First-class service

Service and upgrades lengthen HVDC equipment lifetime and maximize performance

ANNA JANSSON, HANS BJÖRKLUND – High-voltage direct current (HVDC) transmission links are being used all over the world to efficiently and cost-effectively transmit large amounts of power from generators to distant centers of consumption. But such links represent significant investments for the utilities who own them. Also, HVDC assets typically have an expected lifetime that runs into decades. These two aspects of HVDC mean that properly servicing and upgrading these assets is of major importance. ABB has extensive experience with HVDC service – covering regular maintenance and support as well as major service and upgrades. Control system upgrades, which can be done with a relatively short system outage, are, in particular, an efficient way to prolong the high performance of an HVDC link. Service, maintenance and upgrades have been applied by ABB in many cases to maximize output, increase functionality and extend the lifetime of HVDC assets.

1 ABB has many years of experience in HVDC and has maintenance and service agreements with many HVDC systems operators.

When an HVDC transmission asset has a lifetime of many decades, then very often newer, better technology has come along by the time the asset has reached the middle of its expected lifetime. Carrying out an upgrade at this point can add many years to the asset's lifetime as well as further increase its availability and reliability. ABB has a long experience with HVDC and is trusted by many operators of HVDC systems with maintenance and service agreements → 1. One recent example of a long-term service undertaking that typifies this sort of arrangement is found in the Estlink 1 HVDC Light project, where ABB has been providing services since the commissioning of the link in 2006.

These consist of:
- HVDC converter station operation support, eg, weekly inspection of unmanned stations
- Regular preventive and corrective maintenance
- Annual planned maintenance
- 24/7 standby
- Spare parts and other additional services
- Control system maintenance

Title picture
HVDC equipment, like this converter station in Finnböle, Sweden, represents a significant investment. Servicing and upgrading can ensure that the operator gets the most out of the equipment as well as extend its life.

Assessments maximize system lifetime and reduce downtime

In order to put a coherent service and upgrade plan in place for HVDC equipment, it is usually necessary to perform a lifetime assessment of certain systems or items of equipment. Such an assessment is available for all HVDC-specific equipment provided by ABB – eg, converter transformers, thyristor valves, IGBT valves and control equipment. Similar assessments can also be carried out on conventional AC equipment included in the HVDC scheme – eg, breakers, disconnectors, filter reactors and cables → 2. These assessments provide the owner with a firm foundation upon which planning for future upgrades, service and operation can be based.

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Midlife upgrades of HVDC installations

When built, most HVDC installations had a long operational life - typically 30 years – as a design target. When the end of this design life nears, it often turns out that the installations are still running very efficiently and delivering substantial economic benefit to their owners. Often, many important parts – usually representing the bulk of the investment – are still in good working order and can be used for many more years to come. Examples of these are overhead lines, cables, buildings, switchyards and transformers. When elements of these assets, such as breakers, parts of a cable or single-phase transformers, fail, they can often be replaced on component basis. However, there are some parts of an HVDC installation that need to be viewed as an integrated system and for these it is advantageous to look at a more coordinated upgrade activity.

Upgrades of control and protection systems

The lifetime of an HVDC control and protection system can be expected to be at least 30 years. The actual life is often longer, perhaps 40 years, but for installations that will operate for 50 to 60 years it is wise to plan for one replacement of the

2 Breakers at Porto Velho HVDC station

3 Control and protection upgrades

Station	Year commissioned
New Zealand pole 1 and 2	1992
CU	2004
Square Butte	2004
Sylmar converter station, Pacific DC Intertie	2004
Skagerrak 1 and 2	2007
Apollo converter station, Cahora Bassa HVDC link	2008
Blackwater	2009
Chateauguay	2009
IPP	2010
Highgate	2012
FennoSkan 1	2013
The following stations are currently being prepared for control upgrades:	
Eel River	2014
Skagerrak 3	2014
Inga Kolwezi	2014
Celilo converter station, Pacific DC Intertie	2015
Quebec New England multiterminal HVDC	2016-17

control equipment during the lifetime of the plant – perhaps after about 20 to 35 years. In this way, an optimal return on investment for the new controls can be achieved. If the plan is to retire the complete plant after 40 years, the control equipment can most likely be used during the entire operational lifetime of the plant if the spare part supply is monitored closely during the last years of operation.

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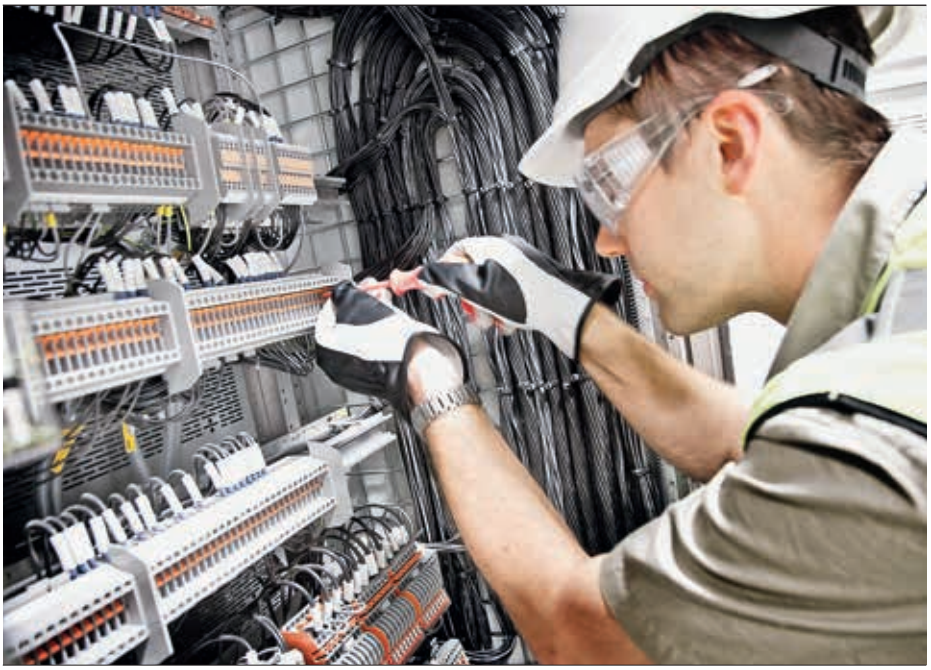
These assumptions are supported by data from the large number of plants around the world that have long service histories and by the different reasons for upgrading their control and protection systems.

A complete control equipment upgrade essentially means replacing the brain of the converter; this will inevitably result in power transmission being interrupted at least for one pole at a time. The cost of this period of unavailability may be as much as, or higher than, the actual upgrade and ABB has therefore focused both the design of new control and protection systems and the organization of the upgrade work on keeping outage times to a minimum.

One example of this type of work is the recent successful upgrade and testing on Great River Energy's CU HVDC project – a 1,000 MW / ±400 kV DC bulk power transmission corridor between Underwood, North Dakota and Dickinson, Minnesota, that was built and commissioned by ABB in 1978. Here, the controls were changed with just a two-week outage of one pole at a time while the other pole of the bipole was running. Thus, the complete bipole could be upgraded in one month, during which time the HVDC link could still carry 50 percent of its rated power.

In the Intermountain Power Project (IPP) in the United States, commissioned in 1986 to bring power from a 1,600 MW coal-fired generating plant in Utah to Southern California, a similar approach was used but here a three-week outage per pole was needed because not just the control system, but also the valve cooling and the transformer cooling sys-

4 MACH control system



tems were upgraded to handle higher powers.

In Skagerrak 1 and 2 – HVDC links between Norway and Denmark – a different approach was used because maintenance work on the overhead line was needed and this required a bipolar outage. A three-week bipolar outage was planned, but the installation activities went very smoothly and power transfer was restarted after an outage of just 15 days.

There are many such examples of completed control and protection upgrades → 3. ABB's long experience in HVDC and the very advantageous structure of the MACH control system → 4 stands ABB in good stead when such upgrades are executed.

Thyristor and IGBT valve upgrades

Remarkably, most of the HVDC thyristor converters ever supplied by ABB/ASEA are still in operation. From the technical data available, it can be concluded that the lifetime of a thyristor valve is very long, probably around 50 to 60 years.

Because thyristor technology has advanced so dramatically in the last 40 years, replacing an old thyristor valve with a new one may be a good business proposition for the customer, resulting in life extension, lower losses and decreased maintenance. ABB has a leading position in this area and has conducted valve upgrades in the Sylmar, Apollo, Inga and Kolwezi converter stations. Future valve upgrades are being prepared for the Eel River and Celilo HVDC converter stations.

So far, IGBT valves (the successor to thyristor valves) have only been in operation for 15 years. In due course, upgrades of IGBT valves will be available in ways similar to that of thyristor valves.

The further development and improvement of ABB's HVDC service product portfolio is very important and is an ongoing exercise. For example, ABB is placing great emphasis on Web-based systems that speed up support and service information exchange between customers and ABB. Further, an annual users' conference (celebrating its 21st anniversary this year) ensures that customer feedback is clearly understood and mutual proposals for service improvements can be heard. These and many more measures that enhance upgrades and service ensure a commitment to quality throughout the entire life cycle of a product.

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