California ISO
Shaping a Renewed Future

Reactive Power Requirements and Financial Compensation

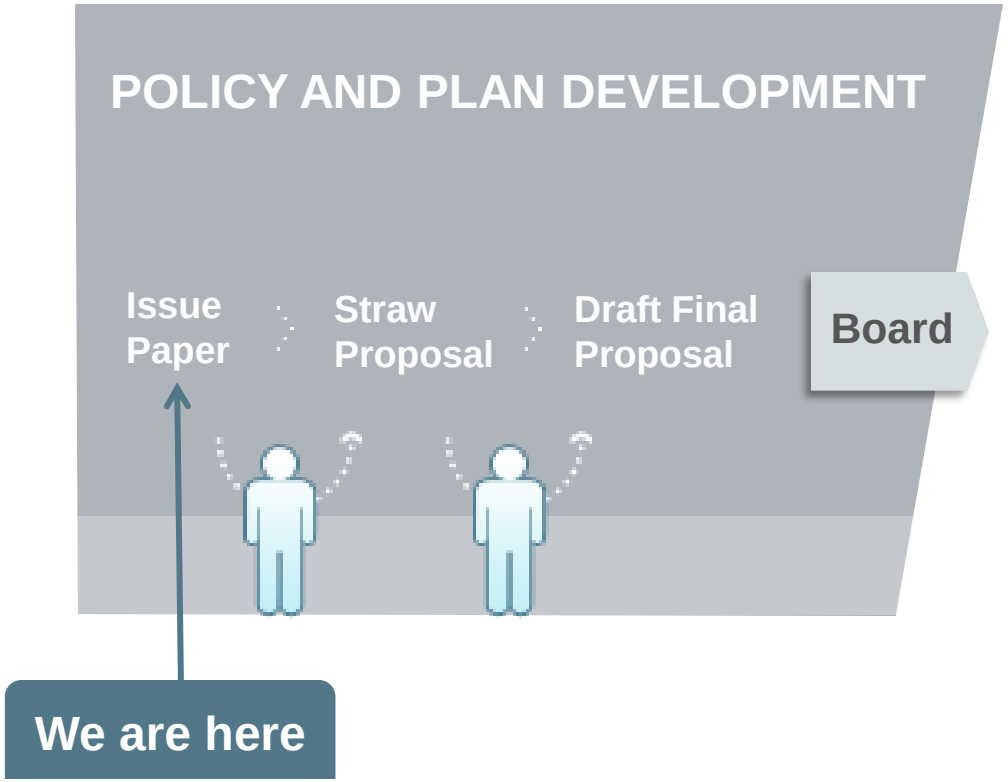
Issue paper

May 28, 2015

Agenda

Time	Topic	Presenters
1:00 – 1:05	Introduction and schedule	Kim Perez
1:05 – 1:30	Reactive power background and current rules	Carrie Bentley
1:30 – 2:00	Proposed rules	Clyde Loutan
2:00 – 2:45	Financial compensation	Carrie Bentley
2:45 – 3:00	Short Break	
3:00 – 3:55	Financial compensation cont.	Carrie Bentley
3:55 – 4:00	Wrap up and next steps	Kim Perez

ISO policy initiative stakeholder process



Initiative schedule

- Technical working group was on 4/22/15
- Issue paper posted May 22:
  - Updated asynchronous generation issues
  - Description of current requirements for synchronous generators
  - Compensation
    - Other ISO/RTO compensation policy
    - Options for compensation
- Straw proposal posted early July
- Target November 2015 BOG

REACTIVE POWER BACKGROUND

What is reactive power?

- Two elements are needed for electric power to flow:
  - Real power is measured in Watts (W)
  - Reactive power measured in Volt Amps Reactive (VAR)
- Insufficient reactive power may cause unstable grid conditions and system voltage may collapse
- Virtually any properly equipped generating facility can supply reactive power

Synchronous and asynchronous resources

- Synchronous resources: resource that is mechanically synchronized to the system frequency

- Asynchronous resources: resource that is electronically synchronized to the system frequency (e.g. variable energy resources, battery storage)

How does the ISO ensure there is sufficient reactive power on the grid?

ISO ensures reactive capability exists:			ISO ensures reactive capability provision:	
Generation Interconnection Process	Transmission Planning Process	Annual Local Capacity Study	Automatic provision requirements	Exceptional dispatch
Market resource	Transmission asset	Market resource, RMR contract	Some market resources, transmission asset, RMR contract	Market resource, RMR contract

Generation Interconnection Process (GIP)

- All participating generators must go through the process and sign an interconnection agreement with the ISO
  - Follow the reactive power rules under tariff section 8 and appendices
  - All synchronous resources have an automatic requirement
- GIP studies batches of resources to determine reactive power requirements for interconnection
  - Additional requirements on asynchronous resources
  - Additional transmission assets needed

Transmission Planning Process (TPP)

- Identifies if additional reactive power capability accounting for the GIP reactive capability requirements
- If additional capability is needed, the ISO will identify the most effective and efficient transmission asset to provide reactive power
- The capability payment and provision requirements are done through the transmission planning rules
- Transmission assets cannot participate in the ISO market and are compensated through non-market mechanisms (i.e. are out of scope in this initiative)

Annual Local Capacity Study

- Finds the minimum capacity needed to meet the Local Capacity Requirement criteria including reactive power needs
  - LSEs allowed to mitigate this need
  - If the LSEs do not mitigate, ISO may invoke backstop
- Backstop capability
  - RMR contract: RMR resource
- Extremely rare that ISO will invoke RMR for reactive power needs

CURRENT RULES FOR MARKET RESOURCES

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
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
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 at maximum real power capability

- Must have an over-excited (lagging) or under-excited (leading) reactive power capability to achieve a net power factor from 0.95 lead/lag at the Point of Interconnection (POI)
- Shall provide dynamic voltage response between 0.985 leading to .985 lagging at the POI
- Outside the dynamic range of .985 lead/lag, and within the overall reactive capability range of .95 lead/lag capability, the power factor range could be met with:
  - Controllable external static or dynamic reactive support equipment (default requirement)
  - External dynamic reactive support equipment (should interconnection studies show the full need of dynamic support)

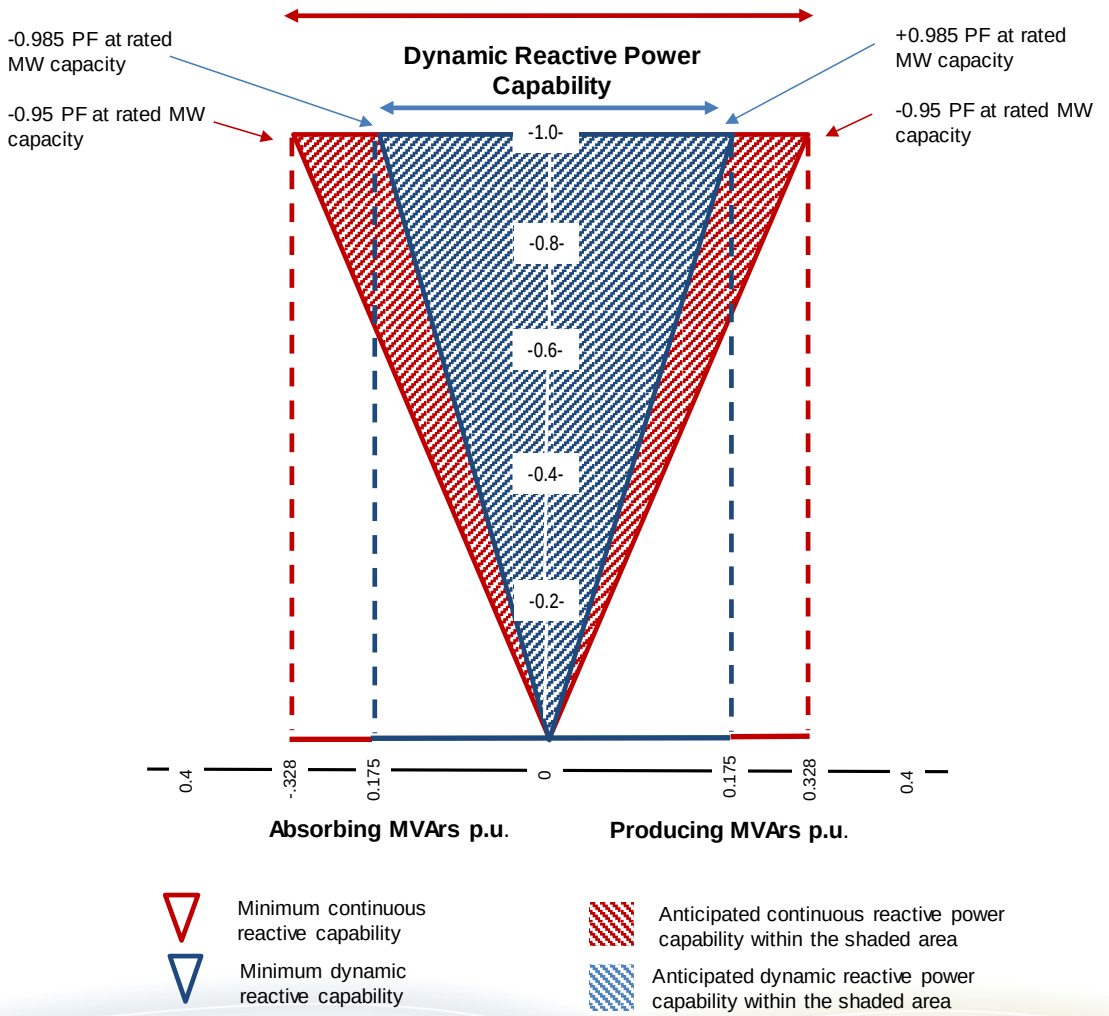
Proposed Requirements
Asynchronous resource default requirements

The red and blue isosceles triangles show the expected reactive capability of the Facility with reference to the POI. 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.

Should the interconnection studies show the need for dynamic reactive power within the overall reactive capability range of .95 leading to .95 lagging, then the full power factor range must be dynamic.



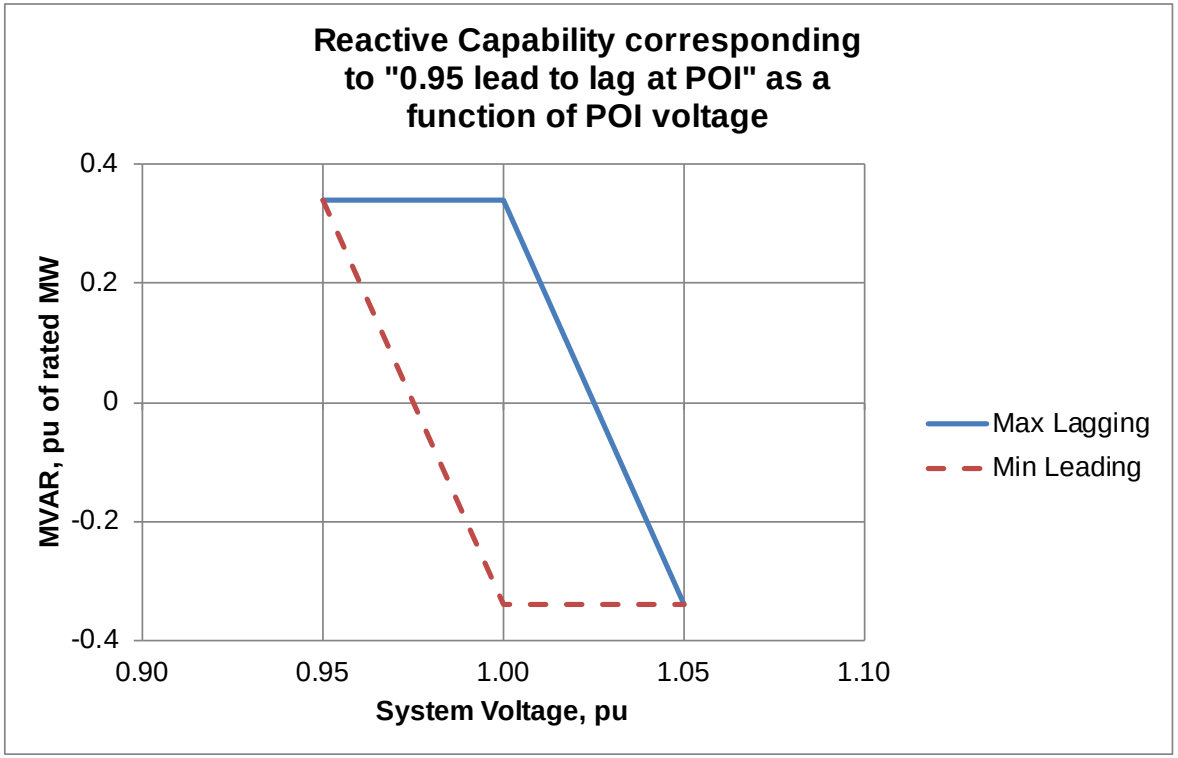
Proposed Requirements
Reactive power and voltage requirements

The Asynchronous Generating Facility shall have the capability to provide reactive power at .95 lagging when voltage levels are between .95 per unit and unity power at the POI

The capability to provide reactive power decreases as the voltage at the POI exceeds unity power factor.

Likewise, the Facility shall have the capability to absorb reactive power at .95 leading when the voltage levels are between 1.05 per unit and unity power at the POI

The capability to absorb reactive power decreases as the voltage at the POI 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 with reference to the POI
- The ISO may permit multiple generators to regulate the voltage at a point beyond the POI with reference to the POI
- The customer shall not disable voltage regulation controls while the asynchronous resource is in operation without prior consent from the ISO

FINANCIAL COMPENSATION

Financial compensation overview

- Capability payment
  - Compensation for having the capability to provide reactive power capability to the grid
- Provision payment
  - Compensation for providing reactive power to the grid outside .95 lead/lag
  - Typically, this compensation is only to recover costs that cannot be recovered through real power provision

Financial compensation at the CAISO

- Capability:
  - None for market resources
- Provision payment:
  - lost opportunity cost component associated with providing reactive support outside the requirements below:
    - Synchronous- .90 lag to .95 lead at gen terminal
    - Asynchronous- .95 lag/lead referenced to POI
  - commitment costs to bring a generator online and/or continue running generator at minimum load

Financial compensation regulatory review – ISO NE

- Both capability and provision payments
- Provision:
  - lost opportunity cost component associated with providing reactive support
  - cost of energy consumed to provide reactive support
  - cost of energy produced to provide reactive support
- Capability:
  - fixed capital costs resources incur to install and maintain equipment necessary to provide reactive power
  - established each year on a prospective basis

Financial compensation regulatory review – SPP

- Provision payments only
- Provision:
  - SPP charges a reactive compensation rate of $2.26 per MVAr-hour
  - multiplied by the monthly amount of reactive power provided by a qualifying generator outside of the standard range to calculate monthly payments to each individual qualified generator
  - SPP sums these payments by zone and subtracts the revenue collected for “through” and “out transactions” for a particular zone to calculate the zonal charges it collects

Financial compensation regulatory review – PJM

- Both capability and provision payments
- Provision:
  - Paid difference between offer price and LMP
- Capability:
  - Fixed costs calculated using the AEP methodology and filed with FERC

Capability payment – options

- As discussed many ISOs/RTOs provide financial compensation for the capability (MISO and NYISO as well)
  - All are cost-based compensation
- Two options to consider:
  - Enhanced American Electric Power (AEP) methodology
  - Safe harbor using FERC established rates

Capability payment – Enhanced AEP option

- FERC-approved method for thermal generation that breaks out components of a generating unit into components for reactive power and real power
  - Generator and its exciter
  - Accessory electric equipment that supports the operator of the generator and exciter
  - Remaining total production investment requirement required to provide real power and operate exciter
- Annual requirements allocated based on $MVAr^2/MVA^2$, where MVAr is megavolt amperes reactive capability and the MVA is the megavolt amperes capability at a power factor of 1

Capability payment – Enhanced AEP option payments

- Generators use actual costs data, either in their FERC form 1 or independent data to justify these costs at FERC
- Using this methodology the ISO would pay the eligible rate divided by 12 each month the generator is interconnected

Capability payment – AEP asynchronous enhancements

- Could breaks out components of asynchronous resource into components for reactive power and real power
  - Inverter and/or capacitor
  - Accessory electric equipment that supports the operation of the inverter or capacitor
  - Remaining total production investment needed to provide real power and operate inverters and/or capacitors

Capability payment – AEP clutch enhancements

- Add to component list for synchronous resources the cost recovery of fixed costs required for resources to install a “clutch” or the ability for the resource to move between providing real power and reactive power to only reactive power
- A clutch would allow a resource that is not taken by energy optimization for real power to provide reactive power
- Would need eligibility criteria to establish whether installation of clutch would be beneficial to grid

Capability payment – Safe harbor using commission established rate

- Suggested in Reactive Power FERC Staff Report
- FERC could establish ranges of acceptable allocators for any thermal generation type
  - ISO could rely on these values to recreate a “safe harbor” value that generators could recover without filing at FERC
- Any costs above their generation-specific safe harbor value resources could use the approved AEP methodology
- Would still need to extend AEP methodology at a minimum for asynchronous resources

Eligibility for capability payment

- ISO would need to establish eligibility requirements for synchronous and asynchronous market resources
- Considerations:
  - Availability of reactive power
  - Under requirement to provide reactive power
  - Reason for need (whether or not the interconnection of the resource driving the need for the reactive power requirement)
  - Demonstrated compliance
    - Flip side would be ineligible if demonstrated non-compliance

Provision payment – enhancement to opportunity cost methodology

- Opportunity cost payments provide compensation for the opportunity cost of not being dispatched for energy if exceptionally dispatched for reactive power

- In addition to opportunity cost payments, could potentially provide payments for energy use to provide reactive power, e.g. hydro or synchronous condensers

Next steps

- Comments due by June 11, 2015
  - Comment template will be posted
  - Sent comments to: InitiativeComments@caiso.com