Looking Forward: Dynamic Reactive Device Technologies

Power Electronic Devices vs. Synchronous Condensers

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Introduction

- Many voltage-related needs identified in Needs Assessments are addressed using dynamic reactive power devices
  - Today's meeting includes dynamic reactive power device proposals in New Hampshire and Upper Maine
- A few choices of dynamic reactive power device types exist
  - Static VAR Compensators (SVCs)
  - STATCOMs
  - Synchronous Condensers
- While one type may be the most cost-effective solution through the ten-year planning horizon, longer-term trends may be more favorable to another type

Scope of Today's Discussion

- For ongoing and future Solutions Studies and Transmission RFPs, the ISO agrees that long-term trends in the evolution of the power system need to be taken into consideration, in addition to the initial capital cost
- Today's discussion is not intended to revisit preferred solutions which have already been chosen
- Today's discussion is not intended to directly influence upgrades identified through resource/ETU interconnection studies

Background: STATCOMs & SVCs

- STATCOMs and SVCs are power electronic devices that regulate voltage by injecting current into the power system
- As a power electronic device, the current injected is not a perfect sine wave
  - Requires electromagnetic transient (EMT) analysis to evaluate interactions between SVC/STATCOM controls and other equipment
  - Introduces harmonics into the power system, requiring filtering for SVCs and some STATCOMs to reduce their injection to required levels
- Minimal contribution to short-circuit current
- STATCOMs typically have symmetric capability (same MVAR capability in the positive and negative directions); SVCs can be designed for any combination of positive and negative MVARs

Background: Synchronous Condensers

- Synchronous condensers are rotating mechanical machines with an excitation system that controls MVAR output
  - Very similar to a synchronous generator, but without a turbine to generate mechanical power
- Synchronous condensers create sinusoidal current, providing some advantages over STATCOMs and SVCs
  - Virtually no risk of control interactions between synchronous condensers and other equipment, no need for EMT analysis
  - Virtually no harmonics, and no need for filtering
- Synchronous condensers contribute short-circuit current and inertia, just as synchronous generators do
- Capability in the positive MVAR direction is often twice the capability in the negative MVAR direction (ex. +50/-25 MVAR)
- Attention to protective relays, such as reverse power, is necessary

Power Electronic Interactions

- Many renewable generation technologies expected to grow in the coming years are based on power electronics
  - Wind turbines: Type III use power electronics for DFIG controls, and Type IV use power electronics for all power conversion
  - Solar photovoltaic: inverters are based on power electronics
  - HVDC: inverters are based on power electronics
  - Battery energy storage: inverters are based on power electronics
- Decreases in short circuit strength combined with increases in power electronic generation will increase the potential for interactions between different power electronic devices

Effects of Decreasing Short-Circuit Current and Inertia

- Available short-circuit current and inertia will decrease as synchronous generators retire or operate less frequently
- Many problems beyond power electronic interaction can become more severe as short-circuit current decreases
  - System protection: faults become harder to detect, and additional communication between substations may be required
  - Transient stability: inertia can help to prevent system separation across major interfaces
  - Frequency control: inertia helps to maintain system frequency immediately following a system disturbance
- Synchronous condensers contribute both short-circuit current and inertia, and may help to mitigate all of these problems

STATCOM/SVC vs. Synchronous Condenser Costs

- Every installation is different; many factors besides technology choice can influence capital costs
  - Pre-existing site conditions
  - Need for substation expansion & additional equipment (breakers)
  - In-service date
  - Project status – proposed/planned estimates vs. actual costs
- Moving parts in synchronous condensers may cause higher operating & maintenance costs
- The following cost estimates are meant to give a rough comparison of the relative capital cost difference between STATCOMs/SVCs and synchronous condensers
- All capital costs are taken from the October 2020 RSP Project List update unless otherwise noted

STATCOM vs. Synchronous Condenser Costs

Location	Technology	Size	Cost	Cost/MVAR
Ascutney	SVC	50 MVAR	$32.2M	$0.644M
Tewksbury[1]	STATCOM	167 MVAR	$33.4M	$0.200M
Highland[2]	STATCOM	50 MVAR	$13.0M	$0.260M
Boggy Brook[2, 4]	STATCOM	50 MVAR	$37.9M	$0.758M
Shunock	Sync. Condenser	50 MVAR	$43.8M	$0.876M
Stony Hill	Sync. Condenser	25 MVAR	$22.2M	$0.888M
Saco Valley	Sync. Condenser	50 MVAR (2x25)	$21.8M	$0.436M
North Keene[3]	Sync. Condenser	50 MVAR	$36.2M	$0.724M
Huckins Hill[3]	Sync. Condenser	50 MVAR	$36.2M	$0.724M

[1] Source: Boston 2028 Solutions Study – Mystic Retirement – Preliminary Preferred Solution, August 27, 2020 PAC meeting
[2] Source: Upper Maine 2029 Preliminary Preferred Solutions, February 17, 2020 PAC meeting
[3] Source: New Hampshire 2029 Preliminary Preferred Solutions, February 17, 2020 PAC meeting
[4] The Boggy Brook cost estimate also includes new 115 kV breakers to expand the Boggy Brook substation

Discussion

- A STATCOM or SVC may satisfy a system need seen in 2030 – but may not be the best long term solution
- The ISO would like to move to using synchronous condensers as the preferred dynamic reactive device to address system concerns identified in Needs Assessments, unless specific system limitations cause the need for a different type of device
  - As an example, there may be some locations on the system where the addition of synchronous condensers may cause fault current levels that cannot be reasonably addressed until after existing synchronous generators in the area retire. In this case a STATCOM or SVC would be considered.

Feedback and Next Steps

- ISO-NE welcomes any additional stakeholder feedback on this point
  - Written feedback may be submitted to PACmatters@iso-ne.com by March 4, 2021
- Feedback received will inform ISO-NE as to whether to pursue power electronic devices or synchronous condensers for the solution alternatives presented today, as well as future transmission solutions