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HVDC Operation and Maintenance

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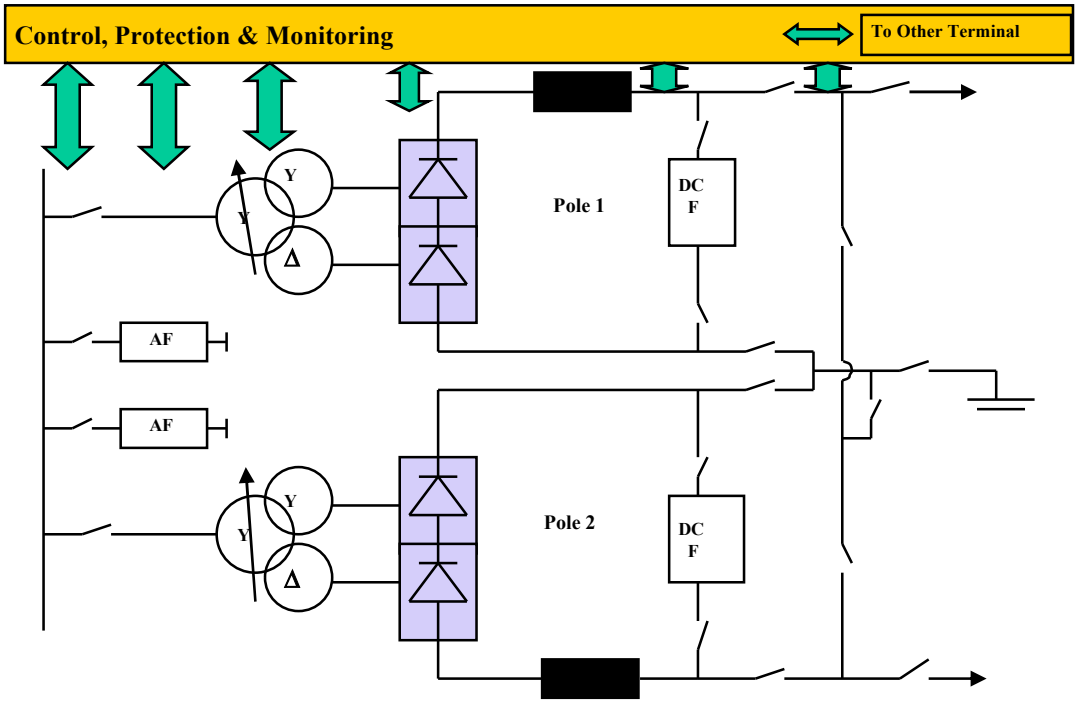
Technology Overview

- Line commutated converter LCC based on the thyristor valve technology
- Voltage source converter VSC based on the Insulated Gate Bipolar Transistor IGBT

LCC HVDC Station Equipment



LCC HVDC Station Equipment

- CONVERTER TRANSFORMERS
- THRYISTOR VALVES
- AC FILTERS
- DC FILTERS
- DC SWITCHGEAR
- SMOOTHING REACTORS
- DC MEASURING DEVICES
- VALVE COOLING
- AUXILIARY POWER SYSTEMS
- CONTROL AND PROTECTION
- TELECOMUNICATION

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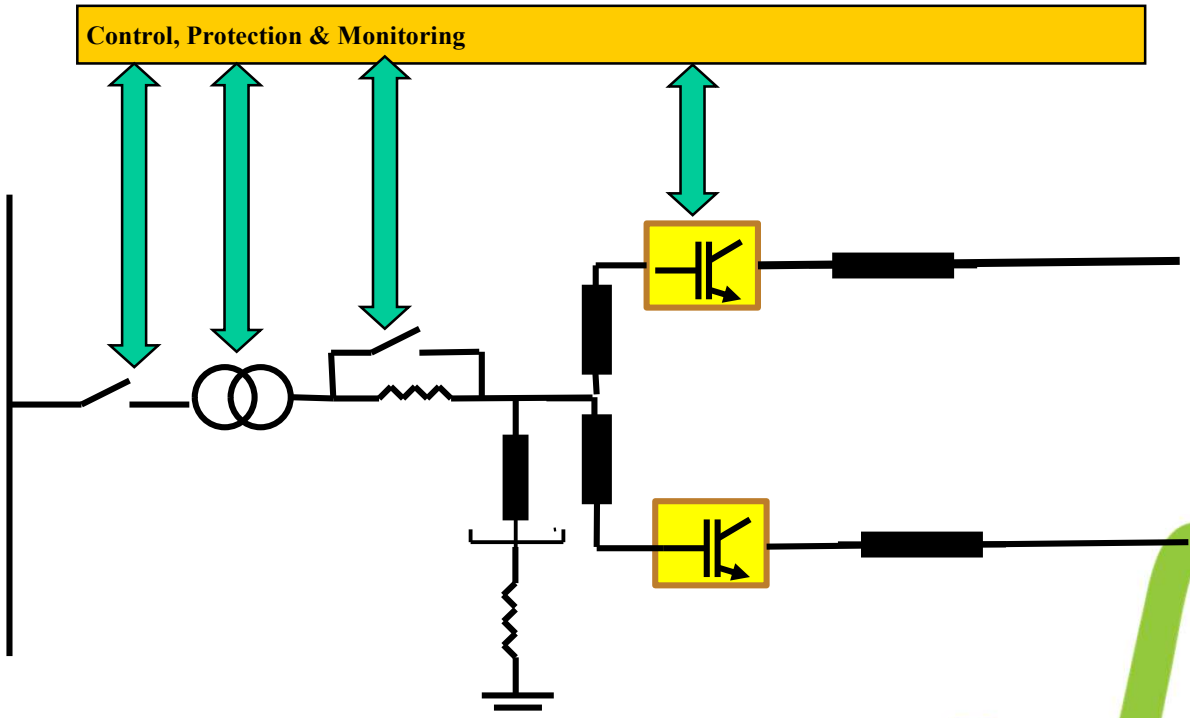
VSC HVDC Station Equipment



VSC HVDC Station Equipment

- TRANSFORMERS
- Phase reactors
- Charging resistor
- VALVES
- DC SWITCHGEAR
- SMOOTHING REACTORS
- DC MEASURING DEVICES
- VALVE COOLING
- AUXILIARY POWER SYSTEMS
- CONTROL AND PROTECTION
- TELECOMUNICATION

HVDC Life expectancy

Equipment	Life expectancy (years)
Valves	35-40
Transformers	35-40
Reactors (based on air core type)	30-35
Filter Capacitors	25-30
Filter resistors	35-40
Circuit breakers	35-40
Control and protection	15-20
Scada/RTU	10-15
DC switchgear	35-40
Valve cooling	30-35
Charging resistor	35-40
Batteries	15-20

Factors Impacting Reliability and Availability

From a performance perspective, the forced energy unavailability, the number of outages per year and the duration of outages depend on many factors:

1. Proper specifications
2. Proper design
3. Level of redundancy
4. Major spares availability
5. Spares availability

Factors Impacting Reliability and Availability

6. Speed of response
7. Training
8. Experience
9. Manufacturers support
10. Good documentation
11. Cooperation between utilities, TSOs and owners

OPERATING STRATEGY

- **UNMANNED**
  - **NO PERSONNEL AT THE CONVERTER STATION DURING NORMAL OPERATION**
  - **ALL SWITCHING AND CONTROL FUNCTIONS PERFORMED REMOTELY FROM CONTROL CENTRE.**
  - **CONTROL CENTERE WILL INITIATE APPROPERIATE ACTION IN CASE OF ALARM.**

OPERATING STRATEGY

- **MANNED**
  - **THERE ARE ADDITIONAL OPERATORS AT THE STATIONS**
  - **MAY ONLY BE DURING THE DAY OR 24 HRS.**
  - **POWER CONTROL IS NORMALLY DONE FROM MAIN CONTROL CENTER**
  - **IN EMERGENCY THE LOCAL OPERATOR CAN DO THE POWER CONTROL**

MAINTENANCE PHILOSOPHY

- **CIGRE PROTOCOL (TB-590) CLASSIFIES MAINTENANCE AS**
  - **PLANNED MAINTENANCE**
  - **DEFERRED MAINTENANCE**

- **PLANNED MAINTENANCE**

ALL MAINTENANCE TASKS PERFORMED AS PART OF LONG TERM MAINTENENACE PROGRAM ARE CLASSIFIED AS PLANNED MAINTENANCE

PERFORMED AT REGULAR FIXED INTERVALS

HVDC Projects in Canada

Long Distance

- **Lower Churchill New Foundland LCC**
- **Maritime Link between New Foundland and Nova Scotia VSC**
- **Hydro Quebec to New England LCC Multi-terminal**
- **Nelson River LCC**
- **Alberta HVDC links (WATL and EATL) LCC**
- **Vancouver Island LCC**

Nelson River HVDC System

- Three bipoles
- Bipole 1 rated for 1660 MW at +/- 450 kV (1972-1977)
- Bipole 2 rated for 2000 MW at +/- 500 kV (1978-1985)
- Bipole 3 rated for 2200 MW at +/- 500 kV (2018)
- The average forced energy unavailability for bipole 1 between 2013 and 2018 is 1.3%
- The average forced energy unavailability for bipole 2 between 2013 and 2018 is 0.52%
- In Nelson River, series converters are utilized. Which is not typical for HVDC projects except for large 800 kV or 1100 kV projects
- The system is designed to operate Bipoles 1 and 2 on one bipolar dc line(3500MW), and bipoles 2 and 3 on one bipolar line (4000 MW)
- Bipoles 1 and 2 operated in this mode in 1996 during an emmergency

Nelson River HVDC System

- Why HVDC for Nelson River

1. Economics
2. This is isolated generation HVDC link. Meaning there are no customers connected to the sending end ac busbar. Therefore, the receiving end has the benefit of many stability controls
3. Interconnections with neighboring systems

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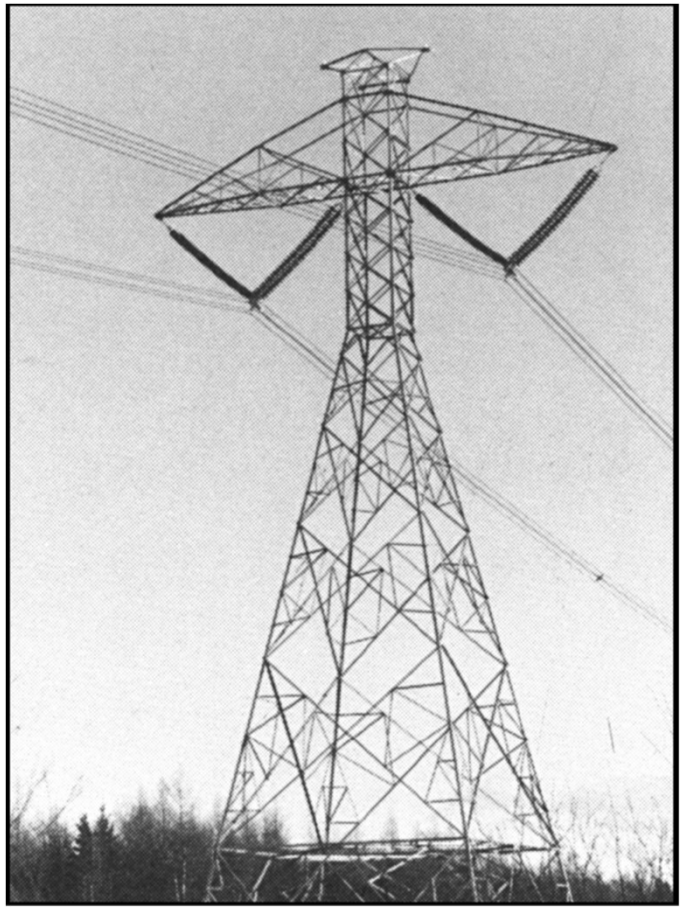

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Thank You

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