Dominion Resources Services, Inc.
P.O. Box 26532, Richmond, Virginia 23261

Dominion℠

July 16, 2014

The PJM Board of Managers
PJM Interconnection, L.L.C.
955 Jefferson Avenue
Valley Forge Corporate Center
Norristown, Pennsylvania 19403-2497

Re: Artificial Island Request for Proposals
Dominion High Voltage Proposal 1A

Dear Board of Managers:

Dominion High Voltage Holdings, Inc. ("Dominion High Voltage") submits these comments in support of its Proposal 1A as the appropriate solution to the identified potential criteria violations in the Artificial Island Area, alone or in combination with the selected PSE&G solution. PJM seems to have discounted this solution because they incorrectly concluded that the performance of Proposal 1A was not as good as the 230 kV and 500 kV line proposals while the evidence and analysis performed and presented by PJM at the TEAC demonstrates the opposite is true. Proposal 1A outperforms the other proposals in meeting the planning criteria with improved stability performance and a relatively low cost compared to other proposals, and can be placed in service years before any of the others. Therefore, Dominion High Voltage requests that the Board refer Proposal 1A back to the Office of Interconnection for full consideration of its benefits.

On April 29, 2013, PJM issued its Artificial Island Area Proposal Window Problem Statement & Requirements Document (Revised May 15, 2013) ("RFP") requesting proposals to improve operational performance of the transmission and generation system in the Artificial Island Area, which includes Salem Nuclear Power Plant (Units 1 and 2) and Hope Creek Nuclear Generating Station (Unit 1). Specifically, the RFP sought "technical solution alternatives … to improve PJM Operational Performance in the Artificial Island area under a range of anticipated system conditions and to eliminate potential planning criteria … violations in the Artificial Island area." The potential criteria violations included not only PJM criteria, but also North American Electric Reliability Corporation ("NERC"), ReliabilityFirst Corporation ("RFC") and local transmission owner criteria.

The response to the RFP submitted by Dominion High Voltage on June 27, 2013[1] included the following three proposals:

PROJECT PROPOSAL	DESCRIPTION	ESTIMATED COST (MILLIONS)
P2013_1-1A: ***DHV 1A***	New 500 MVAr static var compensator (SVC) and two thyristor controlled series compensation (TCSC) devices near New Freedom	$133
P2013_1-1B: ***DHV 1B***	New 500/230 kV station in Delaware and overhead 500 kV line crossing the Delaware River to connect existing 230 kV Cedar Creek-Red Lion and Catanza-Red Lion	$126
P2013_1-1C: ***DHV 1C***	New 500 kV 3000 MVA overhead line between Salem and expanded Hope Creek stations to Red Lion station	$202

At the May 19, 2014 special meeting of the Transmission Expansion Advisory Committee ("TEAC"), PJM's Office of Interconnection provided a 213-page presentation discussing the proposals submitted in response to the RFP and PJM's analysis ("May 19 Analysis"). The May 19 Analysis identified Dominion High Voltage Proposal 1A as rejected without a complete review of its ability to satisfy the additional criteria considered by PJM. Specifically, for all proposals rejected without further study, PJM identified the basis for rejection as "estimated costs higher than other proposals" except for Dominion High Voltage Proposal 1A.[2] In the May presentation, ten proposals were identified as fully considered by PJM ("Selected Ten"), which did not include Dominion High Voltage's Proposal 1A. Proposal 1A was not given full and equal consideration and was ruled out early in the process without adequate justification.

In its Artificial Island Recommendation TEAC presentation on June 16, 2014 ("June 16 Analysis"), the Office of Interconnection identified the preferred solution as a 500 kV transmission line connecting Artificial Island and Red Lion stations, and recommended selection of PSE&G's proposal for a new 500 kV circuit across the Delaware River between Hope Creek and Salem stations with a static var compensator ("SVC") to be added at PSE&G's existing New

[1] The June 27, 2013 proposal was initially submitted by Virginia Electric & Power Company, a pre-qualified Transmission Owner within PJM. Subsequent to its pre-qualification, Dominion High Voltage was identified as the entity proposing the technical solutions.

[2] Atlantic Wind Proposal 6A, which entails the installation of a static var compensator at Artificial Island converter station and a high voltage direct current transmission line between Artificial Island and Cardiff, was identified by PJM as rejected both because its estimated costs in excess of $1 billion are higher than other proposals and for failure to satisfy the required performance objectives.

Freedom station. PJM's selected solution, PSE&G's Proposal 7K, was included in the Selected Ten.

Dominion High Voltage has the highest regard for the PJM staff who have supported the RFP process and fully appreciates the technical, management and scheduling challenges they face in implementing the RFP. However, the RFP analysis failed to fully analyze Dominion High Voltage's Proposal 1A, and further failed to advise respondents to the RFP of PJM's bias in favor of conventional technical solutions for the potential criteria violations in the Artificial Island Area. Dominion High Voltage's Proposal 1A, as proposed or as modified by PJM to enhance performance under certain scenarios, is a fraction of the cost of the ten proposals that passed PJM's primarily cost-based initial screening. By neglecting the second step of the more thorough constructability and cost analysis performed for all other cost-competitive proposals, PJM underrepresents the particular benefits of Proposal 1A. Beyond relative costs compared to each of the line proposals, constructability considerations including right-of-way and land acquisition, siting and permitting, operational impacts, and especially schedule benefits make Proposal 1A significantly more competitive.

Dominion High Voltage Proposal 1A, briefly summarized above, involves the construction of a new switching station near existing New Freedom substation to include eight 500 kV breakers, a new SVC and two new thyristor controlled series compensation devices ("TCSCs"). A TCSC is a static thyristor controlled reactor in parallel with conventional series capacitor for a rapid adjustment of line reactance, which permits the compensation level to be increased for a short time immediately following a contingency event to improve system stability. Dominion High Voltage Proposal 1A presents one TCSC installed on existing New Freedom Station-Hope Creek Line #5023 and one on New Freedom Station-Salem Line #5024 to accommodate the generators' output immediately succeeding a fault. The modification by PJM was to increase the size of the SVC portion of the proposal from 500MVAR to 750MVAR.

Stability Performance

One major reason the Office of Interconnection indicated in both the May 19 and June 16 Special TEAC meetings for not selecting Proposal 1A is that the stability performance was not as good as the 230 kV and 500 kV line proposals. A quote from slide 82 in the June 16 Analysis for rejecting Proposal 1A is as follows:

"Stability performance is not as good as 230kV options + SVC or as good as 500kV options + SVC."

This conclusion drawn by PJM is inherently flawed because it does not compare the maximum swing angle for the worst contingency for each proposal against one another; contingency of

Line 5015 is the most severe for the 230kV options while Line 5038 is the most severe for the TCSC option. Furthermore, a detailed comparison illuminates these observations:

- Slide 242 (see attached and also identical to slide 47 from Dec 11, 2013 TEAC) presented in the June 16 Analysis shows the maximum swing angle for the Proposal 1A option as 88 degrees for the outage of Line 5038.
- Slide 55 (see attached) presented at the December 11, 2013 TEAC shows the maximum swing angle between 77 to 102 degrees for 500kV solutions and between 80-112 degrees for 230kV solutions based on the solution and SVC location selected, respectively.
- In actuality, PJM has selected New Freedom as the SVC location; when using this location for the comparison and referring back to slide 55, the 500kV line options have maximum swing angle of 99 to 102 degrees and the 230kV line options have a maximum swing angle of 109 to 112 degrees.

This side-by-side comparison of worst case contingency results for maximum swing angle demonstrates that Proposal 1A not only meets the reliability criteria, <u>it has the best stability performance of all submitted projects</u> when compared correctly against the other options. The conclusion as stated in the June 16 Analysis was incorrect; in fact the conclusion is Proposal 1A outperforms the other 230 kV and 500 kV line proposals significantly at a lower cost and lower constructability risk.

Nuclear Coordination

PJM further stated that it "anticipate[s] nuclear regulatory concern in approving this configuration" for Proposal 1A. Proposal 1A is a flexible alternating current transmission system ("FACTS") based solution. Similarly a component of the solution PJM has selected for Board approval is an SVC at New Freedom, also a FACTS device. Generally, FACTS devices provide advantages of capacity enhancement, power flow control, transient stability improvement, power oscillation dampening, and voltage stability; with a relatively small footprint as to environmental impacts. The Office of Interconnection has not provided an explanation as to why for the FACTS-based Proposal 1A represents a different nuclear regulatory concern as compared to the SVC that it has added to all proposals. Dominion High Voltage Proposal 1A satisfies all NERC and PJM Reliability Planning Criteria, including the NUC-001 which addresses nuclear regulatory concerns.

Proposal 1A TCSC Application

Although this application of TCSCs in Proposal 1A has not yet been implemented in the PJM region, these devices are used globally for power system transient stability and small signal stability as is shown in Table 1 below[3]. Dominion High Voltage's Proposal 1A presents similar

[3] As described in the DNV-GL report submitted with Dominion High Voltage response to PJM on Monday, June 2.

technical and operational risks as the Selected Ten. While the technical risk may be similar, aside from its lesser impacts to existing infrastructure and nuclear generating units; Proposal 1A, as measured by all other criteria considered by PJM, performs better than any of the Selected Ten. Proposal 1A has significantly lower costs, minimal land use and visual impacts, limited regulatory hurdles, no transmission line siting, no condemnation, and limited work at existing stations. Chiefly, as distinguished from each of the Selected Ten, Proposal 1A does not involve an interstate high-voltage transmission line river crossing.

A summary of current TCSC applications is provided in the table below.

Year	Country	KV	Appliction			Location	Source
			SSR mitigation	Post-contingency stability	Dynamic flow control		
1992	USA	230			✔	Kayenta substation, AZ	1, 2
1993	USA	500	✔		✔	C.J.Slatt substation, OR	1
1998	Sweden	400	✔			Stöde	1, 3
1999	Brazil	500	✔	✔		Imperatriz and Sarra de Mesa	1, 4
2002	China	500	✔	✔		Pinguo substation, Guangzhou	1
2004	India	400	✔	✔		Raipur substation	1, 5
2004	China	220	✔	✔		North-West China	1
2014	United Kingdom	400	✔	✔	✔	Hutton substation	6

Notes:

1. Maruf, Nasimul Islam, et.al. , *Study of Thyristor Controlled Series Capacitor (TCSC) as A Useful Facts Device*, International Journal of Engineering Science and Technology, Vol. 2(9), 2010, pages 4357-4360.
2. Jalali, J. and R. Hedin, *Thyristor Controlled Series Compensation (TCSC) Impedance and Linearized Models for Power Swing and Torsional Analysis*, Electric Power research Institute, May 1988.
3. Holmberg, D., et. al., *The Stöde Thyristor Controlled Series Capacitor*, Cigré 1998 Session, Paper 14-105.
4. Grünbaum, R. and Jacques Pernot, *Thyristor-Controlled Series Compensation: A State of The Art Approach for Optimization of Transmission Over Power Links*, ABB Power Systems, 2001.
5. *North – South 500 kV AC power interconnection: transmission stability improvement by means of TCSC and SC India*, ABB FACTS brochure, 2011.
6. *ABB's FACTS Solution to Facilitate Increased Power Flow from Scotland to England*, ABB UK, 2014.

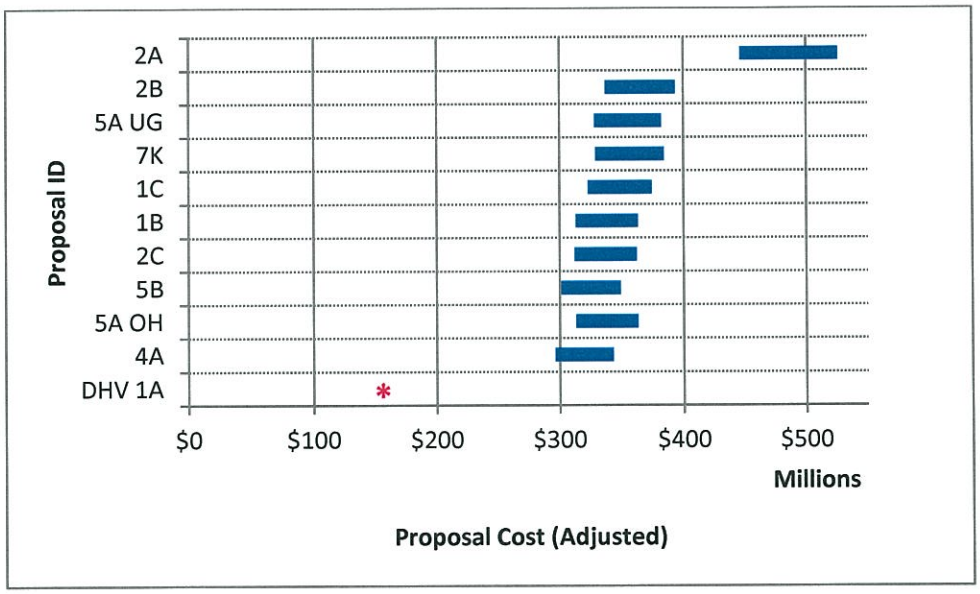
Permitting and Construction Schedule

As has been presented in other comments to the Office of Interconnection's recommended solution, obtaining the necessary property rights for construction of a new 500 kV transmission line will be difficult for any entity. Based on Dominion High Voltage's research and experience, acquisition of and permitting for new and expanded rights-of-way for a 500 kV line to include a new river crossing and extensive wetland impacts will be delayed significantly beyond the 51 months estimated by PSE&G.

Dominion High Voltage estimates completion of Proposal 1A within a 3- to 4-year period in part because of the limited real estate and permitting associated with the solution. Under a best-case scenario for each, Proposal 1A could be in service and improving performance in the Artificial Island Area at least two years ahead of the PSE&G proposal. Under more likely permitting conditions, Proposal 1A would be completed approximately five years in advance of other proposals.

Cost

The estimated cost for Proposal 1A as proposed was $133 million. Although no estimated cost was provided for PJM's modification of Proposal 1A to increase the size of the SVC, Dominion High Voltage estimates that the incremental cost will be $22 million, resulting in a $155 million estimated cost for modified Proposal 1A. PJM added an SVC with an estimated cost of $80 million to each of the Selected Ten proposals. Dominion High Voltage's modified Proposal 1A remains significantly less costly than any of the other Selected Ten, as depicted graphically in the chart below:



Comparative Advantages of Proposal 1A

In addition to its significantly lower cost, Proposal 1A has the following advantages over all or most of the Selected Ten:

- *Licensing, approval and construction times.* Proposal 1A can be completed two to five years earlier than any of the Selected Ten, allowing it to obtain savings from improved

market efficiency. This timing also more quickly eliminates the current risk of cross-tripping Salem Nuclear Power Plant Units 1 and 2.

- *Cross-tripping of Salem Nuclear Power Plant Units 1 and 2.* Proposal 1A will remove this risk two to five years earlier than any of the Selected Ten proposals can be placed in service.
- *Substation construction/reconfiguration.* The construction and reconfiguration of existing stations included in the Selected Ten open a risk of possible mishaps during construction and errors in relaying and coordination. Some of the Selected Ten proposals will require longer *outages and/or curtailments at Salem* Nuclear Power Plant for substation work. Proposal 1A, in contrast, makes no equipment changes at Salem station and only limited changes at Hope Creek station.
- *Permitting, licensing and approval*
    - *River crossing.* Each of the Selected Ten proposals includes an interstate river crossing that will likely cause long permitting and approval delays, with the submarine-crossing proposals likely to be approved more quickly than the overhead crossings. This river crossing may also impact shipping operations and other business interests likely to oppose the project. Proposal 1A does not include a river crossing.
    - *Transmission siting.* The Selected Ten have between three and 17 miles of overhead transmission line to site, and the longer-length proposals cross wetlands that may pose complications resulting in delays or difficulties in getting the siting approved. Proposal 1A does not require any transmission right of way.
    - *Agency approvals.* The number of approvals and agencies required will affect the risk of delays and increased costs. All the Selected Ten proposals require review by regulatory bodies at the local, state and federal level because of the river crossing, overhead transmission siting and significant substation work at the stations located at the nuclear generating plants in the Artificial Island Area. As described above, Proposal 1A has minimal land use and little impact on existing stations.

The primary benefits of Proposal 1A are that it meets the planning criteria with improved stability performance, has a relatively low cost and can be placed in service years before any of the Selected Ten.

The project that PJM is now recommending to the Board for approval is a new 500 kV line from Hope Creek to Red Lion plus a new SVC at New Freedom at an estimated cost of $291-337 million. This PSE&G proposal costs $136-182 million more than Modified Proposal 1A, estimated at $155 million, and will take a minimum of two years longer to complete. The Board should refer Dominion High Voltage's Proposal 1A back to the Office of Interconnection for full consideration of its benefits, at a minimum, in combination with the selected linear proposal to

accelerate the improvements to PJM's operational performance in the Artificial Island Area during the approval and construction periods for the selected transmission line and station technical solution alternatives. Dominion High Voltage continues to believe, however, that Proposal 1A fully addresses the planning criteria and performs better than any of the other Selected Ten proposals fully considered by PJM in the RFP, including the selected PSE&G proposal.

For all the reasons articulated above, Dominion High Voltage requests the PJM Board refer Proposal 1A back to the Office of Interconnection for full consideration of its substantial benefits over all considered alternatives.

Sincerely,

Scot C. Hathaway
Vice President, Transmission

cc: Michael Kormos, PJM
Steven Herling, PJM
Paul McGlynn, PJM

TCSC+SVC vs. 230kV+SVC

Compare TCSC + SVC (assumes +750 MVAR) alternative to 230 kV + SVC alternatives

Project	Project ID	TO	SVC location	AI 500kV bus voltage	AI MVAr output	Outage	Contingency	Maximum Angle Swing
230kV+SVC	P2013_1-5A-SVC	LS Power	New Freedom	1.032	645	5038	2a	**54**
	P2013_1-2B-SVC	Transource	New Freedom	1.040	645	5038	2a	**47**
	P2013_1-2A-SVC	Transource	New Freedom	1.042	645	5038	2a	**48**
	P2013_1-1B-SVC	DVP	New Freedom	1.037	645	5038	2a	**46**
TCSC+SVC	P2013_1-1A	DVP	New Freedom	1.029	645	5038	2a	**88**

(500kV to Red Lion + SVC) vs. (230kV + SVC)

Comparison Method:
For each proposal, assume the addition of an SVC at each of three locations. Simulate the combination of the most critical fault and outage.
Result:
Observe the maximum machine angle swing.
The AI-Red Lion 500kV+SVC options show marginally better performance than the 230k+SVC options.
All evaluated proposals with SVC noted below pass the stability criteria with greater margin than without SVCs.

500kV+SVC options

Project ID	TO	SVC option	AI 500kV bus voltage	Maximum Angle Swing
P2013_1-5B-SVC	LS Power	Artificial Island	1.040	77
		Orchard	1.040	98
		New Freedom	1.040	102
P2013_1-2C-SVC	Transource	Artificial Island	1.041	77
		Orchard	1.041	98
		New Freedom	1.041	101
P2013_1-1C-SVC	DVP	Artificial Island	1.041	76
		Orchard	1.041	96
		New Freedom	1.041	99
P2013_1-4A-SVC	PHI/Exelon	Artificial Island	1.041	78
		Orchard	1.041	99
		New Freedom	1.041	102
Various	PSE&G	In-progress, expected to be similar to above		

230kV+SVC options

Project ID	TO	SVC option	AI 500kV bus voltage	Maximum Angle Swing
P2013_1-5A-SVC	LS Power	Artificial Island	1.042	80
		Orchard	1.041	108
		New Freedom	1.041	112
P2013_1-2B-SVC	Transource	Artificial Island	1.042	81
		Orchard	1.042	105
		New Freedom	1.042	109
P2013_1-2A-SVC	Transource	Artificial Island	1.043	82
		Orchard	1.042	107
		New Freedom	1.042	112
P2013_1-1B-SVC	DVP	Artificial Island	1.042	85
		Orchard	1.041	106
		New Freedom	1.041	110