Voltage Support Service

Most generators currently provide voltage support service in the form of reactive power (VARs) produced in response to automatic voltage regulation (AVR) control. Yet there is no clear mechanism for generators to be compensated for providing this service.

Current Standards

WECC standards currently require that generating units that are 10 MVA or larger be equipped with automatic voltage control equipment and operate in voltage control mode unless otherwise instructed.[1] Furthermore, WECC planning standards require that "at continuous rated power output, new synchronous generators should have an overexcited power factor capability, measured at the generator terminals, of 0.9 or less and an underexcited power factor capability of 0.95 or less." The range, 0.9 over and 0.95 under, could also be used as the initial range within which all generators are expected to operate without additional compensation for voltage support. Compensation for voltage support services would occur when generators are instructed to operate at power factors less than these values.

VAR Production Outside Standard Requirements

As described in PSERC, provision of VARs by generators imposes a lost opportunity cost on the generator owner since it may be unable to operate the unit at full real power capability.[2] The trade-off between MW and VAR production is described by the generator PQ capability constraint curve. For power factors near unity, real power output is less affected than when power factors are significantly less than unity. If a generator has bid to produce real power, but is instead required to provide reactive power for voltage support, RTO West should have a means to compensate this generator for voltage support service beyond the nominal range required by reliability council standards. RTO West must also develop a means for charging the cost of this service to transmission customer in a just and reasonable way.

Pricing VAR Production

RTO West may consider a range of choices and factors that affect how VAR production may be priced in ancillary service markets. These include:

- Calculating the VAR cost using the opportunity cost method discussed in PSERC.
- Permitting generators to bid hourly VAR production prices under the assumption that generators can compete to provide this service.
- Investigation into techniques used in other regions.

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1 WECC MORC. August 9, 2002. Page 10.

2 Reactive Power Support Services in Electricity Markets: Costing and Pricing of Ancillary Services Project Final Report. PSERC Publication 00-08. May 2001. Section 4, Page 23.

Opportunity Cost Method

In PSERC, the authors show that the PQ capability constraint curve can be used to determine the real power production that is foregone by the production of reactive power. For example, a generator could produce 800 MW and 0 MVAR, or produce 700 MW and 100 MVAR if instructed to do so by the voltage schedule for the generator bus. Without provisions for compensating generators for voltage support services, the generator constrained to producing 700 MW/100 MVAR would forego revenue for the 100 MW that it is unable to produce in real-time due to the action of its voltage regulator. In addition it should be mentioned that there are out-of-pocket costs associated with the production of 100 MVAR since fuel (or water power) is only needed to offset the higher exciter, armature and transformer losses associated with VAR production, however, these losses are not equal to the amount of real power production foregone. Thus the generator foregoes a marginal profit equal to the nodal price of real power minus its marginal cost. From this relationship, RTO West could develop a voltage support pricing formula based on bids existing in the energy and ancillary services bid stacks, but would need to know the marginal cost of all generators in order to determine the profits foregone by the generators.

From the perspective of an LSE that owns the affected generator, the foregone energy production may expose it to spot market energy price risk. That is, it may be relying on the full 800 MW for service to load and under the voltage constrained condition it would face a spot market purchase of 100 MW if the conditions of the above example were to apply.

Pricing VSS Through Bid-Based Markets

Generators that can provide voltage support could submit bids to RTO West in Day-Ahead or a suitable time period prior to real-time. For VSS the bid would consist of capacity cost, quantity limits and availability parameters. Generators that are committed for energy production would need to state a decremental energy price that would be used by the RTO to determine which unit is most economical to dispatch for VAR production.[3] As stated above, there are incremental out-of-pocket energy costs associated with reactive power production provided by operating generators, but these costs can be netted by the bidder against its decremental energy price bid. For generators that are not committed to run during the relevant operating period and synchronous condensers, startup and no-load costs may be relevant.

The locational nature of voltage support requirements will likely raise market power concerns under a bidding scheme. The RTO and Market Monitor will need to address this issue and may be immediately confronted with the need to establish Out-of-Market pricing measures (for examples, see the ERCOT A/S Protocols, sections 6.8.4 and 6.8.2.3 (4)).

[3] Intuitively it would seem that the unit with the highest decremental price bid would be selected first since this would indicate that its out-of-pocket savings from decreasing output would be greater than those submitting lower bids.

ERCOT VSS Protocol

Section 6.8.4 of the ERCOT A/S Protocols requires that generators be capable of maintaining a voltage profile within the generator ratings, and a 0.95 leading or lagging power factor measured at the main unit transformer high voltage terminals. Generators will not be asked to reduce MW output to provide more reactive power unless it is necessary and an out-of-market dispatch order needs to be made. PIP102 of the ERCOT A/S Protocols provides a mechanism for compensating generators for reactive power in excess of the Unit Reactive Limit (URL).

Proposed Technical Requirements and Bid Characteristics

The proposed technical requirements and bid characteristics are as shown below.

IOS	Technical Requirement	Bid Characteristic
C.10. **Voltage Support** • Voltage Support Service is the provision of generation or other resources that are capable of delivering or absorbing reactive power that RTO West can use for the purpose of maintaining transmission system voltages within acceptable limits throughout the RTO West Transmission System. • Location Specific	♦ Generating units that are 10 MVA or larger be equipped with automatic voltage control equipment and operate in voltage control mode unless otherwise instructed. ♦ Synchronous generators should have an over-excited power factor capability, measured at the generator terminals, of 0.9 or less and an under-excited power factor capability of 0.95 or less. ♦ Within the power factor range of 0.9 over- and 0.95 under-excited, generators would not receive additional compensation for voltage support. ♦ When operating at power factors less than 0.9 over- and 0.95 under-excited, generators would be permitted to bid prices/recover costs for provision of voltage support services.	♦ Physical location – Bid at node ♦ Hours available ♦ Resource type (generator, synchronous condenser) ♦ Start up, no load, minimum runtime ♦ MVAR capability range ♦ Capacity price bid ♦ Decremental energy strike price