

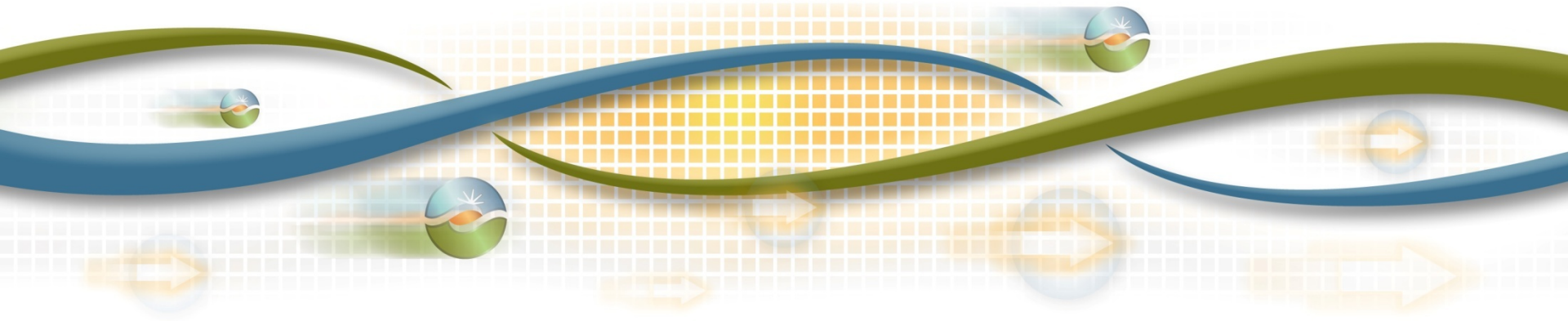


California ISO
Shaping a Renewed Future

Reactive Power Requirements and Financial Compensation

Technical Working Group

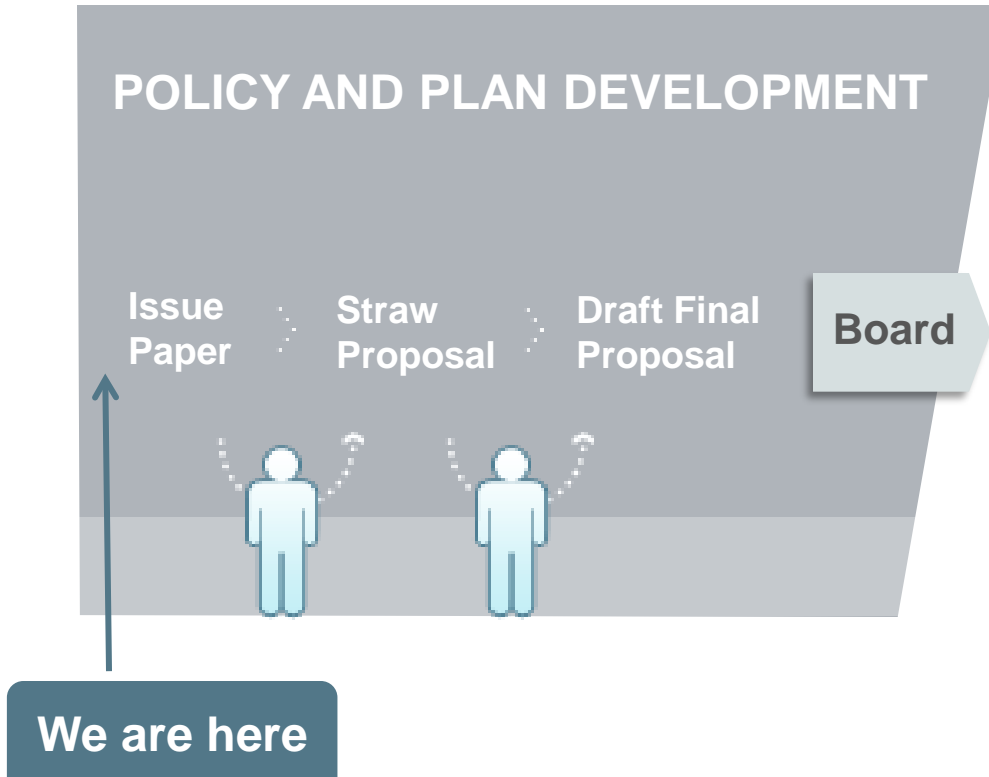
April 22, 2015



Agenda

| Time | Topic | Presenters |
|---------------|-------------------------------------|--|
| 10:00 – 10:05 | Introduction and schedule | Carrie Bentley |
| 10:05 – 11:00 | Current reactive power requirements | Clyde Loutan |
| 11:00 – 12:00 | Proposed requirements | |
| 12:00 – 1:00 | Lunch | |
| 1:00 – 1:45 | Presentations by First Solar and GE | Vladimir Chadliev, (First Solar) and Joseph Heinzmann (GE) |
| 1:45 – 2:45 | Technical issues | Clyde Loutan, Danny Johnson, Tom Flynn, Carrie Bentley |
| 2:45 – 2:55 | Compliance | Carrie Bentley |
| 2:55 – 3:00 | Next steps | |

ISO policy initiative stakeholder process



ISO working groups

- Unless noted in the market notice, working groups are open to the public
- Working groups are to facilitate discussion and work through challenging issues prior to the ISO issuing a paper on the topic
- Statements and discussions made in the working group are not recorded as “official comments” of the participants company
 - Comments after the working group are helpful to the ISO and can be submitted if you would like any comments “on the record”

Initiative schedule

- Technical working group on 4/22/15
- Comments due 5/6/15
- New issue paper posted early May:
 - Updated asynchronous generation issues
 - Description of current requirements for synchronous generators
 - Compensation
 - Penalties/rules for non-compliance
 - Other ISO/RTO compensation policy
 - Options for compensation
- Stakeholder call on issue paper- TBD

CURRENT REQUIREMENTS

Current Reactive Power Requirements

Synchronous generation

- Unit must maintain voltage schedule set by ISO or Participating Transmission Operator
- Unit must maintain composite power delivery at continuous rated power output at the terminals of the unit at a power factor within the range of .95 leading to .9 lagging
 - For synchronous generation this is always dynamic reactive power
 - Response is almost instantly (i.e. within a cycle) supporting the system during transient events
- Voltage regulators must operate in automatic operation

Current Reactive Power Requirements

Asynchronous generation

- Must operate within a power factor range of 0.95 leading to 0.95 lagging, at the POI, if Phase II interconnection study show requirement is needed
 - Must be able to provide sufficient dynamic voltage if study shows there is a need
- If dynamic voltage support needed, voltage regulators must operate in automatic mode

Current Reactive Power Requirements

Interconnection – GIA inverter limit

- Generation interconnection BPM is being modified to allow an increase in inverter capability by up to 10% or 3 MW, whichever is larger (CAISO Proposed Revision Request 825, BPM for Generator Management Section 3.5.1)
- Generators that increase their capability to go from unity power factor to .95 lead/lag power factor only need a 5.2% increase in inverter capability which is within the 10% limit

Current Reactive Power Requirements

ISO reactive power dispatch

- Primarily operate to a voltage schedule which is set by the Participating Transmission Owner (PTO)
- The ISO may revise voltage schedule as needed and will coordinate PTOs
- ISO may procure voltage support through exceptionally dispatching a resource

PROPOSED REQUIREMENTS

Proposed Requirements

Expanded reactive power requirements

CAISO proposes that all asynchronous resources interconnecting to the CAISO controlled grid comply with the new requirements

The CAISO plans:

- To exempt existing asynchronous resources from these new requirements for the remaining life of the existing generating unit
- To require existing resources that are repowered to meet these new requirements

Proposed Requirements

Asynchronous resource requirements

- Must have an over-excited (lagging) or under-excited (leading) reactive power producing capability to achieve a net power factor from 0.95 lead/lag at the Point of Interconnection, at the Generating Facility's maximum real power capability
- Shall provide dynamic voltage response between 0.985 leading to .985 lagging at rated MW capacity at the Point of Interconnection

Proposed Requirements

Static and dynamic reactive power capability

- Static reactive power capability is discreet in value and is typically provided by mechanically switched capacitors or reactors
- Dynamic reactive power indicates smooth and rapid operation between the specified power factor range
 - Response should be similar to a synchronous resource i.e. within a cycle to support the system during transient events

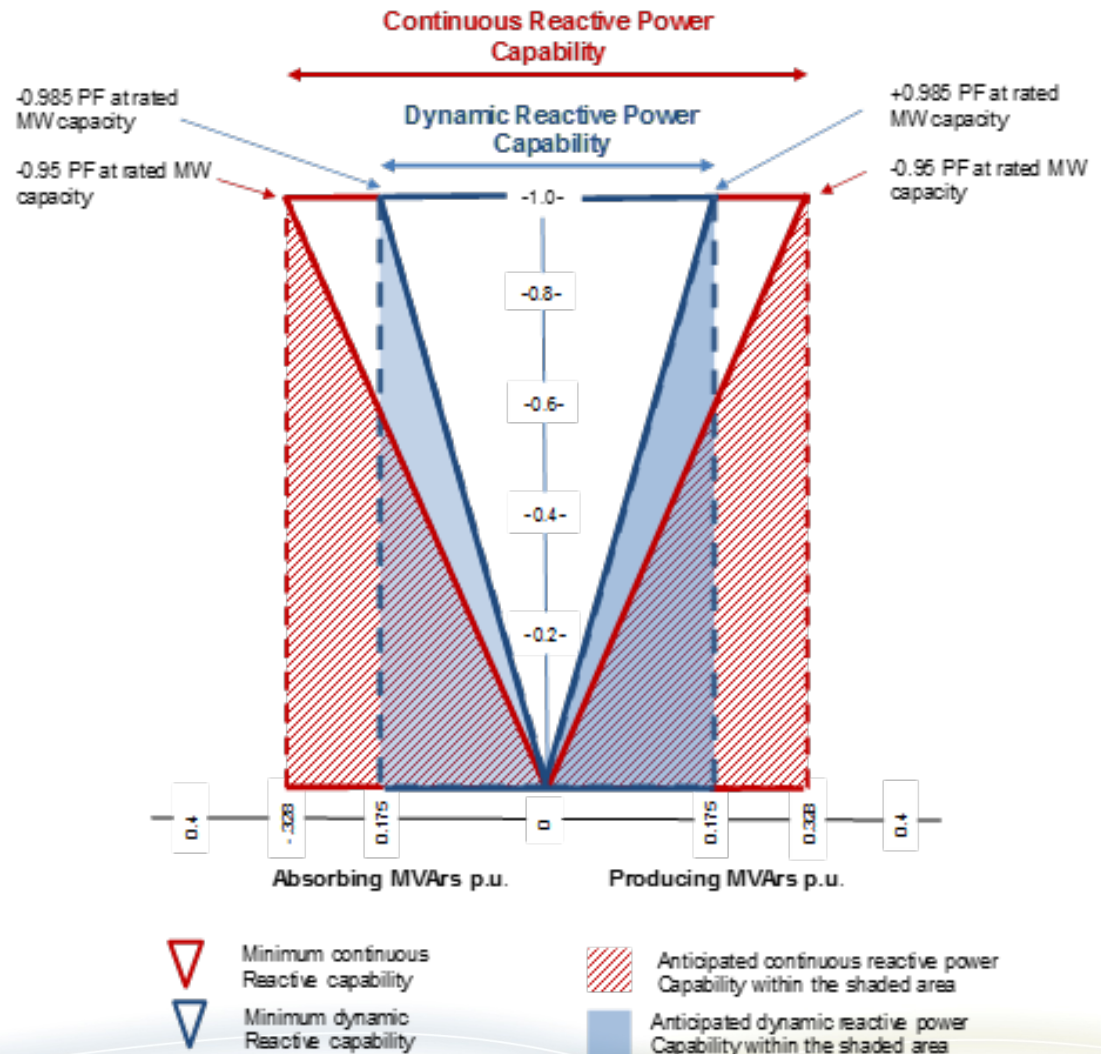
Proposed Requirements

Asynchronous resource requirements

The red and blue triangles show the expected reactive capability of the unit at the point of interconnection. At maximum real power capability of the Facility, the expected dynamic reactive capability should be between .985 lagging to .985 leading.

Also, at maximum real power capability, the overall expected continuous reactive capability should be between .95 lagging to .95 leading.

As the real power output decreases both the dynamic and continuous reactive capabilities also decreases.

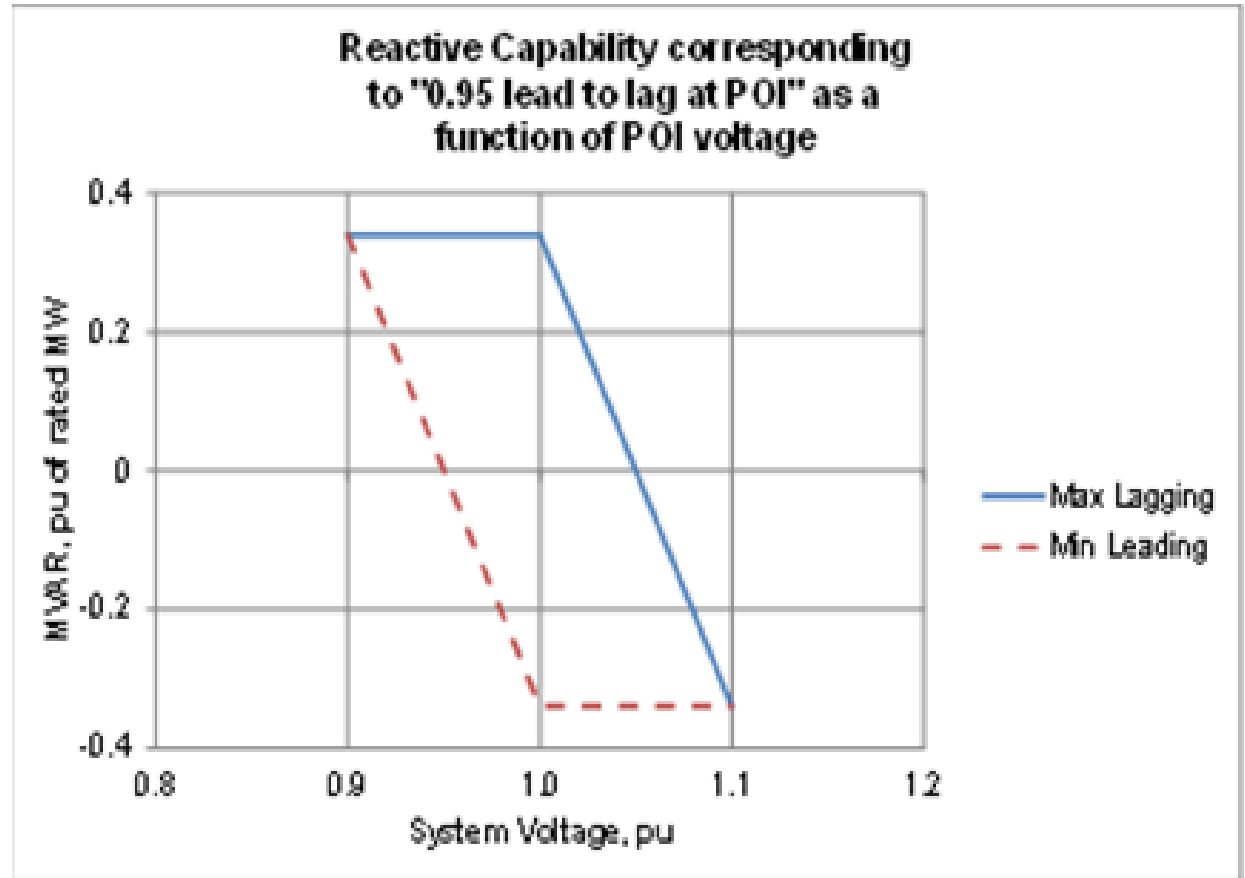


Proposed Requirements

Reactive power and voltage requirements

This figure specifies when the real power output is at its maximum capability, the Asynchronous Generating Facility shall have the capability to provide reactive power at .95 lagging when voltage levels are between .9 per unit and unity power and unity power at the Point of Interconnection.

The capability to provide reactive power decreases as the voltage at the Point of Interconnection exceeds unity power factor. Likewise, the capability to absorb reactive power decreases as the voltage at the Point of Interconnection drops below unity power factor.



Proposed Requirements

Voltage and reactive power control requirements

- The reactive power capability shall be controlled by an automatic voltage regulator (AVR)
- The voltage regulation function mode shall automatically control the net reactive power to regulate the POI scheduled voltage within the reactive constraints of the resource
- The ISO may permit the generator to regulate the voltage at a point before the POI
- The ISO may permit multiple generators to regulate the voltage at a point beyond the POI
- The customer shall not disable voltage regulation controls while the asynchronous resource is in operation without prior consent from the ISO

Proposed Requirements

Current control capabilities from inverter based resources efforts

- Electrical and Electronics Engineer's Standard – IEEE 1547
- NERC PRC 024-2: Generator Frequency and Voltage Protective Relay Settings
- NERC's Essential Reliability Task Force
- CPUC Electric Tariff Rule 21
 - Anti-Islanding Protection
 - Low and High Voltage Ride-Through
 - Low and High Frequency Ride-Through
 - Dynamic Volt-Var Operation
 - Ramp Rates
 - Fixed Power Factor
 - Soft Start Reconnection

Proposed Requirements

NERC / WECC rules

- WECC Standard VAR-001-3
 - R4: Each Transmission Owner shall specify a voltage...schedule at the interconnection between the generator facility and the Transmission Owner's facility
- NERC VAR-002-3
 - R2: Generator Owner shall maintain the generator voltage or Reactive Power schedule within each generating Facility's capabilities

MARKET PARTICIPANT PRESENTATIONS

TECHNICAL ISSUES

Technical Issues

What is hunting?

- Hunting can result when:
 - Multiple asynchronous resources in close electrical proximity can result in unstable voltage control when their voltage controls are not coordinated
 - Two or more facilities on shared generation ties, where some have reactive power capability and the others do not

Technical Issues

How can we mitigate hunting?

- The ISO's proposal mitigates hunting by allowing:
 - Power factor controls at the asynchronous resources' terminal(s) (with reactive power compensation to the POI)
 - Allowing power factor controls at a point before or after the POI (with reactive power compensation to the POI)
- In addition, developers can install “reactive droop” characteristic
 - Reactive droop setting typically range from 2 to 10 percent
 - For example, a 4% droop means that the plant would linearly provide full reactive capability if actual voltage drops by 4% from schedule

Technical Issues

Generation Projects

- Generating projects connected at a single point of interconnection can meet requirement collectively
 - entire project is required to meet collective requirement
 - must be dispatched with a single resource ID

Technical Issues

Smaller Generators (e.g. a small generator connecting to a stiff high voltage system)

- Differing generator size is not justification for failing to providing reactive power capability
- Current proposal includes adoption of a uniform reactive power and voltage control requirement for all resources, likely at 0.95 lead/lag
 - This reactive power production within this range is determined by the unit parameters and MW output
 - This requirement ensures all participants are contributing a pro-rated approximate of their unit output for voltage support

Technical Issues

Repowering

- Repowering is for existing generating facilities, including QFs, that wish to make insubstantial changes
 - Facilities who propose substantial changes must enter Generation Interconnection and Deliverability Allocation Procedures (GIDAP)
 - Substantially is determined based on impact of changed electrical characteristics, as outlined in the Generator Management BPM
- Must utilize the same fuel source and point of interconnection
- Affidavit to QueueManagement@caiso.com initiates the request
 - Information provided in the affidavit is subject to audit by the ISO

Technical Issues

Demand response and storage

- All loads directly connected to the grid must maintain reactive flow within the specified power factor band of .97 lag and .99 lead
 - Are not compensated for performing within this band
- Potential for load to provide reactive power outside this band
- No specific rules for storage currently exist in tariff

Technical Issues

Metering

- All new participants that want to participate in ISO markets must sign a meter service agreement and install ISO meters
 - BPM for metering, appendix B, outlines technical specifications required for these meters
 - These include reactive power metering requirements
- No exemptions for size or unit type

Technical Issues

Telemetry

- Generating Units connected to the electric grid within the CAISO BAA must install equipment and/or software that can interface with the CAISO's Energy Management System (EMS) to supply telemetered real-time data
- These rules apply to all resources that:
 - (1) have a capacity of ten MW or greater, or
 - (2) provide Ancillary Services, or
 - (3) are Eligible Intermittent Resources
- BPM for telemetry defines reactive power telemetry requirements

Technical Issues

Applicable Telemetry requirements

- Resource must provide MVAR value at point of delivery (POD/POI) - where unit connects to the ISO controlled grid
- POD MVAR establishes reactive power delivery to the system and the impact on system voltage
 - Value obtained by installing instrument devices at the POD
 - Value calculated by providing an accurate conversion of another data point measured at the same voltage level as the POD
 - The value must represent an accuracy of +/-2% of the true value of POD MVAR represented in the CAISO revenue meter

COMPLIANCE

Compliance - Testing for Voltage Support Capability

- Prior to compensating resources for the capability to provide voltage support, the ISO needs to ensure the capability exists (i.e. qualify the resource)
- Other ISO/RTOs have qualification procedures (See Appendix 3 of FERC Staff Report in AD14-7: Payment for Reactive Power dated April 22, 2014:
<http://www.ferc.gov/CalendarFiles/20140414101009-04-11-14-reactive-power.pdf>)

Compliance – Qualification procedures to receive payment

- Size of resource
- Market participant
- Point of interconnection
- Request for compensation
- Equipment (e.g. functioning automatic voltage regulator)
- Telemetry and metering (including power factor, reactive power output and voltage control)
- Production and absorption of VARs outside of power factor range within safe operating parameters
- Other testing requirements

Compliance Testing and Penalties

- Existing ISO tariff section 8.9.4 authorizes the ISO to test voltage support capability by issuing unannounced dispatch instructions
- Consequences for failure to pass tests:
 - Payment Rescission or other penalties
 - Disqualification from receiving compensation as a qualified resource

Next Steps

- Issue paper posted in mid May
 - Will include financial compensation issues
- Comments on working group due May 6th
- Please send to initiativecomments@caiso.com

APPENDIX

Compliance - Selected Source Material

- ISO- NE:
- http://www.iso-ne.com/static_assets/documents/rules_proceeds/operating/gen_var_cap/schedule_2_var_business_procedure.pdf
- NYISO:
http://www.nyiso.com/public/webdocs/markets_operations/documents/Manuals_and_Guides/Manuals/Operations/ancserv.pdf
- MISO:
https://www.misoenergy.org/_layouts/MISO/ECM/Download.aspx?ID=19190)