Life Extension Projects in Vermont

- Highgate Converter BTB HVDC Refurbishment (2009-2012)
- Essex STATCOM Refurbishment (2014 – Present)
HIGHGATE CONVERTER BTB HVDC REFURBISHMENT
Highgate Converter BTB HVDC Refurbishment

Reasons for Refurbishment

• Age of the equipment (26+ years)
• Lack of knowledge of control system industry wide
• Lack of spare parts
• Increased control system failures
• Increased utilization of the converter
• The desire to increase nominal import rating from 200 MW to 225 MW under max temperature rating (40°C)
• The desire for 30 more years of operation
• Upgrading of North Bus (HQ Side) for protection against TOV events
Highgate Converter BTB HVDC Refurbishment

Basic Ratings of the Converter - *Prior to Refurbishment*

- 200 MW Back-to-Back Interconnection between Hydro Quebec and VELCO
- Commissioned in 1985
- Recognized as the fastest constructed HVDC Substation from Drawing Board to Commissioning
- Continuous Overload Capacity of 225 MW rated (up to 30°C)
  - Due to the HQ System we are limited to 218 MW
- North AC bus is connected to the HQ System (120kV)
- South AC bus is connected to the VELCO system (115kV)
Highgate Converter BTB HVDC Refurbishment

Basic Ratings of the Converter – *After Refurbishment*

- Continuous Capacity of 225 MW rated (up to 40°C)
  - North to South
  - Requires transformer cooling fans and pumps
  - Requires 4 cooling towers in-service
    - 5th tower added for redundancy, does not increase power transfer rating

- Continuous Capacity of 170 MW rated (up to 40°C)
  - South to North (System not converter constraint)
Highgate Converter BTB HVDC Refurbishment

Controls & Protections

- One of the first HVDC digital control systems based on circa 1984 ASEA PLM language
- Limited options using today’s technology to continue to communicate and modify code when needed
- Increased failures of the control system resulted in deteriorated reliability and greater exposure for extended forced outages.
  - Control System A experienced four (4) complete stalls one (1) internal fault over the last year
  - Control System B experienced nine (9) stalls and three (3) internal faults over the last year
  - One event on the Control System led to both systems to fail resulting in a forced outage over this last year.
- Increased utilization of and reliance on the facility to serve load and ensure transmission network reliability.
**Note:** HVDC Control System

**Note:** Computer used to reset local alarms.

**Note:** New Control Desk
Highgate Converter BTB HVDC Refurbishment

Valve Hall Equipment

- Original oil-filled snubber capacitors replaced with SF6/Nitrogen filled
- Spare thyristors from storage were purchased and placed into service for verification of operation under warranty period
- Thyristor Control Units were all replaced with standard technology which provided additional information back to the control system

**Note:** Oil Filled Snubber Capacitors

**Note:** New TCU’s and SF6 Filled Snubber Capacitors
Highgate Converter BTB HVDC Refurbishment

Conclusions

• Reliable and safe service for the next 30 years
• Allow for operation of 225 MW up to 40°C
• Intelligent dynamic runback controls
• Protection from TOV conditions on the North Bus
• Reduction in maintenance costs
• Reduction in forced outages
• Increased associate knowledge of the Converter
Essex FACTS Life Extension Project

Background

• Commissioned in 2001

• Rated for -65 MVAR/+85 MVAR
  – Additional 24 MVAR Shunt Capacitors Banks available for Offset
  – One 24 MVAR Shunt Capacitor Bank required due to TIFF issues

• Consist of two independent STATCOM units
  – Each STATCOM contains:
    • 3 Inverters (+/- 12.5 MVAR Each)
    • 1 Non-switchable 5 MVAR Filter Bank
    • Upgraded from GTO to GCT technology in 2004

• Installed to provide dynamic system voltage support during heavy load conditions coincident with outages of transmission or other transmission equipment

• Provide continuous steady state voltage regulation and power quality improvement for the Vermont Transmission System
Essex FACTS Life Extension Project

Reasons for Refurbishment

• Compromised reliability and availability as a result of the following:
  – Obsolescence of the hardware and operating system software
  – Aging digital firing control boards and electronics
  – Increasing cost and longer wait times for spare parts
    • Not possible to identify alternative suppliers apart from the OEM for the critical equipment.
  – Increasing numbers of callouts to service mostly minor items
  – Cooling Related Issues
    • System leaks and inadequate design resulting in requiring outages for servicing equipment
    • The cooling system is comprised of a mixture of deionized water and ethylene glycol which is regulated by the state of Vermont and cause environmental issues and long term health issues for service staff
Essex FACTS Life Extension Project
Scope of Work

Vendor
- Inverter Equipment Replacement
- Cooling System Replacement
  - New Efficient Cooling Towers
  - Replacement of Ethylene Glycol with Propylene Glycol
  - New Cooling Controls and MCCs
- Control & Protections
- Replacement of HVAC system and addition of redundancy to valve halls
- Address known TIFF issues
- Address know issues with extended gateblocks due to overcurrent and DC Capacitors
- Studies

VELCO
- Fire System Upgrades
  - Consolidate Vendors
  - Bring up to Code
  - Properly protect equipment from GE
- Building/Storage Upgrades
  - Waterline added to upper yard to aid in cleaning HVAC units and Cooling Towers
- Transformer Upgrades
  - Addition of DGA
  - Swap In-Service Interface Transformer with Spare Interface Transformer
Essex FACTS Life Extension Project

Conclusions

- Reliable and safe service for the next 35 years
- Reduction in TIFF interference issues
- Reduction in Extended Gate blocking due to Overcurrent and DC Capacitor Charging
- Reduction in maintenance costs
- Reduction in forced outages
- Increased associate knowledge of STATCOM Technology