Artificial Island

Dominion High Voltage MidAtlantic

Projects:
P2013_1-1A
P2013_1-1C

TEAC – Finalist Presentation

December 9, 2014
• Dominion High Voltage MidAtlantic (DHVM) proposals selected as Artificial Island finalists

- P2013_1-1C – 500 kV Transmission Line
- P2013_1-1A – SVC/TCSC Solution
P2013_1-1C

500 kV Transmission Line
500 MVAR SVC
New Freedom

500 kV Line
Hope Creek to Red Lion

P2013_1-1C
500 kV Transmission Line
Project Scope: P2013_1-1C

- **Key Components**
  - Hope Creek to Red Lion 500kV Line – Approximately 17 miles
  - 500 kV 500 MVAR SVC at New Freedom

- **Estimated Cost**
  - $322 M to $372 M

- **Permitting & Construction**
  - Delaware River Crossing
  - Approximately 60 Federal, State and Local Permits
  - Total Project Schedule from PJM Approval – 75 Months

- **Partnership with PHI**
  - MOU with PHI provides 50/50 Partnership should PJM approve 1-1C
  - Provides Dominion access to LDV via PHI – reduces project costs and schedule risks for right of way acquisition
P2013_1-1A
SVC/TCSC Solution
Project Scope: P2013_1-1A

- **Key Components**
  - New 500kV Switching Station near New Freedom Substation
  - Seven 500 kV Breaker Installations at four existing substations

- **Estimated Cost**
  - $164 M to $174 M

- **Permitting & Construction**
  - New Substation in New Jersey
  - Approximately 25 Federal, State and Local Permits
  - Total Project Schedule from PJM Approval – 36 to 48 Months

- **Access to LDV not required**
Tie 500 kV Lines #5023 and #5024 together by constructing new eight-breaker 500 kV Transmission Switching Station near the New Freedom Substation, including

- One 750 MVAR SVC
- Two Thyristor Controlled Series Compensation (TCSC) Devices
- Eight 500 kV breakers
- High-security Control House to contain all controls and protection

Install a total of seven 500kV breakers at four Substations

- East Windsor – two
- Hope Creek – two
- New Freedom – two
- Red Lion – one
New Switching Substation

- 750 MVAR SVC
- Two TCSC Devices on Lines #5023 & #5024
- Connect Lines #5023 & #5024 with 8-breaker ring bus

SVC/TCSC Solution
## How will the TCSC Function?

<table>
<thead>
<tr>
<th>STATE</th>
<th>TCSC/SVC Response</th>
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</table>
| **NORMAL STATE**                     | The normal steady state of the **TCSC**’s will provide the following line compensation  
  • Line #5023 is at 40%  
  • Line #5024 is at 45%                                                                   |
| **FAULT OCCURS**                     | During a fault, the each **TCSC** controller will bypass the series capacitor in one cycle. The **TCSC** impedance becomes inductive to eliminate SSR and protect the capacitor from over-voltage. |}

### AFTER FAULT IS CLEARED – AREA OF CONCERN FOR ARTIFICIAL ISLAND

- The **TCSC** controllers will sense the change in power flow and reinsert the capacitor and boost the compensation to 90% on both lines 5023 and 5024.
- In the boosted mode, the **SVC** becomes electrically “closer” to the Artificial Island generators and contributes to the synchronizing torque by maintaining the scheduled voltage

### RETURN TO NORMAL

- After approximately 3 seconds in the boosted state, the **TCSC** controllers will move the series compensation back to 40% and 45% compensation
TCSC eliminates the risk of SSR

Proven Technology; TCSC is a part of the reputable FACTS family of devices

- Identical controls and components as SVCs
- Series compensation used worldwide to increase transfer capability of transmission lines and improve transient stability of power plants
- Multiple SVC’s in service today throughout PJM
- Two series capacitors have been in service for over 10 years on Bath County Power Station 500kV Lines to Lexington and Valley

PJM analysis presented at TEAC (Oct 2014) found the TCSC solution to be very robust, performing beyond the criteria for failure mode evaluation

Use of TCSC continues to grow worldwide to resolve stability and oscillation problems in a low-cost manner
Figure 5 shows a 500-kV AC feeder (on the left side), the transformers (three single-phase units plus one spare), the medium-voltage bus, and three thyristor-switched capacitor (TSC) banks, as well as the building that houses the thyristor switches and controls.

The SVC shown in Figure 6 is connected to the 420-kV Norwegian ac grid southwest of Oslo. It uses thyristor controlled reactors (TCR) and TSCs, two each, which are visible together with the 9.3-kV high-current buswork on the right side of the building.

Figure 7 shows photos of two 500-kV TCSC installations in the U.S. The platform-mounted valve housings are clearly visible. All (U.S.) has six equal TCSC modules per phase, with two valves combined in each of the three housings per bank.

Source: Siemens, Transmission & Distribution
## Option Comparisons

<table>
<thead>
<tr>
<th>Topic</th>
<th>Dominion 1A</th>
<th>Line Options</th>
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<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>$164-174 Million (total cost for SVC and two TCSC’s)</td>
<td>$ 291-382 Million (includes $80M for SVC)</td>
</tr>
<tr>
<td><strong>Stability Performance</strong></td>
<td>Solves Problem</td>
<td>Solves Problem</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>No river crossing</td>
<td>Significant wetlands</td>
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<tr>
<td><strong>Permitting</strong></td>
<td>25 permits, mostly routine</td>
<td>60 permits, very difficult</td>
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<tr>
<td><strong>Time to construct</strong></td>
<td>36-48 months</td>
<td>60-75 months. High risk of delays.</td>
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<tr>
<td><strong>Overall</strong></td>
<td>Robust solution, per PJM*, providing benefits as early as spring 2018</td>
<td>Reliable solution but significant schedule risk – 2020+</td>
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</tbody>
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* PJM statement, TEAC Oct. 2014 slide 45, “TCSC Outage and Failure Mode Evaluation” revealed stable operations for many “Beyond criteria” scenarios (i.e. N-3, N-1-2)
Costs for proposals 1A, 1C, and 2B taken from the supplemental responses to PJM.

Costs for 5A OH, 5A UG, and 7K taken from TEAC slides 6/16/2014.

All estimates include the cost of an SVC.
Advantages of P2013_1-1A Project

✅ **Construction** – significantly less impact; one new substation and limited work at others

✅ **Lowest regulatory risk** – significantly less permitting and land acquisition

✅ **Reduced overall project impact** to the PJM territory, New Jersey, and localities
  - Minimal land use impact and environmental issues
  - No transmission line siting; no River crossing
  - No condemnation

✅ **Dominion experience** with building and operating Series Compensating Devices

✅ **Shortest duration** for Project Execution and Commissioning; only 36-48 months

✅ **Earliest in-service date** of all proposals

✅ **Limited number of outages** required over a relatively shorter period of time

✅ **Lowest cost solution** $164 M to $174 M with least risk of cost overrun
  - Real estate and permitting accounts for only 5% of total project cost
  - SVC and TCSC estimates are cost capped – approximately 50% of total project cost
Artificial Island

DHVM Projects

P2013_1-1A
P2013_1-1C