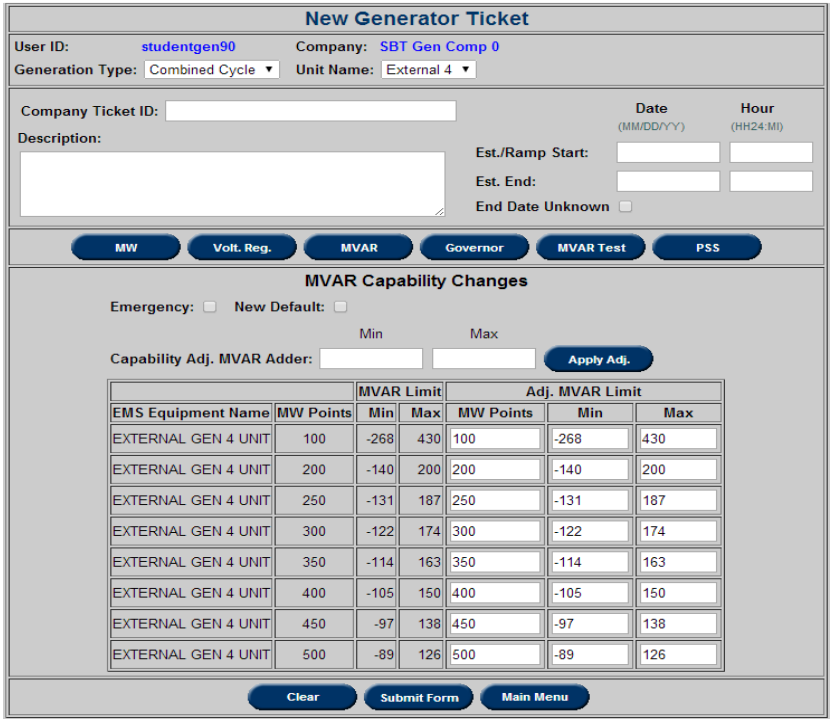
- Data should be provided to PJM in the format shown in the exhibit below via eDART

	MW	Minimum MVAR	Maximum MVAR
Point 1			
Point 2			
Point 3			
Point 4			
Point 5			
Point 6			
Point 7			
Point 8			

*Note that if a unit's current default curve in eDART has less than eight points, a revised curve with more points can be entered in the eDART "Description" field

Reporting Reactive Capability Data to PJM

- Data should be provided to PJM in the format shown in the exhibit below via eDART



New Generator Ticket

User ID: studentgen90 Company: SBT Gen Comp 0

Generation Type: Combined Cycle Unit Name: External 4

Company Ticket ID:

Description:

Date (MM/DD/YY) Hour (HH24:MI)

Est./Ramp Start:

Est. End:

End Date Unknown

MW | Volt. Reg. | MVAR | Governor | MVAR Test | PSS

MVAR Capability Changes

Emergency: New Default:

Min Max

Capability Adj. MVAR Adder: Apply Adj.

		MVAR Limit		Adj. MVAR Limit		
EMS Equipment Name	MW Points	Min	Max	MW Points	Min	Max
EXTERNAL GEN 4 UNIT	100	-268	430	100	-268	430
EXTERNAL GEN 4 UNIT	200	-140	200	200	-140	200
EXTERNAL GEN 4 UNIT	250	-131	187	250	-131	187
EXTERNAL GEN 4 UNIT	300	-122	174	300	-122	174
EXTERNAL GEN 4 UNIT	350	-114	163	350	-114	163
EXTERNAL GEN 4 UNIT	400	-105	150	400	-105	150
EXTERNAL GEN 4 UNIT	450	-97	138	450	-97	138
EXTERNAL GEN 4 UNIT	500	-89	126	500	-89	126

Clear | Submit Form | Main Menu

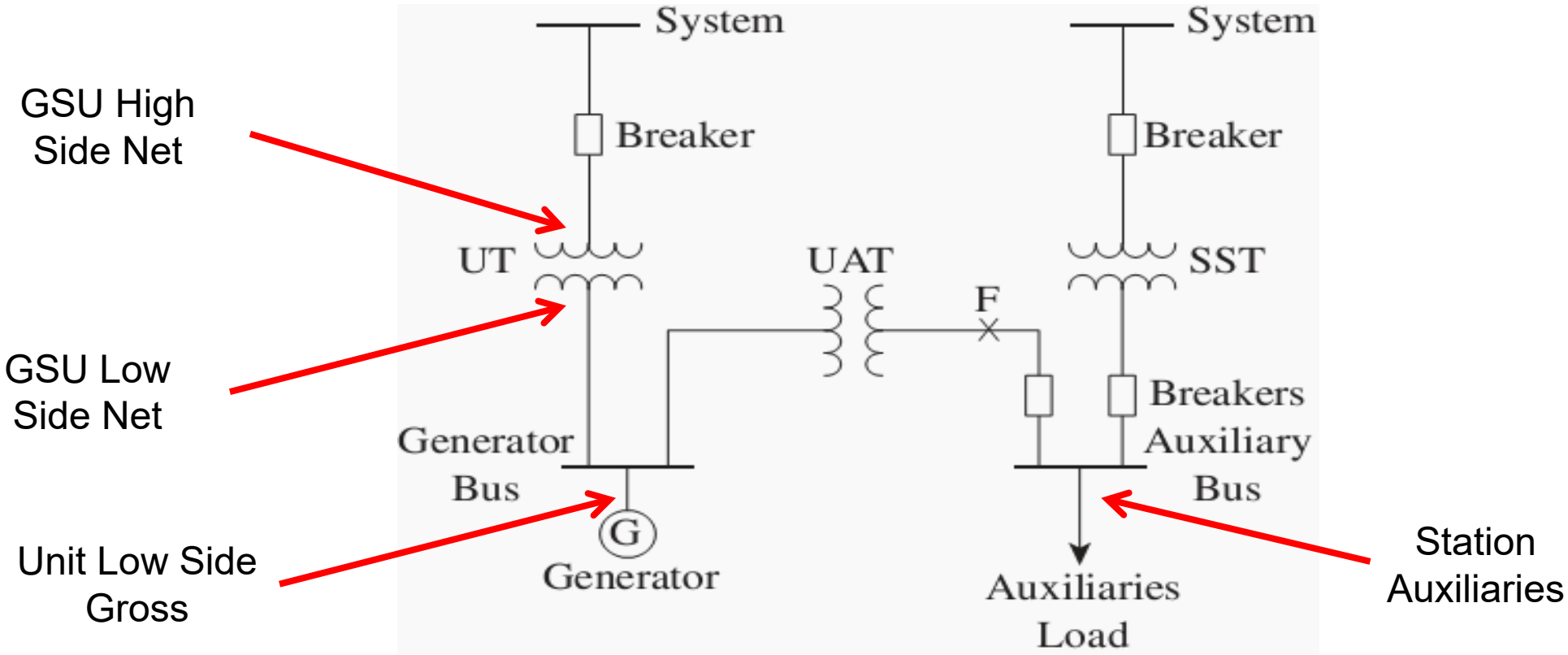
* Note that if a unit's current default curve in eDART has less than eight points, a revised curve with more points can be entered in the eDART "Description" field

Reactive Capability Tests – Testing Criteria

- Units should be tested against their expected capability
  - For new units, Vendor “D” curves and exciter limiter settings should be used
  - For existing units, previous test results would be an expected minimum
- Testing should respect the normal voltage limits at the system bus
  - The TO/PJM may need to make system adjustments to ensure this
  - Voltage schedules may be exceeded during the testing

Reactive Capability Tests – Reporting Data

- For each testing point, record the unit MW and MVAR values for the following



Reactive Capability Testing – Test Scheduling

- MOC/Unit Owner Actions:
  - Prior to scheduling the test, confirm with PJM RE that MW and MVAR data is being provided to PJM via ICCP
  - Identify/resolve any issues prior to scheduling the test
  - Any scheduled (or unscheduled) maintenance on the unit must be completed, and all eDART tickets closed prior to scheduling the MVAR test

Reactive Capability Testing - Test Scheduling

- MOC/Unit Owner Actions:
  - Proposed testing dates/times should be communicated via eDART to PJM Dispatch, PJM Reliability Engineer and the TO no later than noon 3 business days prior to the test
    - Allows testing to be incorporated into the day-ahead studies
  - Test notification shall be submitted using a “MVAR Test” Ticket
    - Test duration
    - Type of test that is planned to be performed
    - Any additional relevant information for the test
  - 30-minute notification shall be provided to PJM and the TO to adjust the system to ensure testing does not result in voltage limit violations

Reactive Capability Testing

- PJM Actions:
  - Review and approve submitted information ensuring there is no conflict between the testing and any planned transmission outage
    - PJM will suggest a more appropriate date for the test, if necessary
    - PJM RE will ensure that PJM dispatch is aware of scheduled testing and communicate the pre-studied mitigating action plan to the PJM Control Room Staff
  - Once the PJM RE is contacted by the MOC or TO, they will contact all impacted TOs in order to initiate the transmission operator's study process

Reactive Capability Testing

- PJM RE Actions:
  - Verify the expected unit output levels with the MOC, or TO, ensuring that the AVR is in service
  - Re-evaluate corrective action plans prior to test commencement and communicate any adjustments to the impacted entities no later than two hours prior to testing to inform them whether mitigation steps will be required
  - Coordinate with the appropriate MOCs and TOs in order to implement the selected mitigation strategy

Reactive Capability Testing

- PJM RE Actions:
  - Coordinate all actions and communications among involved entities to include:
    - Coordinating MVAR output step changes with the testing unit (Step changes should be no greater than 100 MVAR)
    - Contacting impacted entities if the testing must be cancelled or rescheduled
    - Coordinating the exit strategy implementation

Reactive Capability Testing

- Transmission Owner Actions:
  - Conduct studies to determine any scheduled testing effects on their systems contacting the PJM RE with any concerns
  - Prior to studying the test, verify the expected unit MW and MVAR output levels during testing ensuring the AVR is in service
  - Contact the PJM RE no later than 2 hours and 15 minutes prior to the test in order to discuss study results and the mitigating steps required, if any

Reactive Capability Testing – Mitigating Actions

- Adjustments may need to be made to local voltage schedules in order to accommodate the scheduled testing
  - Adjustments will be considered and studied on a case by case basis
  - The impact of these deviations will be monitored by the TO and PJM
- PJM will discuss the changes with the appropriate TO and if the recommendation does not cause a violation of a defined limitation, the TO should implement the PJM request

Reactive Capability Testing – Mitigating Actions

- PJM will retain control of other reactive facilities (capacitors, LTCs, etc.)
- If internal plant or TO limits restrict the request, PJM dispatch will study the limitations and recommend changes to plant facilities if appropriate
  - If the recommended changes cannot be implemented due to equipment or facility limitations, other options will be considered, including test cancellation or rescheduling

Generator Reactive Testing

- Test Window
  - Testing period:
    - Maximum Lagging Test @ Maximum Real Power Output: Between 1200 and 1800 on weekdays from May 1st to September 30th
    - Maximum Leading Test @ Minimum Real Power Output: Between 2300 and 0700 EPT anytime of the year

Reactive Capability Testing – Test Conditions

- PJM will NOT allow any violations of its operating criteria above:
  - Normal rating on an actual basis/Emergency rating on a post-contingency basis
  - For a facility rating discrepancy, PJM will default to the most conservative limit
  - Equipment failure could result in a unplanned constraint require immediate remedial action
  - Mitigation steps will be taken to return the facilities in violation back to normal limits within fifteen minutes

Reactive Capability Testing

- Test Cancellation
  - PJM dispatch and/or the impacted parties may cancel the generator reactive capability testing for the following reasons:
    - Internal planning issues
    - Emergency procedures
    - Inability to control actual or post-contingency voltage issues
    - Operating issues created on TO equipment not monitored by PJM
  - Cancellation of the generator reactive capability test will be communicated to all impacted parties
  - PJM will document all cancellations and terminations including the party responsible and the reason for the cancellation or termination

Generator Testing Requirements

- Results Reporting
  - MOC/GO
    - Test results submitted on “PJM Leading and/or Lagging Test Form R”
    - The form should be completed electronically within 30 calendar days from the test date

      http://www.pjm.com/~/media/documents/manuals/manual-links/m14d/reactive-testing-schedule-form-version-0.ashx
  - PJM
    - Provide feedback to Generation Owners on status of their test results
    - Also provide test results to appropriate TO
    - Conduct periodic audits of test results and provide results to OC and SOS

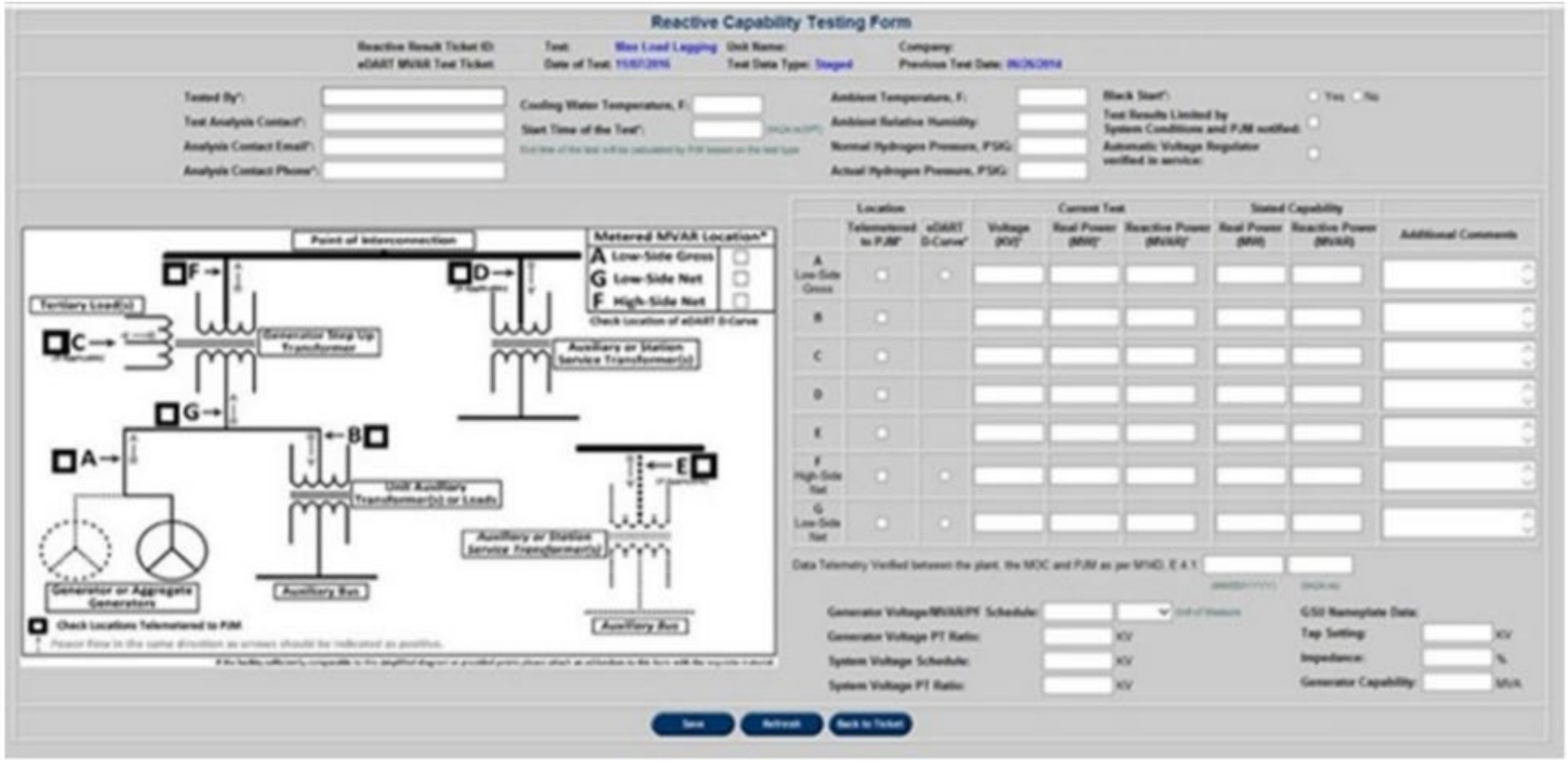
Generator Testing Requirements

- Report scheduled and actual voltages at the system bus and the unit terminals
- Report nameplate data for the unit step-up transformer
  - Impedance
  - MVA rating
  - High and low side voltages
  - Available tap settings
  - Existing tap setting used during the test

Generator Testing Requirements

- The reason for any limitations noted during the testing should also be noted
  - Aux bus voltage limits
  - Generator vibration
  - Generator temperatures
  - Hydrogen pressure limits

Reactive Capability Testing



Generator Testing Requirements

- If testing is done on separate days, data shall be submitted within 30 days after each portion of the test.
  - Use the earliest date as the test/verification date for record and periodicity purposes
  - Updates to eDART capability curves shall be made if required ensuring the most accurate and timely data
  - All portions of the test must be completed within a 6-month time period after the initial test to be valid

Generator Testing Requirements

- Results should be based on capability actually achieved during the operating conditions
  - For some Black Start Unit testing, some calculations can be used
    - This is considered the exception
    - Not used on an ongoing basis
- If the generator uses hydrogen cooling, the hydrogen pressure should be set where it normally operates

Reactive Capability Testing – Analyzing Results

- Units Testing Within 5% of Stated Limits
  - The unit will be considered as having fully demonstrated their stated reactive capability
  - PJM will notify the MOC/GO that their unit(s) achieved their reactive capability, and no further action will be required

Reactive Capability Testing – Analyzing Results

- Units Testing Below 5% of Stated Limits
  - Units with test results under 5% of their stated limits will be considered as not meeting their stated reactive capability
  - PJM will determine if either internal or external operational limitations contributed to the failure to meet the stated capability, based on reasons documented within the submitted test results
  - There is no penalty for not meeting the stated capability, but PJM must investigate to ensure that realistic values for that unit are entered and used going forward

Reactive Capability Testing – Deviation follow-up

- For a unit that claimed external operational limitations;
  - PJM will attempt to confirm the external limitations and identify possible remedial measures in help the unit meet started levels in future tests
  - If an external limitation is confirmed, PJM will provide confirmation to the MOC/GO that their unit performed below its stated reactive capability due to external limitations and will not require any further action
    - The assumption is that the limiting condition is temporary and the unit could perform as stated

Reactive Capability Testing – Deviation follow-up

- If PJM could not confirm the external limitation, the MOC/GO will be required to either;
  - Permanently reduce the reactive capability modeled within the PJM EMS by entering a “New Default” eDART MVAR ticket or,
  - Retest to demonstrates the stated capability of the unit.
    - If the MOC chooses to retest the unit, PJM will require that a temporary eDART MVAR ticket be submitted that will remain active until the unit demonstrates the original stated capability

Reactive Capability Testing – Analyzing Results

- For units that claimed internal operational limitations,
  - PJM will notify the MOC/GO that their unit performed below its stated reactive capability
  - If the internal limitation was caused by an external condition which the TO and PJM could not correct during the testing (i.e. - high or low transmission system voltages) and,
    - The Plant/MOC/GO notified the TO of the condition during the testing
    - PJM confirms the external condition caused the internal limitation
  - The unit will be considered as meeting its stated capabilities, and PJM will require no additional action

Reactive Capability Testing – Analyzing Results

- If the internal limitation was caused by an external condition which the TO and PJM could not correct during the testing (i.e. - high or low transmission system voltages) but the Plant/MOC/GO did not notify the TO of the condition during the testing;
  - PJM will require the MOC/GO to either;
    - Permanently reduce the reactive capability modeled within the PJM EMS by entering a "New Default" eDART MVAR ticket or,
    - Retest to demonstrates the stated capability of the unit.
      - If the MOC chooses to retest the unit, PJM will require that a temporary eDART MVAR ticket be submitted that will remain active until the unit demonstrates the original stated capability

What Reactive Reserve Information is Reported?

- MOC's/GOs must also review and confirm their unit reactive capability data via eDART on a bi-annual basis
  - Pre-Summer Review: From April 1 through April 30
  - Pre-Winter Review: From October 1 through October 31
- PJM and the TOs will then verify accuracy of unit reactive capabilities modeled in their respective EMS systems

What Reactive Reserve Information is Reported?

- The MOC/GO must provide reactive capability curve information to PJM, the TO for the zone where the unit is located, and to any other TOs with eDART authority to receive automatic notification for the unit
  - *Continuous Unit Reactive Capability Curve* - data that provides the realistic usable reactive output that a generating unit is capable of delivering to the PJM Interconnection and sustaining over the steady state operating range of the unit

- For real-time changes, each MOC/GO should also notify PJM and the respective TOs via phone

What Reactive Reserve Information is Reported?

- Planned modifications (tap changer adjustment, GSU replacements, turbine modification, etc.) that impact generator reactive capability should be communicated to the impacted TOs and PJM as far in advance as possible but no later than the return of the unit from the outage

What Reactive Reserve Information is Reported?

- Whenever a unit's Automatic Voltage Regulation (AVR) or Power System Stabilizer (PSS) status is off (or is planned to be off) longer than 30 minutes, the MOC/GO must immediately enter a ticket via eDART
  - This requirement is exempted when the Unit starting up and shutting down
- For real-time changes, the GO/GOP must also notify the PJM Power Dispatcher (PD) and the respective TOs by phone
  - PJM and the TOs will change the status in their EMS systems

Reporting Reactive Capability Changes to PJM

For ***Permanent*** Changes

1. Each GO/GOP must continually provide accurate permanent capability curve changes to PJM via eDART ***as soon as the information is available***. The “New Default” field should be checked in eDART

2. Once the accuracy of the submitted reactive capability curve is verified, PJM will permanently update the PJM Unit Reactive Capability Curves in use by PJM Operating/Planning Studies and PJM EMS Network Applications programs

Reporting Reactive Capability Changes to PJM

For ***Temporary*** Changes

1. Whenever a PJM unit's reactive capability is limited or reduced (or is planned to be limited or reduced) for any reason, the GO/GOP must ***immediately enter a temporary ticket via eDART***. For real-time changes, the generator's owner/operator must also notify the PJM Power Dispatcher (PD) and respective LCC by phone

2. The PJM PD will receive the ticket and either temporarily update the unit's reactive capability curve in use by the PJM EMS Network Applications, or will temporarily set the unit's AVR status in use by the PJM EMS Network Applications to "OFF" for the specified time period

Reporting Reactive Capability Changes to PJM

For ***Temporary*** Changes *(con't)*

3. The GO/GOP must immediately modify the eDART ticket and notify the PJM PD and respective LCC by phone whenever the unit's normal reactive capability is (or is anticipated to be) restored

4. The PJM PD will either restore the unit's normal reactive capability curve in use by the PJM EMS Network Applications. The PJM PD will then close the unit reactive ticket

Net Capability

- Net Capability is defined as the gross output of MW that can be delivered by a generator without restriction less unit auxiliaries and other station use required for electrical generation
- For auxiliary load and other station load that is apportioned over multiple units at a facility, the load must be consistent with the load during summer conditions
- “Without restriction” means that Net Capability is available for use at the request of PJM for operating capacity and energy

Appendix

Unit Capability (Conventional Generation)

- A combined-cycle unit will depend on the structure of the complete unit and its total output
- A steam unit is based on procedures for increasing the unit output
  - Turbine over-pressure, boiler overrating, cycle modification
- A combustion turbine is based on the MW output of the unit
- A nuclear unit is based on its fuel management program and any regulatory restrictions
- A reciprocating engine unit or fuel cell shall be consistent with the owner's policy with respect to outputs and on fuel type

Unit Capability (Planned Conventional Generation)

- A steam or combined-cycle unit shall be based on the manufacturer's guarantee or estimate of performance corrected for the expected site conditions coincident with the last 15 years' PJM summer peaks
- A combustion turbine or combined-cycle unit shall recognize the unit's location elevation, the fuel type, and the owner's policy with respect to the maximum output and the expected site conditions coincident with the last 15 years PJM summer peaks
- A reciprocating engine unit or fuel cell shall be consistent with the owner's policy with respect to maximum outputs and fuel type

Unit Capability (Capacity Storage Units)

- A hydro/pumped storage unit is determined by energy output during the summer PJM peak considering head, operating restrictions and reservoir storage
- A storage (non-hydro) unit shall recognize the MWH energy available, giving consideration to market activities for which the unit may be committed during the expected time of the PJM peak

Unit Capability (Planned Capacity Storage Units)

- A planned hydro/pumped storage unit shall be based on the expected head and/or streamflow in accordance with the specifications on the previous slide
- A planned storage (non-hydro) unit shall be based on the MWH energy available, given proper consideration to other market activities in which the unit may be participating at the expected time of the PJM peak under summer conditions

Unit Capability (Run of River with Pooling/Storage/Dispatch)

- A run of river hydro unit (with pooling/storage/dispatch capability) shall recognize the head available giving consideration to operating restrictions and the reservoir storage program during a normal cycle at the expected time of the PJM peak under summer conditions
- A planned run of river hydro unit (with pooling/ storage/dispatch capability) shall be based on the expected head and/or streamflow in accordance with the above

Unit Capability (Intermittent Except Wind and Solar)

- A hydro unit (without storage and pooling capability) shall be based on the expected head and streamflow at the PJM peak under summer conditions
- A generator consuming landfill gas shall be based on the availability of landfill gas at the PJM peak under summer conditions
- A planned hydro unit (without storage and pooling capability) shall be based on the expected head and streamflow at the PJM peak under summer conditions
- A planned generator unit consuming landfill gas shall be based on the availability of landfill gas at the expected time of the PJM peak under summer conditions.

Wind/Solar Resources

- The Capacity Value for a wind or solar capacity resource is the amount of g capacity, expressed in MW, that it can reliably contribute during summer peak hours and which can be offered as unforced capacity into the PJM capacity markets.
- The wind or solar capacity resource's "Net Maximum Capacity" is the manufacturer's output rating less the Station Load where "Station Load" refers to the amount of energy that is consumed to operate all auxiliary equipment and control systems.

Net Capability Verification

Net Capability is based on current operating performance or test results:

- Summer and Winter Net Capability values confirmed annually
  - If adequate data is available from normal operation, no test is required
- If a known change occurs in the Net Capability of a unit or is indicated by operating data or test results, the change will become effective as soon as possible
- The Resource Adequacy Planning Department of the PJM RTO is responsible for the establishment of test procedures required to confirm such values including any amount which could be treated as limited energy capability

Reductions in Net Capability

- If a known change occurs in the Net Capability of a unit or is indicated by operating data or test results, the change will become effective as soon as possible
  - A unit's net capability will not be reduced for unplanned deratings or temporary capacity restrictions if the capability will be restored
- If the capability cannot be restored by the end of the next Delivery Year, a reduced Net Capability Value may be requested by the owner
  - These changes should be made via the Capacity Modification (CAPMOD) process of the PJM Capacity Market

Unlimited/Limited Energy Capability

- Unlimited energy capability
  - All or any part of a unit's capability that can be sustained for 10 hours of continuous operation
- Limited energy capability
  - All or any part of a unit's capability that cannot be sustained for at least 10 hours
  - Only limited for the periods where it does not meet the 10 hour criteria

Seasonal Capability Value Verification

- Each generation owner is responsible for the determination and reporting of summer and winter Net Capability values
  - The summer verification window is the first day of June through the last day of August
  - The winter verification window is the first day of December through the last day of February
  - Data that is used to satisfy the summer net capability test may be used to satisfy winter test requirements after adjustment to the appropriate ambient winter conditions
  - Data from normal operations during these periods can be used to satisfy the seasonal verification test
  - Reporting is accomplished through the PJM eGADS reporting system
  - The deadlines for seasonal verification test result submittal are September 20 for the summer test period and March 20 for the winter test period*

*a data submission charge of $500/day can be applied to any data not submitted in accordance with published deadlines

Net Capability

- The duration of acceptance and verification tests shall be:
  - 2 contiguous hours for nuclear, fossil steam and combined-cycle units
  - 1 hour for hydro, pumped storage, non-hydro storage, simple cycle combustion turbine, fuel cell, and diesel units
- If a unit does not meet stated capability due to a temporary condition that existed prior to the test, the deficiency shall be covered by a reduction from the date of the problem
  - If the deficiency is uncovered during the verification test, a reduction covering the deficiency shall be entered into the PJM eGADS system retroactive from June 1 or December 1 (based on summer or winter testing)

Data to be Reported

- Event Data
  - Each time a unit experiences a change in operating status or capability, an event is recorded. From these event reports a unit's operational history can be reconstructed
- Generation Performance Data
  - A unit's actual generation data for the month must be reported
- Fuel Performance Data
  - A unit's actual fuel consumption data for the month must be reported
- Net Capacity Verification Test Data
  - Results from the summer or winter verification tests

Reduced Capability

- The Net Capability reported for a generating shall in no case exceed an amount determined by the owner but for PJM accounting purposes may initially be less than that amount.
- The extent of any such reduction in reported capability may be determined by the company in such manner as will permit the most effective use of its own resources

Summer/Winter Conditions

- The Summer/Winter Net Capability of each unit or station is based on summer/winter conditions and on the power factor level normally expected for that unit or station at the time of the PJM summer/winter peak load
- Summer/Winter conditions reflect the 50% probability of occurrence (approximated by the mean) of ambient site conditions at the time of the PJM summer/winter peak load. Conditions are based on plant records or local weather bureau records of the past 15 years, updated at 5 year intervals. When local weather records are not available, the values are estimated from the best data available
- For fossil and nuclear steam units, summer/winter conditions mean the probable condenser intake water temperature at the time of the PJM summer/winter peak load . Conditions include the expected temperature of once-through or open cooling systems as well as the performance of cooling towers under expected ambient conditions

Summer/Winter Conditions *(con't.)*

- For combustion turbine units, summer/winter conditions mean the probable ambient air temperature and humidity condition at the unit location at the time of the annual summer/winter PJM peak
- The determination of the Summer Net Capability of hydro and pumped storage units is based on operational data or test results taken once each PJM delivery year during the Summer verification window
- The determination of the Winter Net Capability is waived for hydro and pumped storage units
- For combined-cycle units, summer/winter conditions mean the probable intake water temperature of once-through or open cooling systems and/or the performance of cooling towers and combustion turbines under expected ambient conditions at the unit location at the time of the annual summer/winter PJM peak

Resources & References

PJM Interconnection. (2019). *PJM Manual 14D: Generation Operational Requirements*. (rev 48). Retrieved from: https://www.pjm.com/~/media/documents/manuals/m14d.ashx

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PJM Interconnection. (2019). *PJM Manual 21: Rules and Procedures for Determination of Generating Capability.* (rev 13). Retrieved from: https://www.pjm.com/~/media/documents/manuals/m21.ashx

Questions?

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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