

Question 1.6:

These papers raise interesting points on the aging of HVDC assets.

- What is the worldwide experience in refurbishing HVDC assets with manufacturers other than the original manufacturer? What are the obstacles for a vendor to refurbish an HVDC asset from another vendor?
- What is the refurbishment experience in VSC HVDC systems? Please state the main items replaced, refurbished, and the age of the assets.

Hitachi Energy has performed upgrades and refurbishments for the following HVDC projects originally delivered by other vendors.

1. Square Butte (United States)

- scope: control and protection system including VBEs
- refurbished in 2004 after 30 years in operation

Light guides to the valve turned out to be very “stiff” and could only be moved a few centimeters, which made it necessary to design the new VBE enclosures (called valve triplets in SqB) with the exact same dimensions as the original.

Suspected asbestos isolated cables were found during the refurbishment work, which required special precautions before the removal.

More info on this interesting refurbishment project can be found in [1].

2. Apollo Station (Republic of South Africa) in the Cahora Bassa HVDC link

- scope: control and protection system, outdoor valves, and filter banks
- upgraded in 2008

The valves of Cahora Bassa are of a very special design. The original valves were oil-cooled, and oil-insulated double valves arranged as 6 pulse groups, 24 double valves in total. These were replaced with outdoor valves in 6-pulse enclosures using air-insulated water-cooled valves.

The installation was carried out on two 6-pulse groups at a time with the rest of the station in operation. This required very careful planning and logistics.

More details on this interesting refurbishment can be found in [2].

3. Chateauguay (Canada)

- scope: control and protection system including VBEs and light guides (VBEs moved out from the valve hall)
- refurbished in 2009 after 25 years in operation

This is a project where the original VBE design really lived up to the name Valve Base Electronics. The VBE units were mounted at the base of the standing valves inside the valve hall. In that location it was of course impossible to perform any maintenance or measurements on the VBE during operation. To allow simple maintenance in the future, part of the scope of the upgrade was to provide new VBE's placed outside the valve hall. This of course also required the installation of new and longer, low loss optical fibers.

4. Eel River (Canada)

- scope: control and protection system and thyristor valves
- refurbished in 2014 after 42 years in operation

5. Madawaska (Canada)

- scope: control and protection system and thyristor valves
- refurbished in 2016 after 31 years in operation

6. KontiSkän 1 (Denmark, Sweden)

- scope: control and protection system including VBEs, also adding bipole control, which had not been supplied in the earlier KontiSkän 1 delivery
- refurbished in 2019 after 11 years in operation

This refurbishment was done in conjunction with the refurbishment of KontiSkän 2 (from 1988), but only KontiSkän 1 is from a different manufacturer.

No major obstacles were encountered for these refurbishments, but the main complication for all, as for many old projects, is the availability and accuracy of the documentation, typically wiring and cabling information.

If documentation is insufficient or unreliable, very detailed site investigations must be carried out to establish the interface points for the new C&P system, otherwise there is a great risk of prolonged outage times.

Hitachi Energy has performed upgrades and refurbishments for the following VSC projects.

1. Direct Link (Terranora) (Australia)

- scope: control and protection system including VBE
- refurbished in 2019 after 19 years in operation

2. Murray Link (Australia)

- scope: control and protection including VBE
- refurbished in 2020 after 18 years in operation

3. Cross Sound (United States)

- scope: control and protection system including VBE
- refurbished in 2022 after 20 years in operation

4. Borwin 1 (Germany)

- scope: control and protection system including VBE
- refurbished in 2022 after 13 years in operation

Bibliography

1. Bjorklund, H. "Upgrading the Control System of the Square Butte HVDC Transmission" (Paper 214, CIGRE Osaka Symposium, November 2007)
2. Goosen, P.; Reddy, C.; Jonsson, B.; Holmgren, T.; Saksvik, O.; Bjorklund, H. "Upgrade of the Apollo HVDC Converter Station" (Paper 107, Cigré 6th Southern Africa Regional Conference, August 2009)