Performance Based Reactive Power Compensation – PJM Package

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Objectives of PJM Package

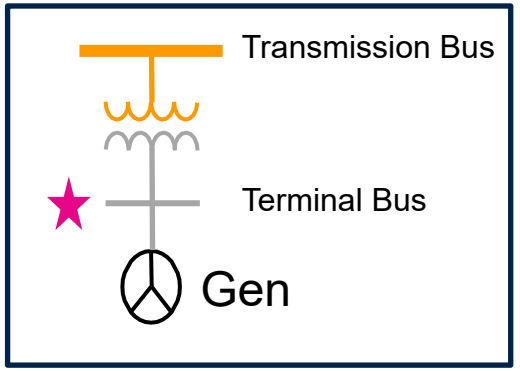
- Focus on PJM operational needs
  - Reactive Power is an essential reliability service
- Provide incentive for full, usable reactive capability
- Encourage and reward resource performance for real time transmission voltage control
- Reduce administrative and legal burden of existing process

Key Elements of PJM Package

- Eligibility criteria to support transmission level voltage control
- Flat rate design
  - Equal compensation for reactive capability regardless of technology type
- Compensation based on demonstrated or tested reactive capability
- Robust performance evaluation to encourage voltage control
  - “Pay for performance”
- Elimination of administrative burden of FERC filed rates

Eligibility Criteria for Reactive Compensation

- 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



Flat Rate Design

- Flat Rate = $\frac{\text{PJM Total Reactive Compensation as of 1/1/23}}{\text{Total System MVAR Capability*}}$
- Flat Rate = $384 m / 130,048 MVAR = $2952/MVAR/year
- Monthly Compensation = (Flat Rate/12)(Unit MVAR Capability)(Availability Factor)
  - Availability Factor (between 0 and 1) reflects resources ability to provide reactive power
    - Synchronous resources/Energy Storage/"Wind-free"/"Q at night" based on full eDART outages
    - Inverter based resources based on when resource is generating

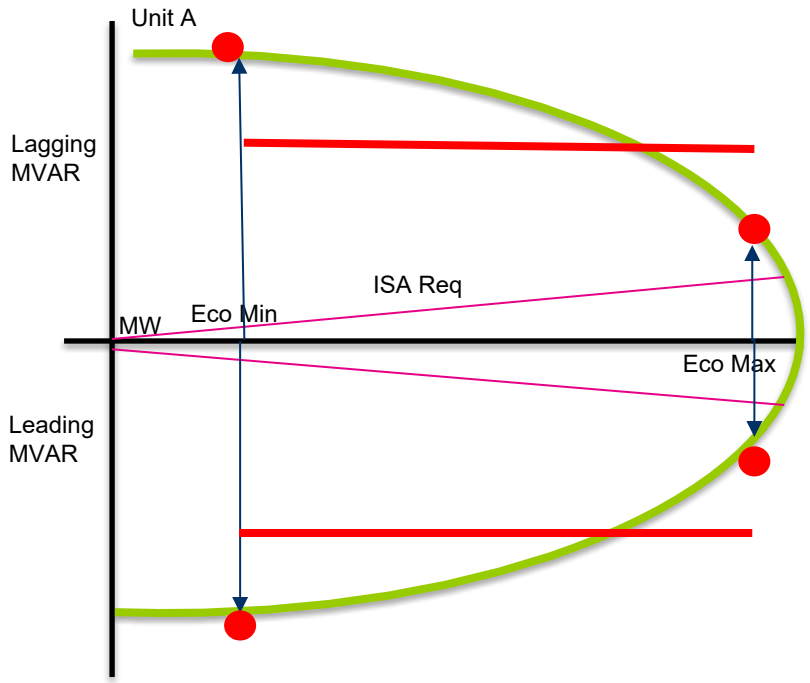
*Total System MVAR Capability based on 95% power factor at Pmax and rectangular D-curve

Basis for Compensation Full Tested/Demonstrated MVAR Capability

Compensated Capability = Avg (Qmax at Pmax, Qmax at Pmin) + | Avg (Qmin at Pmax, Qmin at Pmin)|

Example:
Qmax at Pmax = 20 MVAR
Qmax at Pmin = 40 MVAR
Qmin at Pmax = -20 MVAR
Qmin at Pmin = -40 MVAR

Compensated Capability = Avg (20,40) + |Avg (-20, -40)|
= 30 + 30
= 60 MVAR



Capability is based on tested or demonstrated MVAR output at Pmax and Pmin at POI

Monthly Performance Evaluation

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
   - Tighter of 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
   - Capability could go up if generator provided more MVAR than expected

Monthly Performance Evaluation

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

- Actual MVAR delivered >= (.9)Eligible capability → Eligible for that month
- Actual MVAR delivered < (.9)Eligible capability → Not eligible for that month
  Update D-curve

Other Package Elements

- 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

Implementation

- Transition issues from current Schedule 2
  - New generators and existing generators rolling off legacy Schedule 2 rates would be eligible for new flat rate
  - 18-24 month implementation
    - Smooth transition from status quo
    - Allow time for generators to adjust performance
    - Allow time to develop supporting tools and automation

Concerns with CEC Package

- Proxy formulas for all technology types yet to be developed
  - Cost impact unknown
  - Needed in order to file OATT rates
- Vague and limited performance evaluation process
- MVARs being compensated at different rates based on technology type
- Based on nameplate MVAR capability
  - May not be needed or deliverable
- Distribution connected resources eligible for compensation regardless of impact on transmission voltage
- Mechanism to compensate inverter-based resources for providing reactive power when not providing real power
  - Mechanism required by package but not provided

Concerns with IMM-1 Package

- Applies to capacity units only
- Performance incentives – unclear what penalty would be for non-performance
- No incentive for resources to increase MVAR capability beyond what is required by ISA
- Same concerns with IMM-2 package following 5 year transition period

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