

SwePol HVDC Link

Bernt Abrahamsson, ABB, Sweden
Leif Söderberg, Swedpower, Sweden
Krzysztof Lozinski, PPGC, Sweden

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1. SUMMARY

SwePol Link is the latest and certainly not the last of the High Voltage Direct Current (HVDC) links between the Nordic countries and the continent. SwePol Link ties the 400 kV grids in Poland and Sweden together by means of 245 km long cables. SwePol Link's most unique feature is the absence of sea electrodes, for the first time cables are used to carry the return current rather than using earth return.

2. BACKGROUND

In November 1995 Vattenfall the Swedish State owned power producer signed a Power Purchase Agreement (PPA) with its Polish counterpart Polskie Siece Elektroenergetyczne SA, the national Polish power Grid Company, PPGC. The PPA's intention was to optimize utilization of the generating facilities the two countries possess. Sweden, like the other Nordic countries relies heavily on hydropower while, Poland almost entirely uses coal to generate electricity. Being hydro based, the weather strongly influences the power production and price in Sweden, which can be balanced by the steady fossil, fueled production in Poland. Also, there are peak load differences that may be accommodated by power transmission between the two countries.

SwePol Link AB a dedicated company, was formed by Vattenfall, PPGC and Svenska Kraftnät, the national Swedish power grid authority, to construct, maintain and operate a 600 MW HVDC link between Karlshamn in Sweden and Slupsk in Poland. On July 23, 1997, two contracts were signed with ABB to supply, install and commission the submarine cable in the Baltic Sea along with two converter stations. The transmission link entered commercial operation in June 2000.



Fig. 1 SwePol Link map.

3. TRANSMISSION SYSTEM

SwePol Link was planned as a monopolar HVDC system with earth return. In spite of the very small environmental impact shown at similar systems already in operation, local opinion persuaded the owner to add a metallic return path consisting of two cables in parallel making SwePol Link the first monopolar system with metallic return.

The link connects the 400 kV grids in the two countries by means of a 245 km long mass impregnated cable operating at 450 kV DC, plus two polymer insulated cables rated 20 kV (in parallel) for the return current. The cables are extended from the coastline all the way to the converter stations therefore eliminating the need for overhead lines. The system is grounded at one point - in the valve hall at Stårnö, the Swedish converter station.



Fig. 2 Installation of seacable.

Under sea the cables are buried approximately one meter to avoid damage caused by anchoring or trawling. During the cable laying water jet technique was used wherever possible, (85% of the total length). The high voltage cable was laid separately with a physical separation of 3 to 43m to the two return cables. The high voltage cable has an outer diameter of 140mm and has double crosswind armoring to withstand the mechanical stresses during cable laying. Due to the length of the cable it was manufactured in four sections and joined on board the laying ship.

The rated capacity of SwePol Link is 600 MW, with 20% overload capacity at low ambient temperature and 10% overload capacity at any ambient temperature when redundant cooling is available. The converter stations use ABB's classic and well-proven current stiff technology, which has proven its reliability since the introduction in 1954. Today performance has been largely improved through the introduction of different features (see below) and advanced control functions.

The converter valves are located inside the 20 m high valve halls. The transformers are located just outside the halls with the valve side bushings protruding through the walls.

Single-phase three winding transformers are used. There are 66 thyristors in each single valve. The valves are cooled using a water/ glycol mixture in the single circuit system.



Figure 3 Valve hall.

4. ENVIRONMENTAL CONCERNS

Earlier HVDC transmissions across the sea have used seawater and earth to carry the return current by an electrode connected to the station low voltage bus. The impact on the environment has been thoroughly discussed in the past and has been concentrated to the following issues:

- Magnetic field in the vicinity of DC cables
- Chlorine generation at the positive electrode
- Corrosion on metallic objects in the water or buried in the ground

Through the introduction of a metallic return path there are no longer concerns regarding chlorine formation or corrosion. While the magnetic field around DC cables is still present, it has been reduced. With the cable laying technique employed it was not possible to lay the return cables at the same time as the high voltage cable. Therefore physical separation had to be kept, which is also necessary because of thermal consideration during operation.

At a distance of 10m from a single DC cable, the intensity of the earth's natural magnetic field is greater than the field of the cable. With the introduction of the two return cables the magnetic field on the surface is typically reduced by 20% in shallow waters and 50% at a depth of 100m. While the magnetic field is still there, no adverse impact on marine life has been found, nor is modern navigation dependent on magnetic compasses.

5. TECHNICAL FEATURES

To avoid combustible material in the valve hall ABB has developed a dry type, high voltage transformer bushing. One SwePol link transformer unit is equipped with two such bushings, as a reference installation. The insulating medium used on the valve side of the bushing flange is sulphur hexafluoride (SF₆). The operating experience to date is excellent, promoting the use of this bushing type for future projects.

One 95 Mvar filter meets the requirements on harmonic filtering with four branches. There are two branches tuned to the 11th and 13th harmonic plus two branches of high pass type tuned to the 24th and 36th harmonic. To satisfy the demand for reactive power there are also two 95 Mvar shunt banks. In addition there is a 117 Mvar shunt reactor on the Polish side.

The two sharply tuned filter branches employ the ConTune™ reactor. The control winding of this reactor allows continuous adjustment of the reactor inductance. Thereby perfect tuning of the filter is maintained at all times, irrespective of network frequency excursions and variations in ambient temperature. The reactor has no moving parts permitting a high quality factor and low filter loss.

The control system continuously monitors the filter current and AC bus voltage for the harmonic of interest. The regulating direct current fed to the control winding of the reactor is adjusted to minimize the impedance of the filter.

The Compact switchgear is employed to save space in the switchyard. The switchgear is used for switching the reactive banks and consists of conventional switchgear units mounted on a common platform. The number of units may vary between applications. The Compact units for SwePol Link comprises of one SF6 breaker, one disconnecter, one earthing switch and one Optical Current Transducer (shunt capacitor banks only). The OCTs are used for differential protection purposes. A core-and-coil assembly mounted on high potential monitors the bank current. The signal is digitized and transferred to ground with fiber optics. The measurement is fast and accurate enough to avoid protective actions at bank connection, which cause transients of high frequency.

Thyristors of high voltage rating, 9 kV, are used in the converter valves. With the introduction of gas insulated snubber capacitors and PVDF pipes in the water-cooling circuit, no combustible material exist in the valve halls.

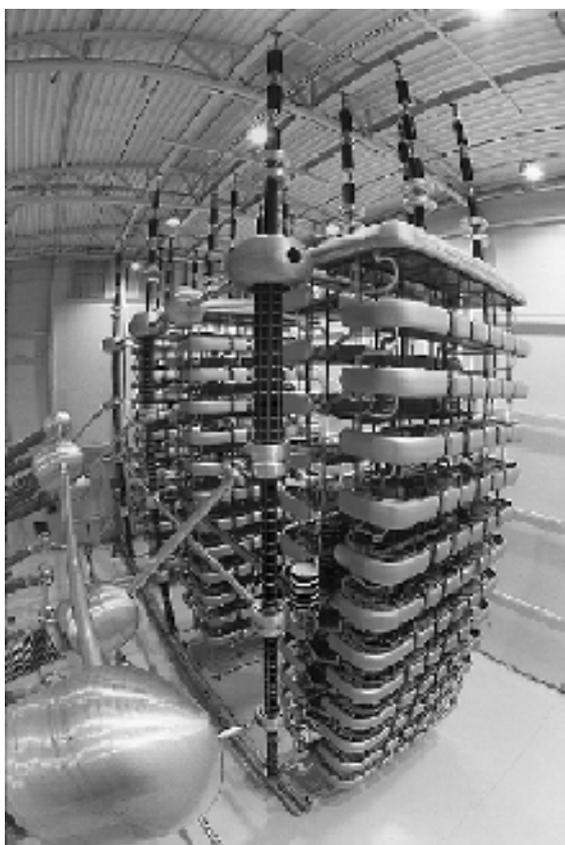


Fig. 4 Interior of valve hall.

ABB's recently developed MACH 2 control system is used to control, monitor and protect SwePol Link. This highly integrated system uses commercially available hardware and software to a great extent. Running under Windows NT, the main computers handle the operator's interface, event recording and transient fault recording along with controlling the converter process itself. Industry standard serial busses (CAN, TDM) are used for the communication between the main computers and the main circuit I/O cubicles.

The normal control mode is power control. Power modulations such as frequency control and emergency power control (EPC) are included. The settings of these modulations can easily be changed by the utilities. The frequency control is typically activated outside the range 50 ± 0.1 Hz. There are a number of activation criteria for the emergency power function, typically a frequency drop below 49.5 Hz results in an EPC support, which at present is limited to 300 MW.

Telecommunication between stations is operated through one dedicated leased line and a back-up dial-up channel. During loss of telecommunication the link will continue to operate in back-up synchronous mode. Then the actual current is used as current order by the power regulator in the inverter.

5. OPERATION

The converter stations are normally unmanned, the operation is controlled by dispatch centers at Stockholm and Bydgoszcz. However, local control can be taken from the control rooms in the converter stations.

It is anticipated that the link will be primarily used by Vattenfall to export power to meet the growing demand in northern Poland, where consumption is expected to rise by 10 percent within the next five years. Vattenfall plans to export 1.5 percent of the annual Swedish production to Poland using SwePol Link. To date the main power direction has been Sweden to Poland. The link has been in almost constant use during weekdays, while at weekends, the link is mainly used during daytime.

Any transmission capacity in excess of the PPA is available to the market. There are no restrictions from the owners on which party may purchase available transmission capacity from SwePol Link AB. Power deals on short, medium or long-term basis may be contracted as complement to the PPA.