Standard Development Timeline

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

Development Steps Completed

1. Draft 1 of SAR posted for comment August 17 – September 17, 2009.
2. Draft 2 of SAR posted for comment February 24 – March 26, 2010.
3. SC authorized moving the SAR forward to standard development May 13, 2010.
4. SC appoints SDT July 14, 2010.

Description of Current Draft

The VRPC SDT is requesting comments on the draft standard under a 30-day informal comment period.

Anticipated Actions	Anticipated Date
30-day Formal Comment Period	June 2011
45-day Formal Comment Period with Parallel Initial Ballot	
30-day Formal Comment Period with Parallel Successive Ballot	
Recirculation ballot	
BOT adoption	

Effective Dates

Version History

Version	Date	Action	Change Tracking

Definitions of Terms Used in Standard

This section includes all newly defined or revised terms used in the proposed standard. Terms already defined in the Reliability Standards Glossary of Terms are not repeated here. New or revised definitions listed below become approved when the proposed standard is approved. When the standard becomes effective, these defined terms will be removed from the individual standard and added to the Glossary.

Voltage Stability:

Voltage Stability is the ability of a power system to maintain steady voltages at all buses in the system under normal operating conditions and after being subjected to a disturbance.
A criterion for voltage stability is that, at a given operating condition ~~for every bus~~ in the system, the bus voltage magnitude increases as the reactive power injection ~~at the same bus~~ is increased.

~~**Real Power Voltage Margin:**~~

~~An incremental amount of Real Power beyond a given operating point to the level before Voltage Stability will be lost.~~

~~**Reactive Power Voltage Margin:**~~

~~An incremental amount of Reactive Power beyond a given operating point to a level before Voltage Stability will be lost.~~

~~VAR-001 **Term: Reactive Margin** The incremental amount of additional reactive power required to maintain Voltage Stability.~~

When this standard has received ballot approval, the text boxes will be moved to the Application Guidelines Section of the Standard.

A. Introduction

1. **Title:** Voltage and Reactive Planning and Control

2. **Number:** VAR-003-1

3. **Purpose:** To manage the risk of voltage instability by planning, operating and managing reactive power resources which enable compliance with VAR-001 and VAR-002.

4. **Applicability:**

   4.1. Functional Entities:

   4.1.1 PC, TP, TO, DP, LSE, RP, GO, PSE, and TSP

   4.1.2 RC, TOP, GOP, BA

   4.2. Facilities:

   4.2.1 The associated facilities (if any) of each owner, operator and user for the Functional Entity listed above.

5. **Background:**

   Goals:

   - "To revise the VAR Standards to require that appropriate functional entities develop and coordinate voltage and reactive planning and operating criteria to ensure that there are sufficient reactive resources, and voltage and reactive margins, to manage the risk of voltage instability.". . quoted from the SAR first paragraph.
   - Appropriate functional entities to ***deliver*** the following which identify the criteria and plans to provide a system which is ***capable*** of meeting the Purpose of this standard.
     - ***Criteria and Methodology*** for Voltage Control and Reactive Resource Planning (***C&M*** *documentation*)
     - ***VAR Plan*** to meet the C&M.
   - ***Enable*** the operating functional entities to manage the risk of voltage instability using system capability enhanced by the VAR Plan which complies with the C&M.
   - ***Ensure*** proper planning documentation, communication and review with operations on an annual cycle.

   Objectives:

   - Criteria and Methodology for Voltage Control and Reactive Resource Planning (***C&M***)

- Criteria for adequate voltage - steady state and dynamics
  - high and low limit and time frame expectations
  - voltage control reliability – System Bus Voltage Collapse Control; both steady state and dynamic (i.e. percent voltage drop margin, or P-V curve exponential margin, or other margins for voltage collapse control, and dynamic Voltage Stability)
- Document evidence for;
  - Reactive Load forecasts (i.e. 50/50 or 90/10, etc),
  - Load power factor estimates, assumptions and expectations,
  - Planning and operating contingencies to be analyzed
  - Normal and emergency voltage limits and time frames.
  - Local automatic and manual control designs (TO, GO, & DP)
  - System bus voltage collapse control
  - Address the demand and reactive resources needed among bulk power facilities
  - Reactive Power Conservation Plan including neighboring PC/TPs sharing of reactive resources to meet customer demand plus losses.
  - Dynamic VAR Requirements
- Document the above for comment and make available to functional entities which have a reliability related need within the PC/TPs footprint, and neighboring PC/TPs footprints.
- Respond to the above comments within a reasonable time frame. [PC/TPs to change the C&M as deemed appropriate by the PC/TPs, or explain why the change was not made.]

- VAR Plan
  - Identify the explicit planning assumptions;
    - Load forecasts (i.e. 50/50 or 90/10, etc), and reactive demand forecast change from last year.
    - Load power factor estimates, assumptions and expectations,
    - Revised existing reactive resources, such as retirements, obsolete equipment replacements, etc.
    - Actual reactive load compared to expectations and assumptions in the C&M.

        - Long term failures of equipment (river crossings, bulk transformers, etc) which impact voltage and reactive requirements.
        - Contingency categories analyzed
        - Normal and emergency voltage limits and time frames, etc.
        - Local automatic and manual control locations (TO, GO, & DP)
        - Address the demand and reactive resources needed among bulk power facilities.
        - Reactive Power Conservation Plan including neighboring PC/TPs sharing of reactive resources to meet customer demand plus losses.
        - Dynamic VAR Requirements
        - Voltage control reliability – System Bus Voltage Collapse Control locations and method; both steady state and dynamic requirements.
    - PC & TP to identify a corrective action plan (as needed to meet the C&M) as part of the VAR Plan.
    - Document the above for comment and make available to functional entities within the PC/TPs footprint, and neighboring PC/TPs footprints which have a reliability related need.
    - Respond to the above comments within a reasonable time frame. [PC/TPs to change the VAR Plan as deemed appropriate by the PC/TPs, or explain why the change was not made.]

- Enable operating functional entities to maintain voltage.
    - Enable the RC and TOPs to abide by the VAR-001-2 Standard
        - Identify the resources, tools, and controls (including Demand Side Management) as contained in the VAR Plan to meet the C&M constraints.
        - Other?
    - Enable the GOP to abide by the VAR-002-2 Standard.
        - Identify the resources, tools, and controls as contained in the VAR Plan to meet the C&M constraints.

- VAR Plan needs to identify the resources, tools, and coordinated controls needed by the GOPs, TOPs as deemed appropriate by the RC or PC.

[For example if the GOP needs the bulk power bus voltage at the point of interconnection to meet the C&M requirements, the VAR Plan should identify how the GOP gets that telemetered number. i.e. new SCADA transducer telemetered to GOP, etc.

If a given high or low side GOP terminal voltage is an anticipated limit which may restrict MVAR capability, in order to meet the C&M requirements, the TOP may need telemetry of the generator terminal voltage sent to the TOP, plus generator terminal MVAR output, etc. The VAR Plan enables the TOPs and GOPs to function properly in real time with the voltage control and monitoring that they need to maintain reliability.]

B. Requirements and Measures

R1 ~~Criteria and Methodology for Voltage Control and Reactive Resource Planning (C&M)~~

Each PC and TP shall establish ~~an appropriate~~ criteria and methodology for voltage control and Reactive Power resource planning (C&M) with the assistance of their associated functional entities to manage voltage limit violations and maintain V~~the risk of v~~oltage ~~ins~~Stability (both steady state and dynamic requirements). ~~[The existing TPL and proposed TPL draft 6 does not require Voltage Stability margin. Additional studies beyond TPL will be required to cover Voltage Stability margin.]~~ The C&M shall address each of the following R1 requirements:

[Violation Risk Factor:] [Time Horizon:]

Rationale for R1: The main driver of VAR-003 is to ensure that functional entities develop a robust C&M to manage the risk of voltage instability within their planning (PC/TP) and operating (TOP) footprints. The C&M ensures the development of a reliable and efficient VAR Plan that will enable operational entities to abide by VAR-001 and VAR-002 requirements. The primary objective in real time Operations is to control system voltages at specified levels and within certain limits (including dynamic limits) for which the applicable operating requirement/criteria is the voltage schedule (at regulated buses) and voltage limits (at load buses). These limits are addressed in VAR-001 and updates to existing TOP standards. The requirements needed to be addressed in VAR-003 is "to ensure that there are sufficient reactive resources (including Demand Side Management resources if any), and voltage and reactive margins, to manage the risk of voltage instability" [SAR Purpose].

The C&M is essentially needed for the planning of reactive resources and controls "to prevent voltage instability and to ensure reliable operations." [Order 693, para 1868]. Therefore, the criteria shall meet two main objectives: (i) identify (i.e. quantify) adequate voltage/reactive margins, and (ii) ensure availability of adequate reactive reserves.

The existing TPL and proposed TPL draft 6 does not require Voltage Stability margin. Additional studies beyond TPL will be required to cover Voltage Stability margin.

Planning for adequate margins ensures that cascading due to voltage instability or collapse will not occur for TPL Category B and Category C contingencies, and the need for UVLS is identified as a potential safety net mitigation for Category D contingencies. Planning for adequate (dynamic) reactive reserves ensures that system voltages can be controlled and maintained at desired levels during real time Operations even when a forced outage occurs on top of a prior outage (TPL Category C.3) which is one of the desirable attributes of reliable system operations.

The resulting VAR Plan shall include size, location, and the mix (static / dynamic) of reactive resources (the 3 characteristics of "sufficient" reactive resources) in order to maintain acceptable steady state and dynamic margins "to ensure voltage instability will not occur under normal and emergency conditions." [paragraph 1870]

R1.1 ~~Voltage and Reactive Criteria and Methodology~~

Each PC and TP shall establish and document the ~~appropriate~~ C&M. ~~Criteria and Methodology~~ to address ~~R1 part R1.1~~ the following requirements:~~.~~

Rationale: ~~[~~TPL requires a System Peak Load study for either Year One or year two, and for year five. TPL draft 6 R2.1.2. requires a System Off-Peak Load study for one of the five years. TPL~~-~~ "R6 Each Transmission Planner and Planning Coordinator shall define and document, within their Planning Assessment, the criteria or methodology used in the analysis to identify System instability for conditions such as Cascading, voltage instability, or uncontrolled islanding." However, TPL R6 does not require a Voltage Stability margin and is not clear if it includes both voltage magnitude stability and angular stability. ~~]~~

R1.1.1~~.~~ Range of ~~C~~contingencies shall ~~to be evaluated~~

~~[Covered already in TPL. VAR Plan should be adequate to~~ cover TPL prevailing Standard Table 1 ~~performance requirements~~and associated Requirements. ~~P0 to P7~~.

~~However, there is no obligation in VAR-001 for the TOP to operate for performance requirements P2 (Bus Section fault) to P7 (multiple facility outages).]~~

M1.1.1 The PC/TP documentation shall explicitly cover the range of contingencies to be evaluated.

Rationale for R1.1.1~~2~~: The criteria and methodology shall provide a . . . "high level of confidence that the system's reactive power needs can be met satisfactorily across a broad range of contingencies that planners might reasonably anticipate.

. . . reactive power evaluations should be conducted within a process that is documented in detail and includes a range of contingencies that might be reasonably anticipated, because this would avoid the 'one size fits all' problem, where a prescriptive analytical methodology does not fit with a particular system configuration." [paragraph 1866 & 1867].

The RC and TOP will determine the contingency set to be used under the operations related Standards (such as VAR-001, TOP-001, etc). R1.1.1 is not intended to define the operational contingency set.

~~1.~~R1.1.2 Identify On-Peak and Off-Peak local Bulk Electric System reactive resource scheduling constraints (if any) for electric system voltage and reactive control. On-Peak studies shall include Voltage Stability margin studies. Off-Peak studies shall include high voltage magnitude studies to avoid equipment limit violations.

Rational 1.1.2: ~~[~~TPL draft 6 does not cover Off-Peak studies up to the ~~in the 3 month to~~ 36 month horizon. TPL requires a System Peak Load study for either Year One or year two, and for year five. TPL draft 6 R2.1.2 requires a System Off-Peak Load study for one of the five years.]~~]~~

M1.1.2 The PC/TP documentation shall explicitly document the C&M to address the above topic.

Rationale for R1.1.2: FERC Order 693 Determination:

Paragraph 1861. "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 asked for these comments in response to concerns that during high loads, if the power factor at the interface between many LSEs and the Bulk-Power System is so low as to result in low voltages at key busses on the Bulk-Power System, then there is risk for voltage collapse. 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.

1862. 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 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.

1863. The 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. The range of power factors developed in this Reliability Standard provides the input to the range of power factors identified in the modifications to the TPL Reliability Standards. In the NOPR, the Commission suggested that sensitivity studies for the TPL Reliability Standards should consider the range of load power factors."

R1.1.3 Identify Voltage Stability margin (VSM) assumptions, and criteria which, shall include performing Voltage Stability analysis including post-transient and steady state time frames.

. [~~Not covered in TPL. This requirement will require additional PC/TP studies to confirm the VAR Plan covers R1.1.3.~~]

M1.1.3 The PC/TP documentation shall explicitly cover the Voltage Stability margin assumptions and criteria.

Rationale for R1.1.3: The criteria shall . . . "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." [paragraph 1868]. In addition it shall include . . . "requirements that clearly define what voltage limits are used and how much reactive resources are needed to ensure voltage instability will not occur under normal and emergency conditions." It shall. . . "contain specific and definitive technical requirements on voltage and margin application." . . . and "represent a good example of clearly-defined requirements for voltage and reactive margins." [paragraph 1870].
Margin for this purpose is a common dictionary definition, "A limit in condition, capacity, etc. , beyond or below which something ceases to exist, be desirable, or be possible." Voltage Stability margin assumptions and criteria are not covered in TPL. Voltage Stability sensitive areas that are susceptible to voltage instability are expected to run studies periodically, and areas that have not been susceptible to voltage instability are expected to periodically update their study results to ensure that these limits are not encountered during real-time operations

~~**.1.3.1** The criteria and methodology shall include performing Voltage Stability analysis [TPL does not require margin. Several ISOs require margin beyond TPL performance requirements.]~~

Rationale for R1.1.3.1: ~~Areas that are susceptible to voltage instability are expected to run studies frequently, and areas that have not been susceptible to voltage instability are expected to periodically update their study results to ensure that these limits are not encountered during real-time operations. [portion of paragraph 1875 and 1876. A portion or all of para 1875 & 1876 should be covered in VAR-001~~
~~].~~

M1.1.3.1 The PC/TP documentation shall explicitly cover the criteria and methodology to perform Voltage Stability analysis for offline studies. ~~where online tools are not currently available to assist real-time operations.~~ The criteria and methodology will be used in R2 the VAR Plan which is updated annually.

~~**R1.1.3.2** Limits to be observed, such as Voltage Stability load and transfer limits, voltage limits, Stability limits, etc. [This Requirement may be redundant and really an example of limits covered in TPL, FAC, or TOP [IROL SOL] Standards and may be removed after confirmation].~~

~~**M1.1.3.2** The PC/TP documentation shall explicitly cover the above topic.~~

~~**R1.1.3.3** Criteria and Methodology for dynamic reactive power requirements including dynamic margins, if any, to maintain Voltage Stability and associated reactive reserves [A complementary requirement is covered in VAR-001 R2 and R2.2].~~

~~Rationale for R1.1.3.3: Criteria to determine the [????? balance (mix) between static & ?????] dynamic reactive resources within the total reactive compensation is identified in the SAR and is a scope item under NERC PC Project 2008-1.~~

M

M1.1.3.3 The PC/TP documentation shall include its criteria and methodology to determine the ~~[????? balance (mix) between static & ?????]~~ dynamic reactive resources within the total reactive compensation identified in the VAR Plan.

~~**R1.1.4** Document~~**R1.1.4 Document** the methodology for the voltage ~~control~~ requirements ~~(v-schedule)~~for ~~including~~ associated functional entities in the footprint.

M1.1.4 The PC/TP documentation shall explicitly cover its methodology for the voltage ~~control~~ requirements. ~~(v-schedule)~~

R1.2 ~~**Voltage and Reactive Data and Study Assumptions**~~

Each PC and TP shall identify ~~assumptions for~~ each of the following voltage and reactive data and study assumption requirements.

R1.2.1 The r~~R~~eactive load forecast ~~assumption~~ criteria for On-Peak and Off-Peak, and the methodology for validating~~, associated methodology, and requirements for reconciliation of~~ the forecast ~~expectations~~ with actual historical reactive load.

[Move to Rationale: Paragraphs 1861-1863. This is a transparency requirement to document the assumption criteria used either in TPL or for the VAR Plan produced by VAR-003. This material is covered, to some extent, in the FERC 715 required jurisdictional entity annual filings. MOD-017 covers MWs but does not cover MVARs. Incorporate changes in your model, based on the validation, per R2.]

M1.2.1 The PC/TP documentation shall explicitly cover the above topic.

~~**R1.2.2.** System peak Load levels shall include a Load model which represents the expected dynamic behavior of Loads that could impact the study area, considering the behavior of induction motor Loads.~~

~~**Rationale R1.2.2:** Models, impedances and tap are covered under MOD standards. The item which is critical to the VAR plan is load modeling assumptions in dynamics. [Eventually the new MOD equivalent Requirement should be referenced here. The above R1.2.2 is from the new TPL Draft 6. It does not need to be covered here. This VAR requirement can be deleted.]~~

> ~~**M1.2.2** The PC/TP documentation shall cover its methodology for Dynamic modeling reactive related assumptions, including load model representing the behavior of motor loads during system On-Peak load levels for dynamic simulation. An aggregate System Load model which represents the overall dynamic behavior of the Load is acceptable.~~

~~**R1.2.3.** Document the assumptions and functional entity source for all generator reactive power resources, including existing resources and any changes.~~

~~**Rationale R1.2.3:** FAC & MOD-025 equivalent Requirement to be referenced as deemed appropriate, for data quality control purposes, then **this duplicate VAR requirement may be removed.**~~

~~**R1.2.4. Document** key facility limitations such as voltage limits, equipment MVA thermal ratings and state the associated assumptions.~~

~~**Rationale R1.2.4:** FAC-008, FAC-009 and MOD 10, MOD 12 equivalent Requirements to be referenced as deemed appropriate, then **this duplicate VAR requirement may be removed.**~~

R1.2.5 The Transmission Service Provider (TSP) shall document its criteria and methodology to include the demands placed on the system by both PSEs and LSEs on a comparable basis.

~~**M1.2.5 The TSP shall explicitly document its C&M for the above item.**~~

~~**R1.2.6** The PC and TP shall document its assumptions regarding the arrangements by PSEs and LSEs to abide by the TSP requirements related to reactive requirements. These TSP requirements must be met by each PSE and LSE to obtain transmission service. As required by the TSP this may include arrangements to provide reactive power by ancillary service, multi-party contracts, or self supply.~~{Include Rationale box that includes discussion on Para. 1856-1858. Add discussion of comparability for LSE and PSE. }

M1.2.5~~6~~ The PC/TP documentation shall explicitly cover its assumptions regarding the arrangements by PSEs and LSEs to abide by the TSP requirements related to reactive requirements.

VAR-001-2, R5 work from Tiger team. Need to consider implications here.

Each Purchasing-Selling Entity and Load Serving Entity shall arrange for (self-provide or purchase) reactive resources – which may include, but is not limited to, reactive generation scheduling; transmission line and reactive resource switching; controllable load, and if necessary, controllable load shedding – to satisfy its reactive requirements identified by its Transmission Service Provider.

R1.3 The synchronously connected neighboring PCs/TPs shall coordinate the following requirements.

R1.3.1. Voltage requirement ~~(v-schedule)~~ control methodology used by planning

M1.3.1 ~~Text~~The PC/TP documentation shall explicitly cover the above topic.

R1.3.2. Contingency categories covered in the C&M and VAR Plan.

M1.3.2 ~~Text~~The PC/TP documentation shall explicitly cover the above topic.

~~**R1.3.3** Other neighboring limits to be observed, such as Voltage Stability load and transfer limits, voltage limits, Stability limits, etc. [This Requirement may be already covered in TPL, FAC, or TOP [IROL SOL] Standards and may be removed after confirmation].~~

~~**M1.1.3** The PC/TP documentation shall explicitly cover the above topic.~~

R1.3.4 Firm transactions to be observed and modeled for this time horizon by ~~both~~ neighboring PC/TPs ~~parties~~ with respect to Voltage Stability.

M1.1.4 The PC/TP documentation shall explicitly cover the above topic.

R1.3.5 Coordination of On-Peak and Off-Peak load reactive forecasts for models.

M1.3.5 ~~Text~~The PC/TP documentation shall explicitly cover the above topic.

R2 Each PC and TP shall establish and update each calendar year, not to exceed 15 months between updates, a n appropriate reactive support and control plan ("VAR Plan") that address . VAR Plan shall address each of the requirements of the Criteria and Methodology for Voltage Control and Reactive Resource Planning developed by the associated PC and TP in R1, and the following requirements:

M2 The PC/TP shall explicitly address in the VAR Plan each of its C&M requirements for R1 and the following requirements.

Rationale for R2: In a similar fashion with TOP-002, R2 operational studies, the associated RC and TOPs shall be involved with their associated PCs and TPs. As jointly desired by the entities, this VAR-003 R2 requirement may be fulfilled at the same time as the TOP operation studies are conducted for an agreed upon planning and operations time horizon such as a time horizon from operations planning time frame (3 months) out to 36 months).

R2.1 Voltage and Reactive Constraints based Constraints based on the Analysis to meet the C&M

R.2.1.1. Specific voltage limits of TO, GO, DP classes of equipment which shall not be exceeded. [The Requirement to establish these limits is covered in the FAC Standards.] The limits used in the VAR Plan shall be stated here.

Rationale for R2.1.1: These are the limits provided by the owners of the equipment in developing the VAR plan. These limits are also used in the study analysis to determine compliance with the R1 required C&M.

M2.1.1 The VAR Plan shall explicitly identify the above limits.

R2.1.2. Develop a Reactive resource Automatic vVoltage Control requirement (V-Schedule) and deliver to appropriate parties as listed in Requirement R3used in the above VAR Plan.

M2.1.2 The VAR Plan shall explicitly identify the above control schedule requirements.

R2.1.3 GSU Fixed Tap Setting Studies

~~(scope below from legacy standard I.D.M2)~~

Generation entities ~~-~~(GOs and GOPs) and transmission entities (TPs, TOs, and TOPs) shall ~~work jointly to~~ coordinate~~optimize~~ the use of generator reactive power capability~~.~~ These ~~joint~~ efforts shall include:

R2.1.3.1~~a.~~ Coordination of generator step-up transformer impedance and tap specifications and settings,

R2.1.3.2~~b.~~ Coordination~~alculation~~ of over / under excited limits based on machine thermal and stability considerations, and

R2.1.3.3~~c.~~ Coordination of ~~To the extent possible based on~~ generator~~ion~~ terminal voltage limits. ~~resulting from (a) above, and (b) under excited limits, ensuring that the full range of generator reactive power capability is available for applicable normal and emergency bulk network voltage ranges.~~

Rationale: add statement here. Add desire to centralize all of these requirements, MOD, PRC FAC, VAR, so there is not multiple compliance risks, etc. . .. . .

M2.1.3 GOs and TOs shall document the results of R2.1.3.1, 2 & 3 ~~(a), (b) and (c)~~ above based on the assumptions in the VAR Plan.

GOPs and TOPs shall document any changes to R2.1.3.1, 2 & 3 ~~(a), (b) and (c)~~ above based on operational studies conducted which supersede the VAR Plan.

R2.1.4. Identify s~~S~~ystem b~~B~~us v~~V~~oltage c~~C~~ollapse c~~C~~ontrol l~~L~~imits (if any)

~~T~~to reduce the risk of voltage collapse. ~~, i~~Indentify the bus voltage magnitude limits to be maintained if higher than applicable FAC minimum voltage limits.

M2.1.4 The VAR Plan shall explicitly identify the above system bus voltage constraints.

R2.1.5. Identify Bulk Electric System areas (if any) which require additional ~~monitoring and control~~reactive power resource scheduling and control ~~constraints~~ to maintain Voltage Stability for a given range of On-Peak and Off-Peak load levels.

M2.1.5 The VAR Plan shall explicitly identify BES areas (if any) which require additional monitoring and control to meet C&M Voltage Stability constraints.

R2.1.6 ~~Power Transfer Margin and Reactive Margin monitoring and control limit identification.~~ The VAR Plan shall identify the ~~monitoring~~ locations and ~~control~~ transfer limits (if any) necessary to maintain ~~a given C&M amount (or more) of~~ Voltage Stability ~~Power Transfer~~r ~~Margin~~margin ~~and Reactive Margin~~ for the given range of On-Peak and Off-Peak load levels.

M2.1.6 The VAR Plan shall explicitly identify the above ~~monitoring~~ locations and transfer~~control~~ limits (if any) for the given range of On-Peak and Off-Peak load levels.

~~**R.2.1.7.** On-Peak and Off-Peak local Bulk Electric System reactive resource scheduling constraints (if any) to maintain C&M voltage compliance under the given contingency categories.~~

~~**M2.1.7** The VAR Plan shall explicitly identify the above scheduling constraints (if any).~~

~~**R2.1.8**. Under Voltage Load Shedding (UVLS) Relays~~

~~UVLS relay locations and settings required (if any) to prevent voltage collapse for credible contingencies, and UVLS relays used for extreme contingencies (safety net).~~

~~**M2.1.8** The VAR Plan shall explicitly identify the above relay locations and settings.~~

R 2.2. Identify the ~~V~~VAR d~~D~~emand and r~~R~~esources ~~Plan~~ needed among bulk power ~~-~~ facilities ~~—~~and associated support from owners, operators, and users as follows:~~.~~

R2.2.1 The PC and TP shall document its On-Peak and Off-Peak real and reactive power load ~~level forecasts~~ used in the VAR Plan regarding the arrangements by PSEs and LSEs to abide by the TSP requirements related to reactive load and loss requirements. TSP requirements must be met by each PSE and LSE to obtain transmission service. As required by the TSP this may include arrangements to provide reactive power by ancillary service, multi-party contracts, or self supply. If a PSE or LSE has not met the TSP reactive requirements (if any), the VAR Plan shall document each PSE and LSE mitigation plan that was approved by the PC and TSP.

M2.2.1 The VAR Plan shall explicitly cover the above topic.

~~**R2.2.2** Reactive load forecast (including losses) used in the above analysis. Summarize by TOP and TO footprint.~~

~~**M2.2.2** The VAR Plan documentation shall explicitly identify the MW and MVAR load forecast (including losses) used in the VAR Plan – summarized by TOP and TO footprint.~~

Rationale for R2.2.1 and R2.2.2 ~~and R2.2.3~~: Summarize plan demand and supply resources that are needed by and enable compliance with VAR-001 and VAR-002 needs for N-0

R2.2.2~~3~~. Identify the ~~R~~reactive ~~P~~-power ~~C~~conservation ~~P~~plan for ~~N~~normal ~~O~~operations

~~W~~within a given PC footprint, summarize by TOP and TO footprint the VAR Plan On-Peak and Off-Peak load MW and MVAR as follows;

R2.2.3.1~~(a)~~ Demand (including losses)

R2.2.3.2~~(b)~~ Reactive resource output (static and dynamic) in the solved load flow base case, and their associated modeled voltage schedule. List reactive devices in-service.

R2.2.3.3~~(c)~~ the interchange table of MW and MVAR imports (or exports) from adjacent TO boundary footprints/tie lines, and

R2.2.3.4~~(d)~~ the remaining portion of unscheduled or unused Reactive resources (static MVAR reserve and dynamic MVAR reserve) within the footprints.

The TO footprint total demand ~~shall~~ (R2.2.3.1~~a~~) shall include the impact of PSE and LSE owned bulk electric system facilities (if any), GO and DP facilities (including losses). For the given load flow base case the sum of ~~(b)~~ Reactive resource output (R2.2.3.2) plus ~~(c)~~ interchange imports (R2.2.3.3) shall equal ~~(a)~~ the total Demand (R2.2.3.1) within each footprint.

M2.2.3 VAR Plan shall explicitly identify the above items (R2.2.3.1 to R2.2.3.4~~a~~)~~, (b), (c) and (d)~~ for both On-Peak and Off-Peak load flow base cases used to develop the VAR Plan.

R2.2.4. ~~R~~Identify the reactive ~~P~~power resources ~~Plan~~ for ~~C~~Contingencies (TPL ~~c~~Category B and Category ~~B &~~ C ~~c~~Contingencies, including N-2, N-1-1 sequential outages, etc.). F

~~F~~or On-Peak and Off-Peak load conditions identify~~;~~ ~~generator~~ reactive capabilities assumed. ~~, static reactive devices and switching requirements for contingencies. Include new~~

Rationale for R2.2.4 and R2.2.5: Summarize the plan for reactive resources that are needed by and enable compliance with VAR-001 and VAR-002 needs for criteria contingencies.

~~switching requirements.~~

M2.2.4 VAR Plan shall explicitly identify the above.

R2.2.5. ~~R~~Identify the reactive ~~P~~power ~~P~~plan for ~~D~~dynamic resources ~~s~~ under

~~For~~ On-Peak and Off-Peak load conditions. Identify~~;~~ generator reactive responsiveness assumed, dynamic reactive devices and switching requirements for contingencies. Include new generators and dynamic devices, and new reactor and line switching requirements.

Include dynamic VAR Requirements including margins, to maintain Voltage Stability and associated VAR reserves for the contingency classes studied.

~~[should we include type of faults? – 3ph, 1 ph, etc]~~

M2.2.5 VAR Plan shall explicitly identify the above.

R 2.3 The VAR Plan~~PC and TP~~ shall document and communicate the following:

The list of newly identified voltage and VAR limit violations (not previously identified in the prior year VAR Plan) ~~based on C&M (R1)~~ and indicate what solutions have been included in the current~~e~~ VAR Plan. ~~to bring them within C&M constraints.~~ These solutions (new facilities or DSM) shall be contained in an implementation plan.

~~ed within [??36??] months from the date they first appear (are published) in the VAR Plan.~~

Rationale R2.3: During the first year of VAR-003 Standard implementation, the VAR Plan may include new hardware to be installed which may take more than one year to implement. In such a case VAR-003 should give the entity [??36??] months from the date of the annual VAR Plan publication to implement such reactive resource and control changes.

[We need to include some ~~mitigation plan~~ statement like this in the VAR-003 Standard mitigation plan] .

M2.3 The VAR Plan shall explicitly identify the solutions and the time table for implementation. ~~not to exceed [??36??] months.~~

R3. ~~Once a year e~~Each PC and associated TPs shall annually conduct a ~~joint~~ planning

Rationale for R3: Based on previous lessons learned, identify R1 and R2 reliability gaps (if any) between the planning horizon and actual operation. PC/TPs then decide whether R1 or R2 should be modified and if not why not.

and operations review ~~and comment~~ process~~:~~

To include;

- ~~(a)~~ PC delivery of R1 and R2 documents within 30 days of completion.
- ~~(b)~~ Entity within the footprint review (as desired) within 45 days.
- ~~(c)~~ PC/TP response within 45 days identifying resulting changes (if any) to the C&M or VAR Plan. If changes are not made the PC/TP shall identify the rationale. ~~[~~ The PC/TPs shall retain decision making authority. ~~]~~

The above shall only to be delivered to those functional entities within the footprint and adjacent TO and TP footprints per request by those functional entities. If the functional entities within the footprint do not request the information below, none will be sent. All entities shall have~~sign~~ a confidentiality agreement to avoid disclosure of security related, market, operational or planning sensitive information.

R3.1. The PC shall provide R1 parts R1.1 and R1.2, and applicable portions of R2 parts R2.1, R2.2, R2.3 to the GOPs, RPs, TOPs, and DPs within their footprint. If comments are received within 45 days of delivery, the PC and respective TPs shall respond as noted above within 45 days.

M3.1 The PC shall provide the above and respond as noted within 45 days.

R3.2. The PC shall provide R1, R2, and R3 to the RC, BA, and TSP within their footprint. If comments are received within 45 days of delivery, the PC and respective TPs shall respond as noted above within 45 days.

M3.2 The PC shall provide the above and respond as noted within 45 days.

R3.3. The PC shall provide R1 parts R1.1 and R1.2 and applicable portions of R2 parts 2.3.1 and 2.3.2 to the LSEs and PSEs within their footprint. If comments are received within 45 days of delivery, the PC and respective TPs shall respond as noted above within 45 days.

M3.3 -The PC shall provide the above and respond as noted within 45 days.

R3.4. The PC shall provide R1 parts R1.1 and R1.2, and R2 parts R2.1, R2.3.1 and R2.3.2 to the neighboring TOPs, PCs, and RCs which have a reliability related need. If comments are received within 45 days of delivery, the PC and respective TPs shall respond as noted above within 45 days.

M3.4 The PC shall provide the above and respond as noted within 45 days.

Text text text: *[Violation Risk Factor:] [Time Horizon:]*

- Choice one
- Choice two
- Choice three

C. Compliance

1. Compliance Monitoring Process

1.1. Compliance Enforcement Authority

Regional Entity

1.2. Evidence Retention

Text

1.3. Compliance Monitoring and Assessment Processes:

Compliance Audits

Self-Certifications

Spot Checking

Compliance Violation Investigations

Self-Reporting

Complaints Text

1.4. Additional Compliance Information

None

Table of Compliance Elements

R #	Time Horizon	VRF	Violation Severity Levels			
			Lower VSL	Moderate VSL	High VSL	Severe VSL
R1						
R2						
R3						

D. Regional Variances

None.

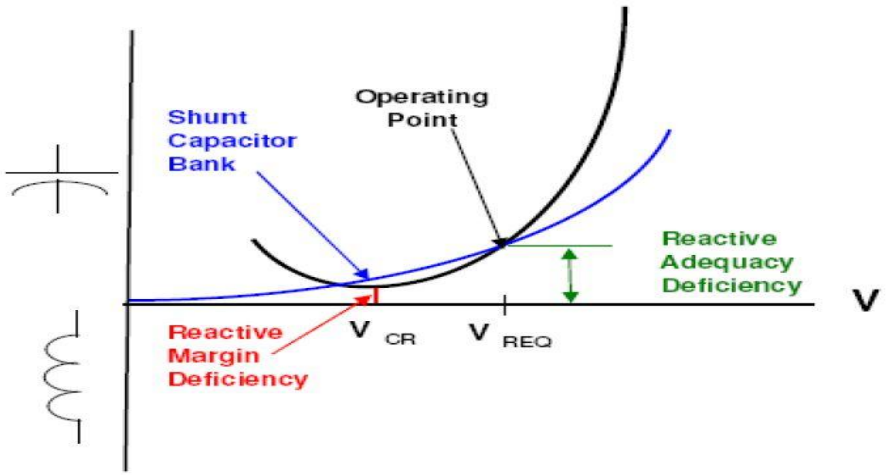
E. Interpretations

None.

F. Associated Documents

None.

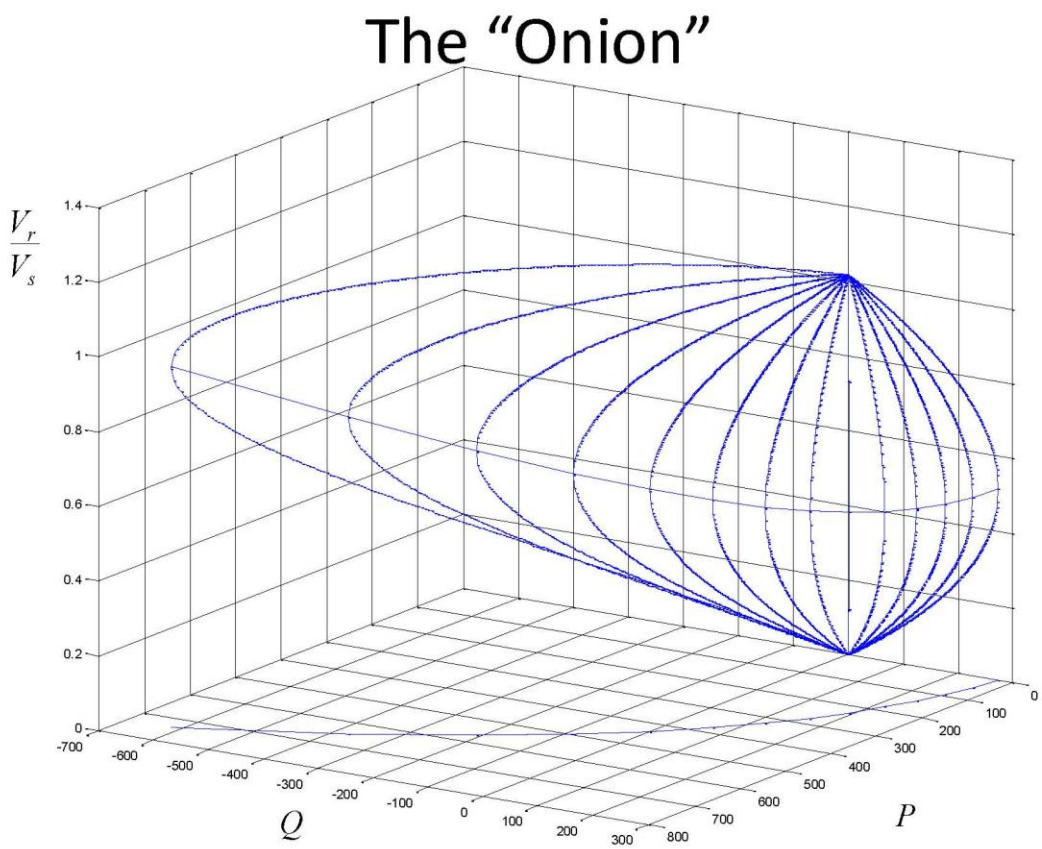
Guidelines and Technical Basis



Requirement R1:

As input to the PC/TPs the TOs, GOs, DPs shall document their own criteria (if any) for reactive planning and operating and give it to the TP and their associated PC. This information will not become public. Each of the registered functional entities within the PC/TP footprint will need to sign a NERC confidentiality agreement. This agreement will limit the dissemination of the documents to those who need to know for reliability purposes within their footprint.

Voltage Collapse Concept – "Onion Diagram"



- ~~*[The above list does not include the entire technical basis from the SAR or examples guidelines from the reference material. Please provide suggested redlines here.]*~~
- ~~*[The above list does not address the entire technical basis from the FERC 693 directives. Please provide suggested redlines here.]*~~

Requirement R2:

What would a high level Summary of the VAR Plan look like?

Think in terms of an individual corporation for each functional entity. The RC and TOP could be in the same ISO, but separate corporations. The NERC Standards should assume each functional entity is a separate corporate entity.

For example assume PC and TPs have finished a C&M document and a VAR plan which complies with the C&M. Summarize the base case load flow, the predominate case for the worst annual On-Peak load (i.e. summer or winter On-Peak load), that passed every contingency test in the C&M. Summarize the load flow base case "total demand summary table" of shunt Bus Loads and reactive losses for each TO (including shunt loads for each DP within the TO). The

system normal base case On-Peak "Total Reactive Demand" is now known. It is the total of the shunt Bus Load VAR demand, plus VAR losses within the TO footprint. This is the TO footprint demand side of the Reactive Conservation Plan. In the same load flow base case see the VAR "resource summary table". Within the TO footprint the VAR resources from capacitors, line charging, generators, and other VAR resources can be totaled. This is the internal footprint expected reactive resource supply during that system On-Peak condition. In the same load flow base case see the "interchange summary table" VAR imports and exports with their TO neighbors. This identifies the expected sharing of VAR resources that is diversified for that particular system On-Peak condition. As always the Reactive Conservation Plan shall follow the laws of physics. The total "VAR Resources" plus neighboring "Net VAR Imports" [minus "VAR Exports"] shall equal to the "Total Reactive Demand". This law of physics is enforced by every solved load flow base case. This "VAR Plan Summary" is an example of a high level tabulation of the Reactive Conservation Plan. The Summary can be that simple. The details in the VAR Plan shall add up to these summary totals for each functional entity within the PC/TPs footprint. The TP and its TOs are not responsible to deliver all of these resources in the VAR Plan. The VAR Plan identifies the expectations of each functional entity within the TO footprint. The VAR Plan is just summarized within the TO footprint boundary. This is one example of how the summary can be presented. In some cases it could be presented for smaller portions of a TO footprint if that makes more electric sense. The PC can make that decision. For very tight electrical TO systems within a PC footprint, it may be appropriate to present the VAR Plan totals on a combined PC/TP/TOs basis. [However, this is expected to be rare since VARs generally cannot be transmitted over long distances without cause significant voltage drops.]

Each PC within a Regional Entity will do this with expected reactive interchanges identified, opportunity for comment by adjacent functional entities. Are the diversified VAR flows (interchange) reasonable and supportable by the neighboring PC/TPs? Are the study voltage schedule set points reasonable?

The RCs and TOPs will have an opportunity to comment on the VAR Plan. Ultimately the VAR Plan content is up to the PC and TPs to decide. As necessary if the RC/TOPs do not agree with the PC/TPs, if the issues are serious, alternative dispute resolution (ADR) is generally available. The PCs are in several cases the ISOs [or RTOs] and their FERC tariff provisions to decide disputes will apply. VAR Plan disputes will not be settled by NERC.

The above will help to get at the voltage and reactive reliability margin issues where people think they have conflicts and no way to resolve them. The C&M and VAR Plan will be structured around the independence of the PC to coordinate resolution to such matters.

The existing (and new) TPL is Standard is where many of its Requirements will be directly applicable to the above. The VRPC STD will need to identify where that the existing Requirements are explicit, and not duplicate explicit TPL or other explicit Requirements in the VAR Standards. Implicit or unclear Requirements in other Standards will need to be identified by the VRPC STD. In general, the VAR Standards should be written so the PC and TP can

continue to do the similar types of studies as they have traditionally completed for other Standards. The VAR Standards are not intended to create duplicate work.

Parking Lot (PL- #) items for VRPC STD review and resolution;

~~**PL-1** Voltage schedule criteria and VAR Plan deliverable -- should it be done by the TP or the PC and delivered to the TOP? . . . then the TOP can modify it as deemed appropriate for near term operation. The TOP would deliver the voltage schedule to each GOP.~~

~~**PL-2**~~ One way to identify power factor range within the TO footprint -- take the existing system On-Peak load flow base case; create more 'zones' within the TO footprint (for each DP if more than one). Put each shunt load bus for DP in a separate DP zone. The load flow model 'summary table' will show the forecasted VAR demand (the total bus VAR load) for each model. This will be the diversified VAR demand to match that load flow case system On-Peak demand. It will not be equal to the sum of DP substation peak VAR loads. It will also not be equal to the DP seasonal peak VAR demand. Load flow model 'diversification' of such MW and MVAR demand is a common "good utility practice" criterion for TP load flow studies. This Standard does not intend to change those criteria assumptions. However, such assumptions and expectations should be made available to the appropriate functional entity within the PC/TPs footprint. Reliability of planning and operation requires situational awareness by all such functional entities within the PC and RC footprints.

- ~~***[The above list does not include the entire technical basis from the SAR or examples guidelines from the reference material. Please provide suggested redlines here.]***~~
- ~~***[The above list does not address the entire technical basis from the FERC 693 directives. Please provide suggested redlines here.]***~~

~~**Requirement R3:**~~

- ~~***To be identified***~~

Parking lot for VAR-001 (TOP requirements)

~~Annual (or seasonal) voltage studies to supplement MW overload seasonal studies done under TOP-002 (R8 for BA? Only; RC and TOP new requirements?), FAC-010, 011 and 014 maybe ok for SOL and IROL limit identification. VAR-001 R2 may be OK... .~~

The criteria and methodology shall include performing Voltage Stability analysis using online techniques where commercially-available [see VAR-001 requirements] and offline simulation tools (used in VAR-003) where online tools are not currently available to assist real-time operations. The criteria and methodology development should consider the available technologies and software and identify a process to assure that this

Reliability Standard does not limit the application of validated software or other tools Areas that are susceptible to voltage instability are expected to run studies frequently, and areas that have not been susceptible to voltage instability are expected to periodically update their study results to ensure that these limits are not encountered during real-time operations. [VAR-001 requirements paragraph 1875 and 1876].

~~**Parking lot for VAR-002** (GOP requirements).~~

- ~~To be identified~~

~~**Parking lot for Background section;**~~

~~These high and low limits shall conform to voltage limits established by the Transmission Owner under FAC Standards, TO-GO-DP interconnection service agreement (ISA) stated voltage limitations (if any) and ANSI standard voltage limitations [“American National Standard Voltage Rating for Electric Power Systems and Equipment (60 Hertz)”, ANSI C??]. The FAC, ISA, and ANSI voltage limits are primarily intended to avoid permanent damage to TO, GO, and DP equipment. Permanent damage to such equipment would jeopardize prompt system restoration. This is a key NERC reliability principal to maintain system operational capability to promptly restore the bulk electric system.~~