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RELIABILITY CORPORATION

White Paper on the VAR Standards

VAR-001 and VAR-002

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RELIABILITY | ACCOUNTABILITY



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Executive Summary

The VAR Reliability Standards provide the minimum requirements for maintaining voltage stability on the bulk-power system. The industry considers VAR-001 to represent transmission requirements for monitoring the reactive power performance of the system, and VAR-002 represents generator obligations for voltage support. When the VAR standards were initially approved by the Federal Energy Regulatory Commission (“FERC” or the “Commission”) in 2006, the Commission provided several directives on how to improve the VAR standards. NERC initiated Project 2008-01 to address these FERC directives, but that project was unable to be completed due to a project reprioritization. Project 2008-01 and its Standard Authorization Request (SAR) used a prescriptive approach to address the FERC directives, and that project also contemplated adding an additional planning standard. This project took a different approach by implementing the Paragraph 81¹ and results-based standards initiatives. This project also utilized the recommendations from a panel of Independent Experts’ Review of the NERC Reliability Standards. Due to this variance in approach, the informal development group is presenting a new SAR to post for industry comment.

In summary, FERC gave the following directives to modify VAR-001:

- Expand the applicability to include Reliability Coordinators (RCs) and load-serving entities (LSEs).
- Include detailed and definitive requirements on “established limits” and “sufficient reactive resources” and identify acceptable margins above the voltage instability points.
- To assist real-time operations for areas susceptible to voltage instability, include requirements to perform voltage stability analysis periodically, using online techniques where commercially available and offline techniques where online techniques are not available.
- Include controllable load among the reactive resources to satisfy reactive requirements.
- Address the power factor range at the interface between LSEs and the transmission grid.

FERC directed NERC to consider modifying VAR-002 to require more detailed and definitive requirements when defining the time frame associated with an “incident” of noncompliance. Hence, FERC directed NERC to consider a timeframe for allowing a generator to be out of schedule before having to make a notification to its TOP.

In early 2013, NERC initiated an informal development project to address the directives, and an informal development group was formed from industry subject matter experts, NERC staff, and staff from FERC’s Office of Electric Regulation. The informal development group sought to answer FERC’s directives and improve some of the compliance issues that exist today for the VAR standards. The informal development group drafted several pro forma versions of the VAR standard and sought broad industry feedback through individual phone conversations, conference calls, technical conferences, and webinars.

Since 2006, many changes have occurred that impact the VAR standards. Several new standards have been drafted and approved in the last seven years. Also, FERC recently issued a Notice of Proposed Rulemaking (NOPR) addressing Paragraph 81, and that NOPR recommends retiring certain VAR requirements that are redundant with Open-Access Transmission Tariffs (OATTs). In addition, VAR-002 has consistently been identified as one of the most violated standards, so certain compliance issues surround VAR-002 had to be addressed.

In concert with the Paragraph 81 initiative, each of the above-mentioned directives does not equate to a new VAR requirement. Instead, the informal development group removed certain redundancies with other standards and created requirements that provide for documented policies and procedures to address the above directives for VAR-001.

The pro forma VAR-001 has added RC monitoring requirements, and the standard requires each Transmission Operator (TOP) to have written operating policies and procedures used to define voltage limits. Those policies and procedures must set definitive guidelines on the frequency of system assessments. Further, the pro forma standard states that controllable load is a viable reactive power resource that can be used in the day-ahead and real-time operations. The informal development project did not address power factor, because the relevant requirement that currently addresses LSEs and

¹ See *North American Electric Reliability Corp.*, 138 FERC ¶ 61,193, at P 81, *order on reh’g and clarification*, 139 FERC ¶ 61,168 (2012).

power factor is proposed for retirement by FERC in its June 2013 NOPR on Paragraph 81 because the OATT covers the arrangement for ancillary services that include VAR purchases to maintain power factor.

Additionally, VAR-002 has been amended in the pro forma standard to provide for a noncompliance timeframe when a generator is out of voltage schedule and when reactive power equipment is out-of-service and then back in-service status again. The language not only addresses FERC's directive, but it also provides resolution to several compliance issues in existence today. Certain timing elements for VAR-002 may be debated during the formal development process, but the informal development group has reached a consensus on the principles of providing these time periods.

As detailed further below, the informal development group drafted the pro forma VAR standard in a manner that would accomplish three objectives: 1) address the FERC directives; 2) mitigate compliance issues for generators in VAR-002; and 3) simplify the TOP's requirements in VAR-001 while maintaining reliability and eliminating nuisance phone calls. The pro forma standard is not overly prescriptive, and Compliance has prepared guidance that will develop into RSAWs and auditor training. This guidance will allow for more predictability when the new VAR standard is implemented, and it will hopefully alleviate some industry concerns regarding future audits.

Purpose

The purpose of this white paper is to provide a summary of the issues, rationale, and support for the proposed revisions to the currently enforceable VAR standards, VAR-001 and VAR-002. This white paper also provides an explanation of how outstanding VAR directives from the Commission contained in Order No. 693² are addressed going forward. This white paper is a product of the informal development process, which provides for the formation of an informal development group. The informal development group met several times and conducted numerous webinars and technical conferences from February through June 2013. The information obtained through industry outreach was discussed thoroughly by the informal development group, and several of the discussion topics are reflected throughout this paper. In addition, the contents of this paper will give a foundation to the formal development process.

The ultimate goal of the Standards team is present the new VAR standards to the Board of Trustees in their November 2013 meeting. Thus, the formal Standards Drafting Team will be seeking final industry approval of the VAR standards by October 2013.

² See *Mandatory Reliability Standards for the Bulk-Power System*, Order No. 693, FERC Stats. & Regs. ¶ 31,242, *order on reh'g*, Order No. 693-A, 120 FERC ¶ 61,053 (2007).

History of the VAR Informal Development

The informal development group started with a group of individuals that were originally part of Project 2008-01. Due to a project reprioritization conducted by the Standards Committee and NERC, Project 2008-01 was halted. There is some overlap between the current VAR project and project 2008-01, but the scope is slightly different. Project 2008-01 was moving toward creating a VAR planning standard in addition to modifying VAR-001 and VAR-002. The current project is only amending VAR-001 and VAR-002, and the current project remains predominantly focused on addressing the outstanding FERC directives.

The informal development group first met on a February 15, 2013 conference call. The meeting was to introduce the various parties and a coordinate logistics for the informal development process. The informal development group is currently comprised of the following:

- Dennis Chastain – Tennessee Valley Authority
- Bill Harm – PJM Interconnection L.L.C.
- Steve Hitchens – Bonneville Power Administration
- Sharma Kolluri – Entergy Services Inc.
- Martin Kaufman – ExxonMobil Research and Engineering Company
- Joshua Pierce – Southern Company
- Hari Singh – Xcel Energy
- Hamid Zakery – Calpine Corporation
- Scott Berry – Indiana Municipal Power Agency

Members of the informal development group met in person on February 27 and 28 in Atlanta. The group then convened several times over conference calls before an April 11 webinar.

The April 11 webinar was the first time the group proposed new VAR language to address a majority of the directives from Order No. 693. The industry provided significant feedback during two subsequent technical conferences. The first technical conference was hosted by Southern Company in Atlanta, Georgia, on April 18, 2013. The second technical conference was held at Xcel Energy in Denver, Colorado, on April 29, 2013. Both conferences provided an opportunity for the informal development group to listen to industry concerns regarding the VAR standards, and the informal development group answered numerous questions on the current draft of the pro forma standards.

The informal development group reconvened for a two-day meeting at Entergy on May 15, 2013. The group also invited several individuals who participated in the webinars and technical conferences to attend the meeting. During the May meeting, the VAR pro forma standard was modified several times. The informal development group continued the discussion on how to best address industry's concerns through electronic communications and several conference calls.

The next iteration of the pro forma standard was then presented to the industry on a June 14 webinar. The webinar contained several survey questions, and the informal development group was able to gauge whether a majority of industry supported the pro forma standard. Based on the survey and webinar feedback, the informal development group was able to amend the pro forma standard further before presenting the final draft to the Standards Committee on July 18, 2013.

Technical Discussion

Background

What is Reactive Power?

Reactive power does not have the same characteristics as real power. Real power is measured in watts and able to be transmitted over long distances. Real power is an energy supply that is eventually distributed to end-use customers. Reactive power is just as important as real power because it is necessary to maintain system stability. Reactive power supports voltage. Voltage is measured in volts, and electrical current is measured in amperes. Reactive power is measured in volt-amperes reactive (VARs). When the Bulk Electric System (BES) does not have enough reactive power, there is risk of a voltage collapse, which could lead to cascading outages. In fact, a lack of reactive power supply was a contributing factor to the large blackouts in 2003 and 2011.

Nature of Reactive Power and Why it is Necessary

Generally reactive power is needed to provide voltage support and maintain system stability. Prabha Kundur, a leading subject matter expert in system stability, explains, “[p]ower system stability may be broadly defined as that property of a power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to a disturbance.”³ The VAR standards ensure that there is enough reactive power on the system to provide the voltage support necessary to avoid voltage collapse. Although there are numerous reactive power resources, the best and largest source of reactive power or VAR support comes from generators. However, the amount of reactive power that a generator can create is proportional to the amount of MWs being produced. Therefore, the more VARs produced at a generating facility, the fewer MWs produced.

VAR-001

The stated purpose of the VAR-001 standard is to ensure that voltage levels, reactive flows, and reactive resources are monitored, controlled, and maintained within limits in real time to protect equipment and the reliable operation of the interconnection. The VAR standards focus on the Operations horizon (which is real-time up to one year into the future). The informal development group is cognizant of the fact that the nature of reactive power on the network varies depending on local conditions. Thus, the group focused on the process that the requirements would detail, not the proper numbers a TOP should enforce in the standard. For VAR-001, the group would not put operational limits on how a TOP should manage voltage stability for its regions; more specifically, the informal development group did not want to place numerical requirements on what the proper operational limits should be for the continent. Operating margins vary due to specific system characteristics as well as the operating conditions. Rather than detailing a continent-wide back-off margin, the informal development group designed the pro forma VAR-001 to require the Transmission Operator to document policies and procedures used to establish, monitor, and control voltage and reactive power flows (Mvars). Those policies are then used to establish voltage and reactive power schedules for the generators.

Requirement R1

R1 requires that documented policies and procedures are in place. These policies and procedures must include criteria for the assessments of the TOP’s systems. The policies will consequently include studies used to establish voltage schedules and associated tolerance bands. In addition, the system assessments must include dynamic voltage limits and operating margins. By requiring a documented policy and procedure, the reliability standard removes the opportunity for auditors or other parties to scrutinize a TOP’s own system studies.

R1 also requires Transmission Operators to communicate their policies and procedures with their associated RC and neighboring TOPs. This type of communication relates to R2, which details how a TOP and RC take a system study and ensure sufficient reactive power is available to support both real-time and day-ahead operations.

Requirement R2

³ Prabha Kundur, *Power System Stability and Control*, Electric Power Research Institute, p. 17 (1994).

R2 requires both TOPs and RCs to perform system assessments in order to schedule reactive resources for both the real-time and day-ahead time frames. By scheduling sufficient reactive resources, the TOP and RC are maintaining voltage levels (and consequently system stability) under both normal and contingency situation. R2 further defines “sufficient reactive resources,” and those resources include controllable load pursuant to FERC Order No. 693.

Requirement R3

R3 requires each TOP to specify what criteria will exempt a generator from 1) having to follow a provided voltage schedule; or 2) providing a notification under VAR-002. The TOP must notify the generator when an exemption is given, but there are no requirements on what the criteria should be for exemptions. This enables TOPs to have flexibility when providing exemptions during maintenance or system events. For example, if a unit is experiencing a malfunction in AVR equipment, the TOP may provide a temporary exemption to the generator until the equipment is repaired.

Requirement R4

R4 requires each TOP to specify a voltage or reactive power schedule and associated tolerance band for each generator. By requiring both a tolerance band and a documented policy or procedure for establishing voltage schedules, there is a level of transparency as to how voltage or reactive power schedules were created. The informal development group refrained from providing any language that requires GOPs to mutually agree with TOPs on specific numbers. Such language could create disputes between the parties as to what the appropriate voltage schedule should be for a unit. To preserve a TOP’s ability to assess and monitor its system, and in an effort not to undermine the TOP standards, R4 provides more transparency while clearly maintaining a TOP’s role in determining voltage schedules.

Requirement R5

R5 ensures that the TOP knows the status of all reactive power resources, automatic voltage regulators, and power system stabilizers in its system. This requirement mandates that the TOP actively monitor the system for voltage issues, and the new measure language now specifies that electronically metered points and EMS data will serve as a compliance mechanism for this particular requirement.

Requirement R6

The informal development group did not modify the requirement regarding step-up transformer tap changes.

WECC Variance

FERC approved the WECC variance to VAR-001 on June 20, 2013.⁴ The WECC variance eliminates the TOP’s ability to allow for exemptions, and it also requires a TOP to (1) issue a choice of voltage schedules for each of the generating resources that are on-line and part of the BES in its area; (2) provide to Generator Operators (GOPs) a voltage schedule reference point; and (3) provide transmission equipment data and operating data requested by GOPs to support their set point conversion methodology.⁵ The informal development group did not adopt the WECC variance because it is more stringent than the existing standard, and numerous TOPs want the flexibility to allow for exemptions from notification requirements, particularly when maintenance is being performed or when a generator’s AVR is malfunctioning. However, the current pro forma standard does not affect the WECC variance. Since the WECC variance is retained, the VAR-001 standard is applicable to GOPs in the WECC region.

VAR-002

The purpose behind the VAR-002 standard is for generators to provide reactive and voltage control necessary to ensure voltage levels, reactive flows, and reactive resources are maintained within applicable Facility Ratings to protect equipment and the reliable operation of the interconnection. Currently, VAR-002 is problematic due the numerous violations for GOPs 1) when a unit deviates from schedule; and 2) when an AVR turns on, then off. In both instances, a generator has an obligation under the currently enforceable standard to call a TOP within 30 minutes. The current standard does not allow for any deviations from notification requirements; thus, the GOP must determine if it is more appropriate to make a notification or address a potential issue that is affecting the voltage schedule or AVR status. The notifications themselves also create “nuisance” phone calls for TOPs. Most TOPs have the ability to monitor voltage through telemeter equipment.

⁴ See *Petition for Approval of Proposed Reliability Standard VAR-001-3 (WECC Variance)*, Letter Order, Docket No. RD13-6-000 (issued June 20, 2013).

⁵ See VAR-001-3

Thus, most TOPs already know when a unit drifts out of schedule. In order to address both the compliance issues and FERC's directive to consider a noncompliance window, the pro forma VAR-002 proposes language that gives a GOP time to respond to an issue before notifying its TOP.

Requirement R2

R2 requires GOPs to follow a TOP-provided voltage or reactive power schedule. However, there is universal agreement among TOPs and GOPs that if a unit drifts out of schedule momentarily and then drifts back into schedule, there is no risk to the reliability of the system. However, under the current VAR-002 standard in effect, when a unit drifts out of schedule there is an obligation to notify the TOP. Also, when the unit goes back into schedule there is an obligation to notify the TOP again. Thus, for a slight deviation, a GOP may face two potential violations for failure to make notifications to the TOP.

Based on industry feedback, a TOP should be notified when a unit cannot follow a voltage schedule. However, notifications for every schedule change are harmful to reliability because such calls detract focus from addressing system issues as they occur. The new language in the pro forma standard for R2 requires a GOP to notify a TOP when 1) the unit has been out of schedule for 15 minutes; AND 2) when a unit cannot return to schedule. In most cases, a unit will not be able to return to schedule when it has encountered an operating limit. There are also instances when a system event is pulling the unit out of schedule, and the unit is too small to move its voltage back in schedule. In these situations, it is important for the TOP to be notified, because those units cannot provide anymore voltage support to combat a system event.

Requirement R3

R3 requires a GOP to notify its TOP within 30 minutes of a "status" change. The status change identifies whether a reactive resource is available for voltage support. In an effort to allow GOP to first identify and address why a status change has occurred, the new pro forma standard Requirement R3 gives the GOP an initial 15 minutes to correct and restore the status of any reactive power resource. However, if the status has not been corrected after 15 minutes, the GOP has 15 minutes to notify its associated TOP of the status change.

Requirements R1, R4, and R5

The informal development group did not modify the requirement regarding AVR and tap changes.

Monitoring

Both R2 and R3 inherently have several compliance issues with regard to how voltage is monitored and controlled. Most TOPs provide GOPs with a voltage schedule as the high side of the generator step-up transformer, but a large number of GOPs only have metering equipment on the low side of the transformer. Therefore, in order to meet a voltage schedule, but these GOPs will convert the "high-side" schedule to a "low-side" schedule. The low-side schedule is then usually translated into an AVR control point or target. However, for several smaller facilities and nuclear facilities, those generators have installed metering on the high-side. Also, some facilities have made additions to their facilities to add load-drop compensation to see monitoring on the high-side. Thus, although many Generators monitor voltage on the low side of the terminal, there are a significant number of facilities that monitor voltage on the high side. Generators that use high-side voltage reference for regulation receive voltage reference signals from their associated TOP. This can create an issue during audits, because the standard does not dictate which method is acceptable for monitoring voltage.

In order to develop a continent-wide standard that allows GOPs to monitor voltage based on existing equipment limitations, the language of pro forma VAR-002's measures was greatly augmented. Specifically, the GOPs were explicitly given the discretion to monitor on either the high side or low side of the transformer. The pertinent language added to M2 is, "[i]n order to identify when a unit is deviating from its schedule, GOPs will monitor voltage based on existing equipment at its facility. Therefore, GOPs have the option to operate on a voltage schedule on the high side or convert the high-side schedule to a low-side schedule at the GOP's discretion." This language is necessary to assure GOPs that the standard will not determine where specific equipment should be installed at a facility. Further, this language clarifies to an auditor that either high-side or low-side monitoring is sufficient for VAR-002 compliance.

AVR

Once the AVR is set and in "voltage controlling" mode, the AVR should automatically adjust to voltage swings. At issue is whether a generator is required to make any adjustments to a control-point or AVR setting when the AVR response is not enough to react to a voltage deviation or system event. There is a current debate in the industry as to what actions are

required to maintain system stability. From the Generator's perspective, the AVR is the best mechanism to address voltage, and several Generators advocate that if an AVR setting should be adjusted, then the respective TOP should direct that AVR change. The TOPs argue that if an event is occurring, there is not enough time to call each generator to dictate the specifications for an adjustment; further, the TOPs assert that generators have an obligation to maintain a voltage schedule that includes making the necessary AVR adjustments. This industry divide is not addressed in the pro forma standard presented today. The informal development group did not address changing underlying principles of the VAR-002 standard, because the scope of the project with regard to VAR-002 was merely to consider a non-compliance window. However, the issue may be revisited during the formal development stage by the standard development team.

Minority Issue on Voltage Coordination

Another issue that arose during the informal outreach was the need for more voltage coordination between GOPs and TOPs. Some GOPs advocated for VAR standards to be re-written in order require more coordination, but again since the scope of this project is to focus on FERC directives, the informal development group opted to require more detail on how the TOPs study their systems. This issue will be presented for comment during the balloting of the pro forma, and the formal drafting team will make recommendations based on comments received as to how to address this issue in the future.

Outstanding FERC Directives

The VAR standards were first approved in FERC Order No. 693.⁶ However, in approving the standards, the Commission also gave several directives on how to improve the VAR standards for reliability purposes. VAR-001 targets the transmission responsibilities for maintaining voltage stability while VAR-002 focuses on generator functions. Order No. 693 summarized the directives for VAR-001 as requiring NERC to do the following:

(1) expand the applicability to include RCs and LSEs; (2) include detailed and definitive requirements on “established limits” and “sufficient reactive resources” as discussed above, and identify acceptable margins above the voltage instability points; (3) to assist real-time operations for areas susceptible to voltage instability include requirements to perform voltage stability analysis periodically, using online techniques where commercially available and offline techniques where online techniques are not available; (4) include controllable load among the reactive resources to satisfy reactive requirements; and (5) address the power factor range at the interface between LSEs and the transmission grid.⁷

For VAR-002, FERC directed NERC to consider providing more definitive requirements on what a noncompliance window should be for mandatory notifications. Each of the relevant directives is explained in further detail below.

Directive from P 1855 of Order No. 693

“Accordingly, the ERO should modify VAR-001-1 to include reliability coordinators as applicable entities and include a new requirement(s) that identifies the reliability coordinator’s monitoring responsibilities.”

VAR Informal Consideration

The informal development group amended VAR-001 to make RCs applicable to this standard, and requirements were added that identify RC monitoring for voltage stability. The informal development group did not expand the VAR standards to be overly prescriptive with regard to how an RC should monitor its own system; further, the group did not want to duplicate the efforts of the IRO standards pending before FERC. Instead the group focused on the most critical elements necessary for an RC to monitor its system for voltage stability. An RC performs many monitoring functions, but for voltage stability it is necessary to ensure that 1) the RC is aware of how its TOPs are monitoring voltage, and 2) the RC is performing the adequate studies to ensure reactive resources are properly scheduled for both real-time and day-ahead operations. Although some entities in Texas provided feedback that certain RCs perform functions equivalent to a TOP, the informal development group did not expand VAR-001 to give parity to TOPs and RCs. Upon further investigation, these situations are addressed through contractual obligations that clearly outline the reliability roles of both parties. The new RC functions are reflected in the new VAR pro forma standard through requirements R1 and R2. Both requirements are detailed further below.

Directive from P 1858 of Order No. 693

“The Commission directs the ERO to address the reactive power requirements for LSEs on a comparable basis with purchasing-selling entities.”

VAR Informal Consideration

This FERC directive was addressed in VAR-001-2.⁸ The Commission also recently issued a NOPR regarding Paragraph 81 that recommended retiring the existing VAR requirement that initially answered FERC’s directive in P 1858.⁹ FERC’s support for Paragraph 81 and rationale for proposing the retirement is:

⁶ See generally, Order No. 693 at PP 1846-1885.

⁷ Order No. 693 at P 1880.

⁸ See FERC letter order, *NERC Petition for Approval of Proposed Modifications to Reliability Standards BAL-002-1; EOP-002-3; FAC-002-1; MOD-021-2; PRC-004-2; and VAR-001-2*, 134 FERC ¶ 61,015 (2011).

⁹ See *Electric Reliability Organization Proposal to Retire Requirements in Reliability Standards*, Notice of Proposed Rulemaking, 143 FERC ¶ 61,251 (2013) (“NOPR”).

We propose to approve the retirement of VAR-001-2, Requirement R5 based on NERC's assertion that Requirement R5 is redundant with provisions of the *pro forma* OATT. Specifically, Schedule 2 of the open access transmission tariff requires transmission providers to provide reactive power resources, either directly or indirectly, and requires transmission customers to either purchase or self-supply reactive power resources.¹⁰

In light of this NOPR, the informal development group is not adding new language to the VAR standard that would address this directive. Further, there is an ongoing NERC effort to evaluate if purchasing-selling entities (PSEs) should continue to be a registered function. The informal development group may address this directive in the future, pending a final rulemaking from FERC and a determination on the status of the future applicability of standards to PSEs.

Directive from P 1861 of Order No. 693

"In the NOPR, the Commission asked for comments on acceptable ranges of net power factor at the interface at which the LSEs receive service from the Bulk-Power System during normal and extreme load conditions... The Commission believes that Reliability Standard VAR-001-1 is an appropriate place for the ERO to take steps to address these concerns by setting out requirements for transmission owners and LSEs to maintain an appropriate power factor range at their interface. **We direct the ERO to develop appropriate modifications to this Reliability Standard to address the power factor range at the interface between LSEs and the Bulk- Power System.**"

VAR Informal Consideration

Initially, the informal development group addressed the directive on power factor in two ways. First, based on P 1863,¹¹ the informal development group considered requiring seasonal power factor data to be provided to the TOPs on request. This would ensure the system studies were based on accurate data. Second, the informal development group considered whether entities could ensure power factor is maintained by arranging for VARs when MWs are purchased. However, the recently issued NOPR recommends retiring the requirement that currently requires VARs to be acquired due to redundancy with OATT. The NOPR also recommends withdrawing P 1863 as a directive because the Commission clarified the paragraph to be general guidance, not a FERC directive to modify the standard.¹²

In addition, the informal development group did not further amend the *pro forma* standard to add obligations to maintain power factors, because the FAC-001 standard requires Transmission Owners (TOs) to set interconnection requirements including "Voltage, Reactive Power, and **power factor control.**"¹³ Interconnection agreements also define minimum power factor requirements as a contractual obligation.¹⁴ In an effort to keep the VAR standard consistent with interconnection requirements established by contract, and consistent with the *pro forma* Generator Interconnection agreements pursuant to FERC Order No. 2003 which requires a 0.95 leading to 0.95 lagging power factor,¹⁵ the informal group did not add any additional requirements at this time to address power factor.

Directive from P 1862 of Order No. 693

"We direct the ERO to include APPA's concern in the Reliability Standards development process. We note that transmission operators currently have access to data through their energy management systems to determine a range of

¹⁰ NOPR at P 83.

¹¹ Order No. 693 at P 1863 (stating "[t]he Commission expects that the appropriate power factor range developed for the interface between the bulk electric system and the LSE from VAR-001-1 would be used as an input to the transmission and operations planning Reliability Standards").

¹² See NOPR at Attachment A.

¹³ See FAC-001-0, R 2.1.9. (available at: <http://www.nerc.com/files/FAC-001-0.pdf>) (emphasis added).

¹⁴ See, e.g., *Standardization of Generator Interconnection Agreements and Procedures*, Order No. 2003, FERC Stats. & Regs. ¶ 31,146 (2003), order on reh'g, Order No. 2003-A, FERC Stats. & Regs. ¶ 31,160, order on reh'g, Order No. 2003-B, FERC Stats. & Regs. ¶ 31,171 (2004), order on reh'g, Order No. 2003-C, FERC Stats. & Regs. ¶ 31,190 (2005), *aff'd sub nom. Nat'l Ass'n of Regulatory Util. Comm'rs v. FERC*, 475 F.3d 1277 (D.C. Cir. 2007), cert. denied, 552 U.S. 1230 (2008) (establishing Large Generator Interconnection Agreement requirement).

¹⁵ Order No. 2003 at P 542 (finding "[w]e adopt the power factor requirement of 0.95 leading to 0.95 lagging because it is a common practice in some NERC regions. If a Transmission Provider wants to adopt a different power factor requirement, Final Rule LGIA Article 9.6.1 permits it to do so as long as the power factor requirement applies to all generators on a comparable basis").

power factors at which load operates during various conditions, and **we suggest that the ERO use this type of data as a starting point for developing this modification.**"

VAR Informal Consideration

APPA stated, "It may be difficult to reach an agreement on acceptable ranges of net power factors at the interfaces where LSEs receive service from the Bulk-Power System because the acceptable range of power factors at any particular point on the electrical system varies based on many location-specific factors. APPA further states that system power factors will be affected by the transmission infrastructure used to supply the load."¹⁶ APPA's concerns were discussed, and the informal development group did not want to establish a particular range on power factor, especially since power factor requirements are detailed in interconnection agreements as discussed with the P 1861 directive.

Directive from P 1868 of Order No. 693

"In the NOPR, the Commission expressed concern that the technical requirements containing terms such as "established limits" or "sufficient reactive resources" are not definitive enough to address voltage instability and ensure reliable operations. To address this concern, the NOPR proposed directing the ERO to modify VAR-001-1 to include more detailed and definitive requirements on "established limits" and "sufficient reactive resources" and identify acceptable margins (i.e. voltage and/or reactive power margins) above voltage instability points to prevent voltage instability and to ensure reliable operations. **We will keep this direction, and direct the ERO to include this modification in this Reliability Standard.**"

Directive from P 1869 of Order No. 693

We recognize that our proposed modification does not identify what definitive requirements the Reliability Standard should use for "established limits" and "sufficient reactive resources." **Rather, the ERO should develop appropriate requirements that address the Commission's concerns through the ERO Reliability Standards development process.** The Commission believes that the concerns of Dynegy, EEI and MISO are best addressed by the ERO in the Reliability Standards development process.

VAR Informal Consideration for PP 1868 and 1869.

In an effort to address this directive and in order to preserve the TOs' flexibility to monitor their systems accordingly, the informal development group added requirements in the pro forma standard VAR-001 Requirement R1 that require steady-state and voltage limits to be included in the criteria used to assess transmission systems:

R1. Each Transmission Operator shall have documented policies or procedures that are implemented to establish, monitor, and control voltage levels and Reactive Power flows (Mvar flows) within limits as defined below:

R. 1.1. These documented policies or procedures shall include criteria used in system assessments. The criteria for the assessments shall include established steady-state and voltage stability limits with associated tolerance bands and operating margins.

Also, a new Requirement R2 was updated to include existing language on reactive resources that a TOP can schedule in both the real-time and day-ahead time frame. That list of sufficient reactive resources includes reactive generation scheduling, transmission line and reactive resource switching, and controllable load.

Directive from P 1875 of Order No. 693

In response to the concerns of APPA, SDG&E and EEI on the availability of tools, the Commission recognizes that transient voltage stability analysis is often conducted as an offline study, and that steady-state voltage stability analysis can be done online. The Commission clarifies that it does not wish to require anyone to use tools that are not validated for real-time operations. Taking these comments into consideration, the Commission clarifies its proposed modification from the NOPR. For the Final Rule, **we direct the ERO, through its Reliability Standards development process, to modify Reliability Standard VAR-001-1 to include Requirements to perform voltage stability analysis periodically, using online techniques where commercially-available, and offline simulation tools where online tools are not available, to assist real-time**

¹⁶ Order No. 693 at P 1860.

operations. The ERO should consider the available technologies and software as it develops this modification to VAR-001-1 and identify a process to assure that the Reliability Standard is not limiting the application of validated software or other tools.

VAR Informal Consideration

The informal group determined that the Commission is not requiring TOPs to purchase new online models or to implement tools that will not adequately study a TOP's reactive power requirements. Instead, the group allowed the TOPs to create their own documented procedures for performing assessments in pro forma standard Requirement R1.

Further, TOPs may under the new pro forma standard align their voltage planning with the pending TPL standards currently being reviewed by the Commission. The TPL standards require voltage studies, as outlined below:

R5. Each Transmission Planner and Planning Coordinator shall have criteria for acceptable System steady-state voltage limits, post-Contingency voltage deviations, and the transient voltage response for its System. For transient voltage response, the criteria shall at a minimum specify a low voltage level and a maximum length of time that transient voltages may remain below that level.¹⁷

Directive from P 1879 of Order No. 693

The Commission noted in the NOPR that in many cases, load response and demand-side investment can reduce the need for reactive power capability in the system. Based on this assertion, the Commission proposed to direct the ERO to include controllable load among the reactive resources to satisfy reactive requirements for incorporation into Reliability Standard VAR-001-1. **While we affirm this requirement, we expect the ERO to consider the comments of SoCal Edison with regard to reliability and SMA in its process for developing the technical capability requirements for using controllable load as a reactive resource in the applicable Reliability Standards.**

VAR Informal Consideration

NERC addressed this directive in a prior version of the VAR standard,¹⁸ but as mentioned above, the list for sufficient reactive resources that includes controllable load has been retained in R2.

Directive from P 1885 of Order No. 693

"Dynergy has suggested an improvement to Reliability Standard VAR-002-1, and NERC should consider this in its Reliability Standards development process."

Dynergy requested that VAR-002 be modified to include "more detailed and definitive requirements when defining the time frame associated with an 'incident' of non compliance."¹⁹

VAR Informal Consideration

The informal development team addressed this directive in two separate requirements. The noncompliance incidences at issue occur 1) when a generator deviates from a voltage or reactive power schedule; and 2) when a generator is not operating a unit in automatic voltage control mode; more specifically, automatic voltage regulator (AVR) should be in service and controlling voltage.

The new pro forma VAR-002 R2.1 addresses when a unit must notify its TOP when a unit is out of schedule:

R.2.1. If a GOP drifts out of schedule, each Generator Operator shall notify its associated Transmission Operator within 15 minutes when both of the following conditions are met: 1) the GOP is operating outside of the prescribed voltage or

¹⁷ See TPL-001-2, R5 (available at <http://www.nerc.com/files/TPL-001-2.pdf>).

¹⁸ See *NERC Petition for Approval of Proposed Modifications to Reliability Standards BAL-002-1; EOP-002-3; FAC-002-1; MOD-021-2; PRC-004-2; and VAR-001-2*, 134 FERC ¶ 61,015 (2011).

¹⁹ Order No. 693 at P 1883.

Reactive Power schedule tolerance band²⁰ for 15 minutes; and 2) the GOP is no longer able to return to its voltage or Reactive Power schedule.

The new pro forma VAR-002 R3 addresses when a unit must contact its TOP when the facility is out of AVR:

R3. Each Generator Operator shall notify its associated Transmission Operator of a status or capability change on any generator Reactive Power resource, including the status of each automatic voltage regulator and power system stabilizer and the expected duration of the change in status or capability within 30 minutes of the change. If the status has been restored within the first 15 minutes of such change, then there is no need to call TOP.

The informal development group established the 15-minute time requirements following much discussion. Several industry stakeholders advocated for a larger window of time before a notification must be made; however, there is no consensus on when a reliability gap would be created by expanding the time requirements. Some stakeholders also argued that 15 minutes was excessive.

²⁰ GOPs monitor and control voltage based on their equipment limitations. GOPs will monitor their voltage or Reactive Power schedule tolerance bands either at the high-side or low-side/terminal voltage.

Conclusion

The goal of the VAR informal development project is to provide a venue for addressing many of the issues that can arise during the formal development process. By engaging with industry stakeholders through an active dialogue, the informal development group was able to efficiently address the concerns of many entities through conference calls, webinars, and informal group meetings. The informal group collaborated over the past five months to develop robust pro forma VAR standards that will serve as the basis for a new VAR standard, which should be posted for industry comment in August 2013. This white paper serves to memorialize some of the discussions surrounding contentious VAR issues, and it provides a basis for the technical discussion that occurred during the informal process. For the aforementioned discussion, the informal development group recommends approval of the accompanying SAR and the posting of the pro forma standards in order to continue the progress on the VAR standards.

Entity Participants

Appendix B: Entity Participants

The below entities represent a non-exhaustive list of entities that had personnel that participated in the VAR informal development effort in some manner, which may include one of the following: direct participation on the ad-hoc group, inclusion on the wider distribution (the “plus” list), attendance at workshops or other technical discussions, participation in a webinar or teleconference, or by providing feedback to the group through a variety of methods (e.g., email, phone calls, etc.). Additionally, though not listed here, announcements were distributed to wider NERC distribution lists to provide the opportunity for entities that were not actively participating to join the effort.

Table 2: Entity Participation in VAR Informal Development

AES	DTE Energy	ISO-NE	Pepco Holdings	TECO Energy
Alcoa	Duke	ITC Transmission	PGE	Tenaska
Ameren	Dynegy	KCP&L	PGN	Texas MPA
Arizona Public Service	Edison Mission Generation	Luminant	PJM	Tri-State G&T
ATC	EDPR	MEAG	PNM	TVA
Austin Energy	Enervision	MidAmerican Energy	PPL	WAPA
BGE	Entegra power	Midwest ISO	PSC	WE Energies
Black Hills Corporation	Energy	MN Power	PSE	WFEC
Bonneville Power Admin.	Energy Fossil & Hydro	National Grid	PSEG	WICF
BP	epelectric	NCEMC	Rayburn Electric	Wisconsin Public Service
Calpine	ERCOT	NERC	San Francisco PU	Xcel Energy
CenterPoint Energy	Essential Power LLC	NextEra	SCANA	Regional Entities:
City of Tallahassee	Exelon Corp	NiSource	SCE	FRCC
Colorado Springs Utilities	ExxonMobil	Northeast Utilities	Seminole electric	MRO
ComEd	FERC	Nova Scotia Power	Siemens	NPCC
ConEd	FPL	NPPD	SMUD	RFC
Constellation	Garland Power & Light	NYISO	Snohomish County PUD	SERC
Constellation Energy Nuclear Group (CENG)	Hydro Quebec	Occidental Energy Ventures Corp.	Southern Company Services	SPP
CSU	Iberdrola Renewables	OGE	Southwest Generation	TRE
Dominion	IMPA	PacifiCorp	Southwest Power Pool	WECC

Table 3: Other Outreach	
NERC Standards and Compliance Workshop	ISO/RTO Council
NAGF	NERC News
NERC Standards Committee	EPRI