



Performance Based Reactive Power Compensation – PJM Package

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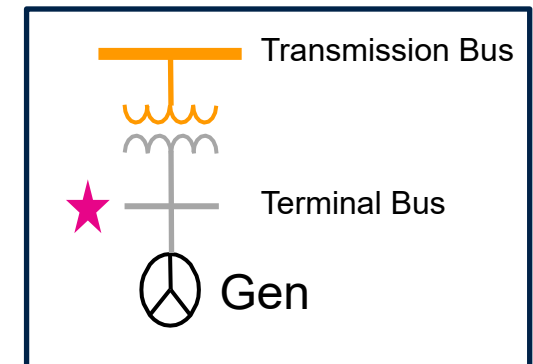
Reactive Power Compensation Task Force

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- Focus on PJM operational needs
 - Reactive Power is an essential reliability service
- Ensure resources are meeting ISA obligations
- Encourage and reward resource performance for real time voltage control
- Reduce administrative and legal burden of existing process

1. Determine eligibility of resource based on eligibility criteria
2. Determine capability
3. Update Reactive Capability Curve
4. Determine MVAR capability eligible for flat rate payment
5. Performance incentive through monthly eligibility assessment for flat rate payment based on unit performance, plus ongoing capability de-rate following inadequate performance

- Physically connected directly (through unit step-up transformer) to PJM Transmission Facilities
 - Modeled and necessary telemetry
- Must have Automatic Voltage Regulation (AVR) set to control transmission level voltage based on PJM approved voltage schedule
 - Units operating on fixed power factor mode not eligible
- AVR must be operating at all times except planned outages
 - Automatic response
- Requirement to be dispatched by PJM for reactive power as needed
- Must be PJM Member or have executed full responsibility DOA



- Upon entry to the program and every 5 year testing/demonstration
- Based on existing testing criteria as today in M-14D
- When internal conditions preclude testing to full capability, only maximum actual delivered MVAR capability will be eligible for flat rate payment
 - Limit of two tests/year/generator
 - Use of actual historic MVAR capability delivered over last 2 years may be used as substitute for tested capability
 - PJM reserves the right to require a retest if prior test capability is not reflected in actual operations
- Measurement location as defined in ISA

- Utilize eDART to update reactive capability curve as required following testing
 - Ensures EMS is modeled with dependable, deliverable MVAR capability
 - Status Quo process as today

- Eligible capability = greater of (0, Eligible Lagging capability + |Eligible Leading capability|)
 - Eligible Lagging Capability = (demonstrated lagging MVAR at Eco Max)
 - Eligible Leading Capability = |(demonstrated leading MVAR at Eco Min)|
 - Must meet at least both ISA required leading and lagging requirements to be eligible (i.e. no netting)
 - ISA required lagging capability = 0.9 pf for synchronous generators
 - ISA required leading capability = 0.95 pf for synchronous generators

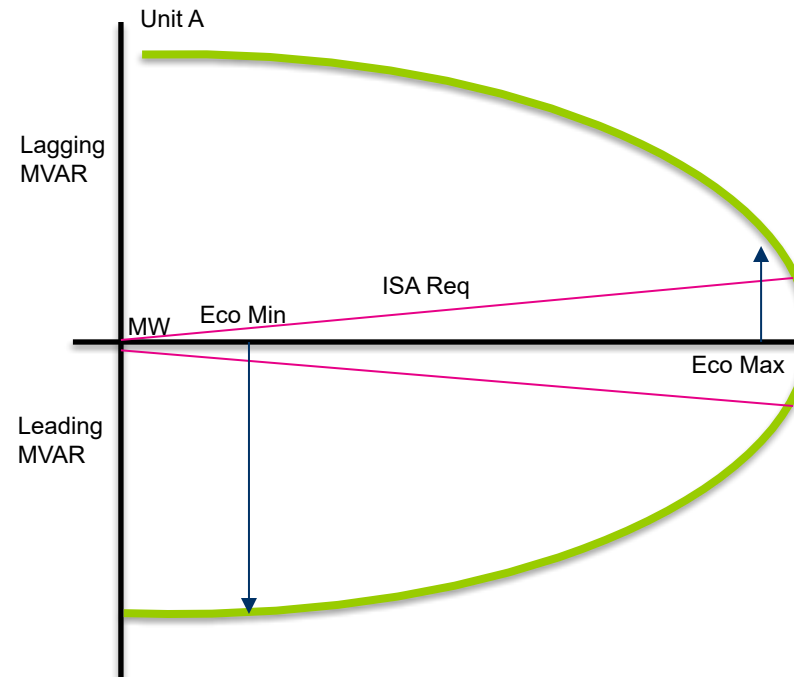


Basis for Compensation – Option A

Full Tested/Demonstrated MVAR Capability

- Resources must meet “gating criteria” on Slide 3
- Resources must at least meet ISA requirements
- Compensation at flat rate based on greater of ISA or tested/historic capability

$$\{\{\text{Lagging MVAR at Eco Max} + \text{abs}(\text{Leading MVAR at Eco Min})\}(\text{flat rate in \$/MVAR-year})\}/12$$



- Eligible capability = greater of (0, Eligible Lagging capability + |Eligible Leading capability|)
- Eligible leading/lagging capability = Demonstrated capability – ISA required capability
 - Eligible Lagging Capability = (demonstrated lagging MVAR at Eco Max) – (ISA required capability at Eco Max)
 - E.g., ISA required lagging capability = 0.9 pf for synchronous generators
 - Eligible Leading Capability = |(demonstrated leading MVAR at Eco Min)| – |(ISA required capability at Eco Min)|
 - E.g., ISA required leading capability = 0.95 pf for synchronous generators
 - Must meet at least both ISA required leading and lagging requirements to be eligible (i.e. no netting)

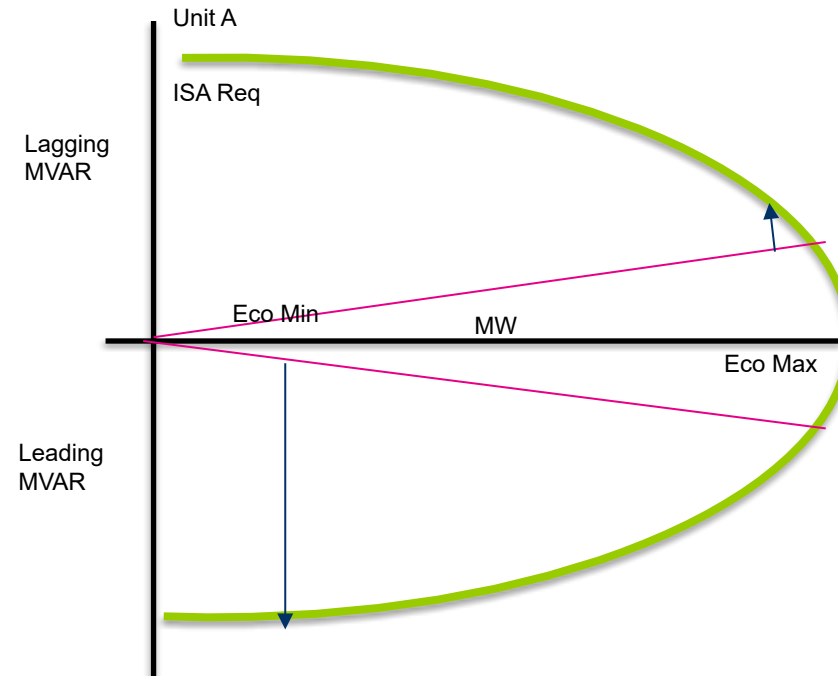


Basis for Compensation – Option B

Tested/Demonstrated MVAR Capability Above ISA

- Resources must meet “gating criteria” on slide 3
- Resources must at least meet ISA requirements
- Compensation at flat rate based on tested/historic capability beyond ISA requirement only

$$\{((\text{Lagging MVAR at Eco Max} - \text{ISA Req}) + \text{abs}(\text{Leading MVAR at Eco Min} - \text{ISA Req}))(\text{flat rate in \$/MVAR-year})\}/12$$



No Flat Rate → Compensation through Existing Markets

- Capability compensation based on existing markets
 - Removal of reactive credit from E&AS offset
- Bonus/penalty structure developed based on actual MVAR performance

To Be Determined

- Option A
 - Based on cost of reactive compensation device
 - Capacitor
- Option B
 - Based on current Schedule 2 reactive payments
 - $(\text{Current Reactive Revenue}) / (\text{Total generator MVAR capability})$



Monthly Eligibility Evaluation for Flat Rate Payment Based on Unit Performance

Monthly pass/fail lookback evaluation to determine eligibility for monthly credit

1. Determine if any regulated bus voltages are outside voltage schedules for 5 consecutive minutes

- PJM default or bus specific
- For example, 230 kV voltage goes above 239 kV or below 231 kV for 5 consecutive minutes

	PJM Default Generator Voltage Schedules								
Voltage Level (kV)	765	500	345	230	161	138	115	69	66
Schedule (kV)	760.0	525.0	350.0	235.0	164.0	139.5	117.0	70.0	67.0
Bandwidth (+/- kV)	+/-10.0	+/- 8.0	+/- 7.0	+/- 4.0	+/- 4.0	+/- 3.5	+/- 3.0	+/- 2.0	+/- 1.5

2. Determine MVAR supplied or absorbed by generator (at measured point consistent with tested capability)
3. Compare actual MVAR delivered to eligible capability (within 10%)
4. If generator provides less than capability, ineligible for monthly credit
- Update D-curve and MVAR eligibility to delivered amount

- If regulated voltage is within voltage schedule limits for entire month, generator is eligible for credit
- If generator was offline during voltage excursion, it is assumed to have passed performance test and remains eligible for credit
- If generator fails performance test due to AVR outage, it is ineligible for credit
- Must pass each check to be eligible for month

- Actual MVAR delivered \geq (.9)Eligible capability \rightarrow Eligible for that month
- Actual MVAR delivered $<$ (.9)Eligible capability \rightarrow Not eligible for that month
Update D-curve

- 500 MW ICAP generator connected directly to 345 kV transmission system
- ISA required MVAR = 242 lagging, -164 leading
- Tested MVAR capability = 350 lagging, -200 leading
- Option A MVAR = $350 + |-200| = 550$ MVAR
- Option B MVAR = $(350-242)+|(-200-(-164))| = 144$ MVAR
- Monthly Performance Evaluation
 - Voltage drops to 342.5 kV for 5 minutes
 - Generator must deliver at least 315 MVAR $(.9)(350)$ in order to pass monthly eligibility evaluation

- Synchronous and non-synchronous resources eligible for uplift if MW output is reduced at PJM direction to provide increased reactive
- Voltage schedules (including AVR mode) set by PJM with TO input
- Capacitors at generator sites can be included in plant MVAR capability if they meet technical conditions
 - Fast enough autonomous response to be useful post-contingency

- MVAR capability eligible for flat rate payment
- Flat rate payment amount
- Transition issues from current Schedule 2
 - New generators and existing generators rolling off legacy Schedule 2 rates would be eligible for new flat rate
 - Break implementation into phases – phase in
 - Smooth transition from status quo
 - Allow time for generators to adjust performance
 - Allow time to develop supporting tools and automation

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