PJM Power Factor Requirements and Deficiency Charges

By
Reactive Power Focus Group
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Executive Summary

Reactive deficiency is defined as the amount of generator Spinning Vars that are needed for a generator to meet the PJM Power Factor (PF) requirements. The PJM Reactive Power Focus Group was formed to address the reactive deficiency issue due particularly to an increase of capacity or energy to an existing generator and to develop a reasonable resolution including installation of PF correction equipment or payment of a reactive deficiency charge.

The group recommends that, if all possible, reactive deficiency be replaced by spinning Vars. If shown infeasible or cost prohibited, the group suggests that the compromised approach is to replace the deficiency with dynamic Vars (e.g. from Static Var Compensators (SVCs) or similar reactive resources). Hence, the reactive deficiency charge should be equal to the most recent cost estimate for installing a SVC with the same reactive capability. Static Vars from shunt capacitors are discouraged or, in most instances, should be disallowed.

The group has also discussed various related issues. To avoid cost shifting between loads and to recognize that reactive power does not travel far from the source, the group suggests the following "reactive deficiency and compensation staying in the same transmission zone" approach:

- PJM collects the reactive deficiency charges from the generator developer whose generator does not meet the PJM PF requirements,
- PJM places the money in an interest bearing account designated to the TO in which zone the reactive deficient generator is located,
- PJM states in the Interconnection Services Agreement that the money is to fund a "But For" reactive project in the specific transmission zone,
- TO notifies PJM which reactive project or projects be designated and funded by this money,
- TO is allowed to install static Vars if the fund is not sufficient to install dynamic Vars,
- TO bills PJM for installing this "But For" project or projects, and
- PJM pays the TO.

Currently, the group is discussing the suppressed post contingency voltage on the effectiveness of SVC comparing to spinning Vars. The right sizing the SVC and a possible voltage adder could increase the deficiency charges.

I. Background

Synchronous and non-synchronous generators interconnected with the PJM system are obligated to supply reactive power within their design limitations to maintain voltage, reactive power or power factor schedules established by PJM *[PJM OATT Section 4.7.2]*. If the system impact study results of a new wind or non-synchronous generator show that this new facility does not cause any reliability problems, the new wind or non-synchronous generator has no Power Factor (PF) requirements.

If a generator cannot meet the PF requirement for whatever reason (i.e. unit upgrade, equipment failure, etc.), the Interconnection Customer shall take "whatever steps are necessary to alleviate the situation <u>at its expense</u>". If the situation has not been resolved, PJM and the Interconnected Transmission Owner "at the Interconnection Customer's expense, may take appropriate action, including installation on the Transmission System of PF correction or other equipment, as is <u>reasonably required</u>…" *[PJM OATT Section 4.7.3]*

PJM is currently determining what would be an "appropriate action" and the "reasonably required" PF equipment in the event that an increase in capacity or energy (upgrade) to an existing generator results in a reactive deficiency implying that the generator does not meet the PF requirements. The Reactive Power Focus Group has been formed to address this issue.

II. PJM Tariff PF Requirements on Generator Upgrades

The PJM PF requirements are stated in Section 4.7 of the PJM OATT. For generator upgrades less than or equal to 20 MW and all increases to wind and non-synchronous generators, the requirements are measured at the Point of Interconnection. For generators or generator upgrades more than 20MW, the measurements are at the generator terminal. The specific requirements are:

- Increase in capacity or energy to an existing generator (i.e. the incremental MW) is required to maintain a power factor of at least 1.0 <u>to</u> 0.90 lagging.

- For a wind or non-synchronous generator that has no PF requirement on the existing MW, the increase in capacity or energy (i.e. the incremental MW) is required to maintain a power factor of at least 1.0 <u>to</u> 0.90 lagging if system impact study results show that this requirement on the incremental MW is necessary.

- For a wind or non-synchronous generator that is required to maintain a power factor of at least 0.95 leading to 0.95 lagging, the increase in capacity or energy (i.e. the incremental MW) is required to maintain a power factor of at least 1.0 <u>to</u> 0.95 lagging if system impact study results show that this requirement on the incremental MW is necessary.

It should also be pointed out that an increase in capacity or energy to an existing and grandfathered synchronous generator that, previously, does not meet the PJM PF requirements will result in the need of the Interconnection Customer to rectify the previous reactive deficiency issue (i.e. bringing the reactive capability of the original rated output back to 0.95 leading to 0.90 lagging for a synchronous generator) and to assure that the incremental MW from the upgrade meets the 1.0 to 0.90 lagging PF requirements.

Note that, for a wind or non-synchronous generator that does not have PF requirements on the original rated output, the 1.0 to 0.90 lagging PF requirements on the incremental MW from the generator upgrade apply only if this incremental MW creates reliability problems.

III. Information on Current Practice

The intent of the PF requirements in the PJM Tariff is for a generator to provide spinning reactive power (i.e. spinning Vars) and to allow continuous control between the PF ranges for maintaining the targeted system voltage or reactive schedule. However, in actual practice when this dynamic reserve is not needed to resolve normal operating problems, PJM often preserves the spinning Vars and uses them to rectify post contingency voltage problems. Hence, the full reactive capability of a generator is rarely utilized during most system operations.

As for the testing (once every five years (PJM Manual 14D)) of the reactive capability of the unit, the capability measured at the generator terminal can be met by a combination of the generator’s actual reactive capability and, if previously approved related to an incremental upgrade, shunt capacitors (i.e. static Vars) or Static Var Compensator (SVC) (i.e. dynamic Vars – note that the use of SVC throughout this document is in reference to a suitable dynamic switching device) installed at the terminal. For wind or non-synchronous generators that have no reactive capability, shunt capacitors are often installed at the Point of Interconnection to meet the PF requirements. Hence, shunt capacitors are being used to meet the PF requirements despite that static Vars, from a reliability standpoint, are not as effective to rectify post contingency voltage issues compared to dynamic Vars from SVCs or to spinning Vars provided by the generators.

It is very important to point out that, for a synchronous generator upgrade, it may not be possible or practical for the generator to maintain the previous Vars capability without replacing or upgrading the existing generator. For a small MW upgrade, requiring the generator to maintain the same Vars capability could be cost prohibited and would overturn the decision to perform the upgrade.

IV. Proposed Reactive Deficiency Replacement and Charges

In the April and May 2009 PJM Planning Committee meetings, the following were proposed:

1. Generator reactive deficiency will be replaced by dynamic Vars from SVCs that will be centrally planned by PJM Planning.
2. Generator reactive deficiency is defined as the Var capability at the required PF minus the Var capability that actually can be provided.
3. Reactive Deficiency Charges is determined as the reactive deficiency times the per unit reactive charge.
4. Per Unit reactive charge is determined by the latest average cost of planned and/or installed 500kV and 230kV SVCs (in $ per MVar (i.e. estimated to be $100k per MVar)).

Other than that the generator reactive deficiency should be replaced by dynamic Vars, there was no consensus among PJM Stakeholders at the PC meetings.

Many issues were raised and some of these issues are listed in the following sections.

V. Topics for Consideration

a. <u>System Reliability</u>

The PF requirements create several issues: (1) many pre-PJM RTO units may not have the PF requirements or obligation when the unit was built under the vertical integrated utility environment; (2) this may require upgrading the generator and could be cost prohibited for small increase of capacity or energy; and (3) this could force units to offer the higher energy output on an as available basis without transmission reinforcements to minimize the financial exposure. While the first issue could be a fairness issue, the latter two issues (2 and 3) would have direct impact on resource adequacy and transmission system reliability, respectively.

The Reactive Power Focus Group agrees that the dynamic Vars from SVCs are not as effective as the spinning Vars from a generator. Hence, system reliability margin could be reduced if the spinning Vars are replaced by dynamic SVCs. However, the group feels that a PJM policy to require Interconnected Customers to replace the reactive deficiency by dynamic Vars from SVCs represents a vast reliability improvement compared to the current practice of installing shunt capacitors at the generator terminal.

The focus group strongly recommends that, if all possible, the generator reactive deficiency be replaced by spinning Vars, and that the generator owner installs dynamic Vars after a review of the plant shows that it is not feasible or is cost prohibited to provide spinning Vars to meet the power factor requirements after the upgrade.

b. <u>Determination of Reactive Deficiency</u>

Although the impact of reactive resources is local in nature, it is clear that the method to determine the reactive deficiency needs to be simple and understandable by all Stakeholders. In that regard, the current method is simple in that the reactive deficiency is equal to the reactive capability at the required PF requirements minus the reactive capability that can be provided at rated output.

The issue remains that an MVar deficiency in the 230kV and above systems has a different system reliability impact comparing to an MVar deficiency in a lower voltage system. It is also suggested that, since the effectiveness of a SVC is a function of the system voltage, the dynamic Vars (i.e. the size of the SVC) may need to be larger than the spinning Vars (i.e. reactive deficiency) that it is planned to replace.

c. Locational Impact of the Reactive Deficiency

The location of the generators should be considered in calculating the reactive deficiency charges recognizing the different system impact of the same MVar supplied to the 500kV or 230kV systems versus to the 138kV or lower voltage systems. As a result, the deficiency charges should be applied differently to a unit connected to facilities operated at 230kV and above than to one connected to a facility operated below 230kV.

Based on the locational difference, the group suggested that a voltage multiplier (with respect to the interconnection voltage) to the reactive deficiency charges should be considered.

d. Reactive Replacement

i. Dynamic versus Static Vars

The group agrees that replacing generator reactive deficiency by dynamic Vars from SVCs is a compromise but such replacement is an improvement over installing shunt capacitors to meet the PF requirements.

ii. Central versus Local Planning Reactive Resource

The issue is that a generator reactive deficiency at a local area may not be addressed by a centrally planned SVC at a distance. As a result, this could lead to a future RTEP reactive project being required at the local area. If the reactive deficiency charges were collected from one transmission zone to pay for a centrally planned SVC in another zone, this creates a cost shifting issue. In this case, the load at the local area would end up paying for a future RTEP project while not getting the benefits from the centrally planned SVC and, at the same time, continue paying an annual reactive service charge to the generator for reactive services it no longer receives.

An example would be that Indian River upgrade found deficient. NRG pays the charges. PJM consolidates all the reactive deficiency charges across the RTO and plans a 500kV SVC at Jack's Mountain (formerly Airydale) in FirstEnergy, whose operation does little in terms of voltage support at Delmarva South. PJM may later require an RTEP project to fix the voltage problem in Delmarva South and the cost of this project will be assigned to the Delmarva customers. Adding to that Delmarva customers still have to pay annual reactive service charges to NRG for reactive services that NRG no longer provides, the Delmarva load ends up paying twice for the reactive services. This Jack's Mountain SVC creates an unfair cost shifting consequence to Delmarva load that receives no benefits from its payment. Additionally, if this SVC creates any transfer capability, PJM would have to develop a method for allocating the ARR/FTR associated with this capability.

To rectify this situation, the group suggests:

- PJM collects the reactive deficiency charges,
- PJM places the money in an interest bearing account designated to the TO in which zone the reactive deficient generator is located,
- PJM states in the Interconnection Services Agreement that the money is to fund a "But For" reactive project (to be determined later) in the specific transmission zone,
- TO notifies PJM which reactive project or projects be designated and funded by this money,
- TO is allowed to install static Vars if the fund is not sufficient to install dynamic Vars,
- TO bills PJM for installing this "But For" project / projects, and
- PJM pays the TO.

The basic concept of the suggestion is that reactive power is local, reactive deficiency hurts local system, customers already pays for the reactive services, and the collected charges should be used to install local reactive projects to benefit customers harmed by the deficiency.

In the above example, Connectiv would use the money to reinforce Delmarva South and Delmarva customers would not be hurt. There will not be cost shifting (between zones) consequences.

An additional benefit will be that it will eliminate the argument on where the centrally planned SVC should be located.

In the original proposal, a determination of the impact of the reactive deficiency to the local area may be needed. In the above suggestion, the impact to local area needs not be addressed at the time the reactive deficiency charges are determined.

iii. Decision Process

Recent RTEP requires many reactive projects to be installed. This issue is to decide which projects, in which transmission zone and at what voltage level will be paid for by the collected reactive deficiency charges.

The above suggestion would eliminate the “where to put it” issue.

e. Management of the Collected Charges

The issue is how the money be handled.

f. Construction and Maintenance Responsibilities

Recognizing that PJM is not a TO, the responsibilities will be on the TOs. However, the issue should be who should be responsible for the maintenance cost of the centrally planned SVCs. The group agrees that the TO of the zone where the SVC is located should be responsible for maintaining the SVCs.

g. Annual Reactive Service Charges versus Reactive Deficiency Charges

Note that generators receive annual reactive service charges from the zonal load to provide the reactive support to the zone. If an upgrade results in the generator not able to provide the reactive service, PJM may need to consider the annual reactive service charges that a generator receives annually versus the one time reactive deficiency charges under this policy. The issue is to avoid this policy creating an arbitrage opportunity or any unintended consequences resulting in depleting the reactive resources on the system.

h. Additional Discussion Topics

i. Power Factor Obligations

The generator is obligated to meet the PF requirements as stated in the Interconnection Service Agreement (ISA) when it first connected to the system. Any subsequent upgrades to the generator should not rid the generator from its original obligation. The issue is whether or not the original rated MW output should continue to meet the initial PF requirements (e.g. 0.95 leading to 0.9 lagging) and this “dynamic Vars for spinning Vars” exchange policy should be applied only to the reactive deficiency due to the incremental MW from the upgrade.

The concern is that generators may consider to increase MW outputs by reducing spinning Vars. This reduction in spinning Vars could impact system reliability if it becomes excessive.

ii. SVC Size versus Reactive Deficiency

The group suggests PJM and the Stakeholders to consider the development of a multiplier or an adder to be applied to the reactive deficiency. The driver is that the size of the SVC may need to be greater than the reactive deficiency. One reason is that the effectiveness of the SVC is a function of the post contingency voltage which is lower that the pre-contingency voltage. As a result, the size of the SVC needs to be determined at a lower than normal voltage resulting in a larger SVC.

The counter argument is that, at a lower post contingency voltage, the spinning Var's that can be produced by a generator will also be lower. Hence, it would be unfair to require a larger SVC to replace the reactive deficiency. Additional consideration is that this policy should not become a financial burden to a generator leading to encouraging generators to install static Vars behind the Point of Interconnection (i.e at the generator terminal) to meet the PF requirements.

iii. Static Vars to meet PF Requirements

It is pointed out that, if static Vars are installed at the generator terminal to offset some of the reactive deficiency of a generator, the system reliability would not be impacted during normal steady state operation. Reliability may not be an issue in the post contingency situation if the post contingency spinning Var requirement from the generator is equal or less than the remaining spinning Var capability of the generator. System reliability would only be an issue if the post contingency Var requirement is greater than the remaining Var capability. This could be the case when the system is in emergency operating conditions.

It is also suggested that during emergency operating conditions and if possible, the generator could be directed to reduce the pre-contingency MW output and to make additional spinning Vars available to guard against the post contingency voltage problems.