UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Reactive Power Resources	**)**	**Docket No. AD12-10-000**

WRITTEN STATEMENT OF JEFF BILLO

I. Introduction

Thank you for the opportunity to participate in today's technical conference on reactive power.[1] I am Jeff Billo, Manager of Transmission Planning for the Electric Reliability Council of Texas, Inc. ("ERCOT"), and I am appearing today on behalf of ERCOT. In support of my participation on the panels at the technical conference, I am providing these comments, which generally discuss the relevant issues, and also specifically address the topics identified by the Commission in its April 2nd supplemental notice.

II. Background

Reactive Power is critical to the reliable operation of alternating current ("AC") electric systems. From an operational perspective, having adequate reactive capability in appropriate locations is essential to mitigating the potential for voltage concerns, including voltage collapse that could lead to an undesired regional or system-wide blackout. Although the issue of reactive power is important to the electric power industry generally, it has also become somewhat of a focused concern given the relatively recent increase in renewable power and the potential for the continued growth of such resources in the future. Accordingly, ERCOT commends the Commission for its recognition of this important issue with respect to the impact of renewables and its initiation of this technical conference to review these matters.

III. ERCOT Comments

A. General Comments

In order to facilitate a reliable grid, system planning entities must ensure there is access to sufficient reactive power resources over the relevant planning periods. ERCOT has significant experience with the integration of renewable generation resources. Presently, there is approximately 9,800 MW of wind generation on the ERCOT system, and it is expected that this amount will continue to grow as a result of the implementation of the renewable policies established by the Texas Legislature and the Public Utility Commission of Texas ("PUCT").

[1] On February 17, 2012, the Federal Energy Regulatory Commission ("FERC" or "Commission") issued a Notice of Technical Conference in the above referenced docket establishing a technical conference on reactive power issues to be held on April 17, 2012. On April 2, 2012, FERC issued a Supplemental Notice of Technical Conference, which established two panels to discuss particular topics related to reactive power matters, each of which included the Electric Reliability Council of Texas, Inc.

These efforts resulted in the establishment of specific Competitive Renewable Energy Zones ("CREZ") and the development of transmission to support the reliable and economic transfer of 18,000 MW of power from renewable resources in those zones to all areas in the ERCOT region. As part of its planning role in supporting these endeavors, ERCOT is responsible for ensuring the transmission build out is supported by adequate reactive capabilities. To that end, ERCOT commissioned a reactive power study specifically focused on the reactive power requirements necessary to reliably integrate the full build out of the CREZ and support the transfer of that supply within the ERCOT region. The reactive challenges presented by these efforts included supporting energy transfers, at low and high loadings, across the significant distances between the CREZ and the load centers in the ERCOT region. As discussed below, the application of uniform reactive obligations in principle across all generation types supports system reliability generally, as well as with respect to the specific challenges presented by the integration of significant amounts of renewable generation in locations that are significant distances from load centers.

In the past, electric supply was generally provided by traditional generation resources (*e.g*. nuclear and fossil fueled) that provided adequate reactive support (*e.g.* 0.95+/- lead and lag) over the entire operational range of the units. Where additional reactive support was needed, appropriate devices were added to the transmission system. Under this construct, the supply component of the grid provided a known quantity of reactive power, and the system could be operated and planned against that known baseline capacity. Recently, the amount of renewable generation on the grid has increased, and although it still represents a minority of supply, it is no longer a trivial consideration from either an operational or planning perspective.[2] Initially, the technology of these resources did not provide the same level of reactive power as traditional generation, and displacement of traditional generating capacity with renewables has the potential to result in a net decrease in a system's reactive capability.[3]

It seems there are three overall ways to address this issue: 1) do not impose any reactive obligations on renewable generators and address any reactive power deficiencies associated with the interconnection of such resources through transmission system upgrades; 2) impose reactive power requirement for renewables on a case-by-case basis in accordance with system needs at the time of interconnection; or 3) impose a uniform reactive power obligation on all generation resources. In practice, options 2 and 3 are the approaches that exist in FERC jurisdictional regions and the ERCOT region, respectively. FERC Order 661-A established the reactive requirements for renewable generation interconnecting to the transmission system outside of the

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[2] *See* NERC *Special Report: Accommodating High Levels of Variable Generation* (April 2009).

[3] FERC recognized the potential challenges of integrating large amounts of wind with respect to the impact on reactive power requirements in the FERC Staff Report, *Principles for Efficient and Reliable Reactive Power Supply and Consumption* (February 4, 2005) issued in Docket No. AD05-1-000. *See* Chapter 2, *Physical Characteristics and Costs of Reactive Power in AC Systems* at 28.

ERCOT region of Texas.[4] The 661-A requirement states that the reactive obligations of renewable generators will be based on the needs of the system when the unit interconnects. In ERCOT, subject to limited exceptions, all generators are required to provide +/- 0.95 power factor, leading and lagging, determined at maximum output of the facility. For traditional generation that capability must be available over the entire operational range of the unit, and for wind the obligation applies when the units are generating above 10% of nameplate capacity. The exceptions to the rule are based on "grandfathered" status for a finite set of generating units that include renewable and conventional units. The uniform approach applied in the ERCOT region provides operational and planning benefits.[5] The benefits are described more fully below in ERCOT's responses to the specific FERC topics presented in the *Supplemental Notice of Technical Conference*.

Based on the experience obtained through managing reactive power issues related to the integration of considerable amounts of renewable resources, including understanding the complexities of implementing a transmission build out to support the transfer of the energy from these resources over long distances, it is ERCOT's position that a uniform reactive obligation is appropriate to support system reliability. ERCOT appreciates the opportunity to comment on this important matter, and offers the following responses to the specific questions posed in the Commission's *Supplemental Notice of Technical Conference*.

B. ERCOT Responses to Specific FERC Technical Conference Topics

Panel 1 Discussion of Reactive Power in Interconnection Studies

Topic 1 Methods used to determine the reactive power requirements for a transmission system

In accordance with the North American Electric Reliability Corporation ("NERC") TPL standards, ERCOT conducts annual steady-state and stability planning studies to determine the reactive power requirements for the transmission system. ERCOT also performs planning studies for new generation and transmission projects to determine the reactive power impact to the system. If a reactive power deficiency is identified, reactive devices, such as shunt

[4] Because ERCOT is not subject to the FERC jurisdiction for interconnection standards, its regional rules govern generators' reactive power obligations.

[5] There are regulatory and/or market design and cost issues associated with reactive power as well. In addition, uniform rules facilitate efficient and effective renewable generation development and manufacturing by providing transparent requirements that are known to industry well in advance of interconnecting to the system. However, those issues are beyond the scope of the issues raised by the Commission in its *Supplemental Notice of Technical Conference* and these comments are not intended to address those matters. For informational purposes, in terms of compensation structure, in ERCOT there is no market or regulated payment for reactive power. Generators are obligated to meet the reactive power requirement, but they are not compensated for the provision of the service. This approach was established by committee process in the ERCOT region and reflects the input and views of all interested parties.

capacitors, static VAR compensators, etc., are identified to achieve the required system performance. ERCOT conducts ad-hoc studies as well to assess transmission system requirements for unique conditions. For example, as discussed above, with respect to the CREZ transmission upgrades, ERCOT conducted a study to determine the system additions necessary to accommodate 18,000 MW of renewable capacity. Part of this analysis included assessing the reactive power needs of the system under the full build out scenario. The analysis assumed that all renewable generation additions would be able to supply reactive power per the ERCOT standard requirement of +/- 0.95 power factor. Shunt capacitors and reactors and static VAr compensators were planned to meet the additional reactive needs of the system.

Topic 2 How system impact and system planning studies take into account changes in technologies connected to the system

ERCOT assumes that all new devices connected to the transmission system will be able to meet the ERCOT standards. As described in ERCOT's general comments, the uniform reactive standard applies to all generation resources without distinction and it is the responsibility of the resource to comply with the obligation. ERCOT planning studies assume that all new generation resources, including wind generation, solar generation, and storage devices will be able to supply reactive power per the ERCOT standard requirement of +/- 0.95 power factor. Accordingly, different types of technologies do not warrant or require different treatment from a reactive power planning perspective.

Topic 3 What evidence could be developed to support a request to apply reactive power requirements more broadly than to individual wind generators during the interconnection study process?

It may be difficult to develop evidence to support a change to a uniform standard based on reliability impacts, because system operators will maintain the reliability of their respective electric systems despite the reactive power rules in place. Accordingly, this question really lends itself to more of a qualitative response that compares the relative benefits of different reactive power rules. While arguments can be made to support different approaches, ERCOT believes the application of a uniform standard more effectively facilitates reliable system operations and planning.

As noted in ERCOT's general comments, the uniform standard approach provides operational and planning benefits. From an operational perspective, system operators have access to the same relative level of reactive power from all generators on the system. This capability allows operators to access comparable support from all generators in the area of concern without distinction, which facilitates operational efficiency because they are not restricted to relying on specific generators for reactive support. This flexibility maximizes

system dispatch in terms of reliability and economic efficiency by facilitating an effective co-optimized dispatch of energy and ancillary services without being hindered by disparate reactive capabilities between resources. In addition, the flexible/dynamic characteristic of reactive power supplied by generators further enhances system operators' ability to respect reliability requirements. Reactive support from generators provides high quality support because it is dynamic, generally very responsive and it is less related to the physical state of the transmission system, unlike shunt capacitors and static VAr compensators whose reactive power outputs decline exponentially as voltage declines. This ability gives system operators an important tool in managing grid reliability.[6]

With respect to planning, planners can rely on this base level of reactive capability, which mitigates the need to plan for disparate contributions from a multitude of resources relative to the system's current and future reactive needs.[7] Given that system needs change over time, an approach where each new generator is analyzed to determine its reactive requirements may present planning challenges, because what may have been adequate at one point in time may not be sufficient later. In that case, the reactive deficiencies resulting from the requirements imposed on a generator at an earlier point in time will have to be addressed either through transmission system upgrades or by the imposition of greater obligations on other generators interconnecting in the future.[8] In the case of a generation pocket, the reactive power needs of the system will largely be dependent on the reactive losses in the transmission system, which are a function of the current squared. Hence, the reactive needs in such an area will increase exponentially with the addition of each new generation addition. A uniform requirement mitigates both the potential for reactive deficiencies resulting from changed conditions, as well as the corresponding need to implement remedies to such matters.

Another consideration is the ability of renewable resources to comply with a uniform standard. At this point in time, renewable resources can comply with a uniform standard, such as the one in the ERCOT region, whether through turbine/generator technology or the installation of supplemental reactive devices. This fact supports consideration of a uniform standard.

Additionally, the policy of establishing uniform rules for reactive power is also supported by NERC. The NERC report referenced in footnote 2 recommended the development of consistent interconnection standards for a number of requirements, including reactive power

[6] There are reactive devices that have characteristics similar to generators, and these devices may substitute for inherent generator capabilities, because it is the dynamic characteristics that ultimately matter, not the means used to provide those operational qualities.

[7] The transmission system changes over time. It is impossible to define the reactive needs in an area over the life of a generation project using a simplified study during the interconnection process. To mitigate this issue, the ERCOT rules impose the uniform requirement - +/- 0.95 power factor - at the point of interconnection. Incremental reactive needs are installed on the transmission system.

obligations. The report specifically states that these should be consistently applied to all generation technologies.

In essence, a uniform standard enhances the reactive capabilities on the system relative to an ad hoc approach based on site specific requirements determined at the time of interconnection. There are no technical obstacles that would prevent renewable resources from complying with a uniform standard, and NERC, the reliability oversight entity, supports parity with respect generators' reactive power obligations. While there may be contrary arguments, such as economic (*e.g.* cost of compliance), that can be made against a uniform rule, from a reliability perspective, such an approach has relative reliability benefits.

Panel 2 Discussion of Reactive Power Resources

Topic 1 The technical and economic characteristics of different types of reactive power resources, including synchronous and asynchronous generation resources, transmission resources and energy storage resources

FERC staff issued a report in 2005, referenced in footnote 3, that provides a thorough overview the relative physical and cost characteristics of different means of meeting the reactive needs of the system. This discussion is presented in chapter 2 of the report. ERCOT generally agrees with FERC's assessment, but offers some specific comments on some of the more common approaches utilized to provide reactive services, including both traditional and renewable generation.

Synchronous generation resources and synchronous condensers provide reactive power via an excitation system. Historically, these types of machines made up the bulk of the generation resources on the transmission system.

Type 1 (squirrel cage induction generator) and Type 2 (wound rotor induction generator with adjustable rotor resistance) wind turbines do not inherently have the ability to control and provide reactive power, but rather consume reactive power as a function of the active power output of the turbines. This is due to the induction machine characteristics of the turbine technology. Wind generation resources in the ERCOT region that utilize Type 1 or Type 2 wind turbines must install reactive devices, such as capacitors, reactors and/ or FACTS devices, to meet the reactive power standards applicable to the units.[9]

For Type 3 wind turbines (doubly-fed induction generator technology) the stator output is directly connected to the grid while the rotor output is connected through an inverter. Typically,

[9] As discussed in the general comments section, the ERCOT rules grandfather certain units and those units may be subject to a lesser standard than the general uniform f +/- 0.95 power factor requirement.

approximately 30% of the generator power goes through the inverter. This configuration allows the generator to perform reactive power control and turbines with +/- 0.90 power factor capability are available on the market today. Approximately 60% of the wind generation capacity on the ERCOT system consists of Type 3 turbines.

Type 4 (full power conversion generator) wind turbines and photovoltaic (PV) solar generation use inverters to connect to the grid. Inverter technology allows for the control of reactive power. In the case of Type 4 wind turbines, the inverter is built into the turbine and +/- 0.90 power factor capability is available – this power factor is greater than, and therefore complies with, the +/- 0.95 ERCOT reactive requirement.

PV solar inverters are typically stand-alone units that are used to convert power to AC output for an aggregation of PV arrays and are commonly available with +/- 0.95 power factor capability. Asynchronous storage devices connect to the grid typically via inverters that are similar in nature and capability to PV solar inverters.

Shunt capacitors and reactors supply and consume reactive power, respectively. These are relatively low cost devices, but they can only be employed in blocks (*e.g.* each capacitor or reactor on the system is either on or off and, when on, partial reactive power supply or consumption is not possible). Additionally, the operation of shunt devices has a delay because they must be mechanically switched into service. Hence, when there is a sudden reactive need on the transmission system, the switching of shunt devices will normally represent the slowest response of all reactive resources.

Static VAr compensators and STATCOMS (generically known as FACTS devices) provide dynamic reactive support to the transmission system. These devices are generally designed to respond relatively quickly and can support operation over a range of reactive power output levels. FACTS devices are considerably more expensive on a per MVAr basis when compared to shunt devices.

Topic 2 The design options for and cost of installing reactive power equipment at the time of interconnection as well as retrofitting a resource with reactive power equipment

ERCOT is not directly involved in these issues, and, therefore, it cannot comment on specific matters raised in this discussion topic. However, ERCOT offers the following comments from the perspective of the system operator in the ERCOT region.

Despite supporting a uniform requirement, ERCOT supports a compliance construct that offers maximum flexibility to generators with respect to the means used to comply with the

obligation. Generators should be able to purchase turbines that have adequate capabilities, or, if it makes economic sense to meet the requirement by purchasing separate reactive devices to meet the requirement that should be allowed, provided the requirement is met. In addition, generators should be allowed to contract with the transmission companies to install equipment on the transmission system that meets the reactive obligations of the generator. Any reasonable means of compliance should be allowed, provided the end result complies with the obligation in terms of all relevant requirements.[10] Accordingly, to the extent the Commission considers revising its approach to reactive requirements for renewable resources any such effort should also be flexible with respect to compliance options.[11]

Topic 3 Other means by which reactive power is currently secured such as through self-supply

As discussed, reactive rules should be flexible with respect to the means used to comply with the obligation. In ERCOT, resources are allowed to install reactive devices in lieu of having generator/turbine technology, or they can compensate transmission owners for installing reactive power equipment on the transmission system in order to meet their reactive power standard obligations. While ERCOT rules provide these alternative means of compliance, from ERCOT's perspective, the principle of flexibility is the important point for this discussion topic. If there are other means that generators can use to achieve compliance with a uniform standard, they should be considered by the system operator and, as necessary, relevant regulatory agencies.

Topic 4 How a technology that is capable of providing reactive power but may not be subject to the generation interconnection process (e.g., FACTs) would be analyzed

In the ERCOT market, generation resources are not compensated for providing reactive power and are assumed to have a required reactive power capability. Planning studies are performed to assess the reactive needs on the transmission system given the reactive power capabilities of the generation resources on the system. When deficiencies are found, the appropriate technology is studied to solve the deficiency. Incremental needs above the capacity provided by generation are installed on the transmission system and are paid for by load via transmission rates.

[10] *i.e.* capability (*e.g.* +/- 0.95 power factor) and characteristics (*e.g.* dynamic v. static qualities).

[11] ERCOT rules allow generators to utilize reactive devices, as opposed to turbine technology, to comply, provided such devices have the required dynamic characteristics. In addition, resources can enter into agreements with transmission owners to install reactive equipment on the transmission system that effectively meets the obligation of the generator.

IV. Conclusion

Consistent with the above comments, the relative operational and planning benefits provided by a uniform standard may warrant Commission review of its current approach to establishing reactive power requirements for renewable resources. There are no technical impediments to implementing a uniform requirement, and technical and/or equity issues with respect to legacy units can be addressed through prospective application of any rule change. With respect to establishing a rule that is consistent with deregulated markets, any prospective change should be flexible in terms of the means allowed to meet the obligation.

Integration of significant amounts of renewable generation presents planning and operational issues. One of these issues is the impact on a system's reactive power requirements. Accordingly, ERCOT appreciates the Commission's initiative to revisit this issue, and for providing the opportunity to participate in the discussion. I look forward to participating in the technical conference, and ERCOT stands ready to respond to any questions the Commission may have with respect to these comments, issues discussed at the technical conference or any other matters related to reactive requirements in the ERCOT region or otherwise.