HVDC Light®

Grid friendly and ecological technology

Five applications that show the 'power' of ABB's innovative technology

Gunnar Bennstam, Lennart Carlsson

What could be more relaxing than a weekend country break, especially after a stressful week of work in the city. Unfortunately, many country landscapes are losing their appeal mainly because of the need to meet increasing energy demands.

While the transmission of electrical power has, in general, low environmental impact, the same cannot be said for the infrastructure needed to carry this power. The sight and increasing volume of voltage overhead transmission lines is forcing landscapes and valuable land to pay a very high price.

Besides many people are increasingly concerned about the possible health risks of living close to these lines. The growing interest in wind power generation is often discouraged because where the wind blows most, the existing infrastructure, ie, the AC-grid, cannot receive the increased production. Building new and more powerful overhead lines is no longer an acceptable solution.

ABB, on the other hand, has a very acceptable and well-proven solution: HVDC Light®. HVDC Light is based on voltage sourced converters (VSCs) and insulated gate bipolar transistors (IGBT). Combined with ABB's HVDC Light cable, this VSC based transmission system offers unique opportunities to overcome many disadvantages previously associated with environmentally friendly sources of electrical power. A journey around the globe to several installations will help better understand the sustainable benefits created by ABB's HVDC Light technology

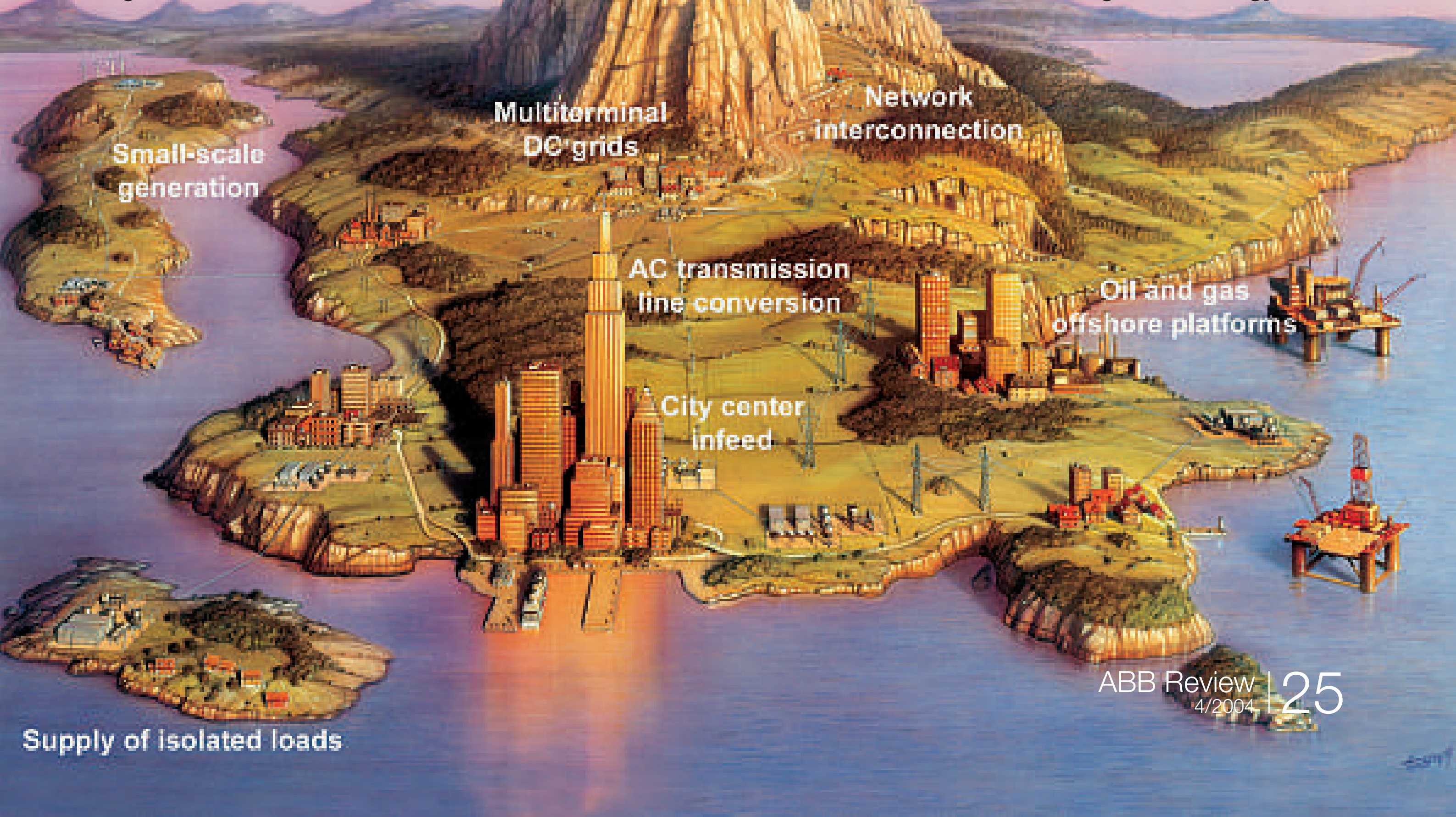

ABB Power Systems has been the world leader in high voltage direct current (HVDC) transmission for over 50 years. In particular, ABB's Ludvika plant in Sweden has overseen the emergence of many major power transmission technologies over the last 110 years. One of these, HVDC Light®, was developed some 10 years ago with the aim of increasing the capacity and reliability of electricity supply systems.

HVDC Light is based on voltage source converters (VSC) with insulated gate bipolar transistors (IGBTs) linked together by underground (or subsea) cables. It improves the stability and reactive power control at each end of the network and it can also operate at very low short circuit power levels.

The HVDC Light cable is made of polymeric material and is therefore very strong and robust, as well as being specifically adopted for direct voltage. These DC underground cables provide significant advantages compared with overhead lines including:
- Reduced risk of damage from natural causes such as storms, icing, wind, earthquakes and fire
- No need for constant trimming and removal of re-growth vegetation
- Considerable cost savings to the community in terms of amenity, property values and possible health risks.

In other words, the installation of a DC cable has little or no environmental impact. There is virtually no magnetic radiation associated with the bi-polar DC cable as the magnetic fields from the positive and the negative conductor cancel each other out.

ABB's HVDC Light cable contains no insulating fluid which means no leaking if the cable is cut. The strength and flexibility of these cables have not only enabled the linking of networks across very deep waters, but also in areas where the laying conditions might otherwise cause damage.

Combining both HVDC Light and HVDC Light cable means a system that is economically viable, reliable and environmentally friendly.

1 Näs Head HVDC Light station with the converter building in the middle of the picture.

The ABB plant in Karlskrona, Sweden is the only manufacturer in the world to have successfully type tested a 150 kV DC extruded cable.

HVDC Light in use

Case one: Invisible collection of wind power in Sweden

An example of HVDC Light in use can be found at Näs head at the southern tip of Gotland (a Swedish island in the middle of the Baltic sea).

Few people live permanently at the southern part of Gotland and for many centuries Näs has been home to mainly fishermen and farmers. Many artists and tourists are attracted to this area primarily because the landscape has remained relatively unspoiled, as there are no major industries requiring electrical power. As the wind blows almost constantly, people have been taking advantage of this natural resource for centuries by building windmills. In the early 20th century, some farmers began producing electricity by connecting car generators to simple windmills.

In 1984, the construction of one of the largest windmill parks in Sweden, 1, began at Näs. Still ongoing, about 50 MW of wind power capacity will be installed in an area where the peak load is only approximately 17 MW. The problem was that the infrastructure built to accommodate the existing consumption was unable to cope with any increase in production. It was therefore decided to dimension the network in order to withstand the transmission of excess power when the load is low.

The laws of nature dictate that wind power production varies randomly, and this puts considerable demands on voltage regulation. The electrical system must therefore be adjusted so that it can regulate and retain voltage quality with regard to reactive and active power, as well as other phenomena that arise. The use of traditional AC alternatives, however, would not only require equipment for the compensation of reactive power, but also a new 70 km long power line across sensitive land from Näs to the load center in Visby, the main urban area of the island.

For this reason, the decision was made to use ABB's DC transmission technology, HVDC Light. Using this technology, both power transmission and electrical quality demands were adequately met.

The station design is based on a modular concept and all modules were factory assembled and pre-tested in response to a short delivery time. Most of the equipment is installed inside the converter building, which has been designed to fit into the surrounding landscape by adopting the architecture of a typical farmhouse. The HVDC Light cables were ploughed into the ground by a tractor equipped with a cable plough. Existing overhead line paths were used, thus limiting visual impact on the environment to an absolute minimum.

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Case two: Long distance underground transmission

The southern part of Australia is a rural area and is characterized by a relatively flat landscape. It is also the site of an award winning high profile power project using ABB's HVDC Light technology. The 177 km long Murraylink underground high-voltage interconnection is currently the world's longest. It links the electricity markets of Victoria, New South Wales and South Australia and exchanges up to 220 MW (enough to meet the needs of 120,000 households) of power between the South Australian and the Victorian grids.

2 Murraylink HVDC Light project in Australia.

Laying cable for the Murraylink HVDC Light project, Australia, the longest underground power transmission cable in the world.

Landscape after laying of cable has been completed.

Underground cables were used **2** because a large proportion of the terrain between the states of Victoria and South Australia is made up of national parks with sensitive wildlife, as well as large privately owned agricultural areas. In addition to the visual and environmental impact, underground cables offer protection against Australia's traditional causes of power outages, such as lightning and the damage caused by wild life or bush fires.

The cables were tunnel-drilled under the Murray River, road and rail crossings and under a number of significant Aboriginal heritage sites. The cable route uses existing road or right-of way corridors and in parts, it follows the path of Sturt Highway, a gas pipeline and telecommunication cables. Construction commenced in June 2001 and the project was successfully commissioned in August 2002.

Not surprisingly the Murraylink has won a couple of environmental awards in Australia:
- In 2002 it received the 'Case EARTH award for Environmental Excellence' for best practice and innovation in the environmental management of civil construction projects
- The Murraylink Transmission Company (a subsidiary of TransÉnergie) was awarded the 'Engineering South Australia Award 2003'.

3 The Cross Sound Cable is a high voltage subsea power interconnection linking the Long Island and New England power grids.

Case three: Securing supply from New Haven to Shoreham

Long Island Sound, just north east of New York City, is an important recreational location for those living in New York and southern New England, notably one of the most densely populated areas of the world. Since the early 1970s there have been plans to link the New England power grid to that of Long Island with a submarine cable across the Long Island Sound **3**. The

4 Shoreham is one of two converter stations of the Cross Sound Cable Interconnector, between Long Island and Connecticut.

Long Island grid had only been connected to the main US main grid through New York. Concerns about the potential environmental impact of such an interconnector, especially on the delicate aquatic ecosystem, have prevented previous schemes from gaining the required statutory approvals.

The urgently needed electricity supply to Long Island was, however, eventually completed by ABB together with TransÉnergie US Ltd. The development required the building of a complete 330 MW HVDC Light transmission system. This system is made up of two 40 km HVDC Light cables buried under the seabed with a bi-directional HVDC Light converter station at each end 4.

The two power cables and a fiber optic cable were bundled and laid on the seabed within a precisely defined corridor across Long Island Sound. A hydraulic jet plough was then used to bury the cables to a depth of up to two meters. This environmentally sensitive technique uses a controlled jet of pressurized water to create a one-meter wide trench. Then during the installation process, the trench remains filled with loose, fluidized sediments into which the cables settle immediately, thus allowing the seabed to return naturally to its pre-construction contours.

Even though the HVDC Light transmission system was in place, the differing political perspectives meant that the required energizing permit was not granted. Unexpectedly, the huge blackout in August 2003 followed quickly by a federal order permitted the Cross Sound Cable Interconnector to operate. In a nutshell, this interconnector played a significant role in bringing Long Island out of the dark as well as restoring power to hundreds of thousands of people.

The success of HVDC Light technology during the blackout lies in its unique ability to independently control reactive power while supplying active power into a very weak network. In June 2004 the Cross Sound cable went into permanent operation and it will provide additional power transfer capability between New Haven in Connecticut and Shoreham in either direction.

5 Troll A platform.
(Photo: Øyvind Hagen, Statoil)

Case four: Reduction of greenhouse gas emissions

The windy and wild North Sea and the largest gas production platform on the Norwegian shelf, Troll A, set the scene for the next example of HVDC Light technology in use.

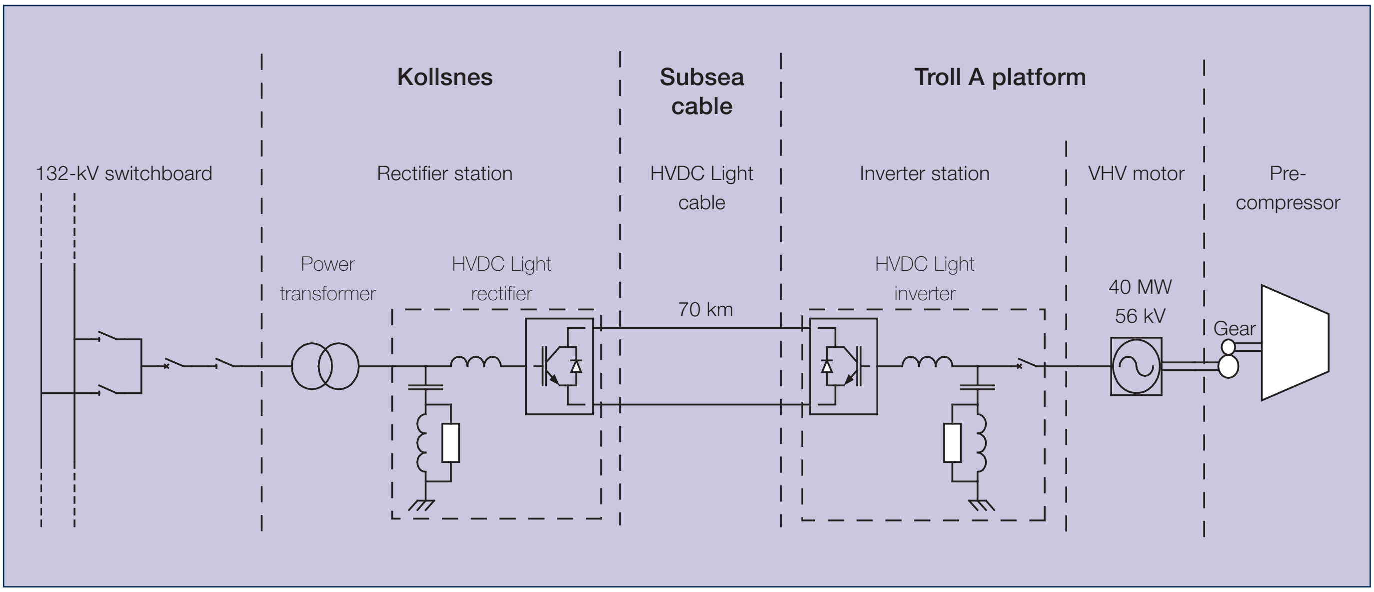
Historically offshore installations have, in themselves, formed electrical islands. With its compressors, motors and electrical systems devouring many tens of megawatts, an offshore installation can be a power hungry beast indeed. The onboard gas turbines or diesel generators that usually supply this power, however, manage no more than 25% efficiency compared with 75–80% onshore! Inefficiency isn't the only problem. CO_2 emissions are unnecessarily high, and because of taxation policies now in place, these high emissions have become a cost factor.

Troll A, 5, can produce up to 100 million cubic meters of gas per day. As the gas is taken out of the reservoir under the seabed, the pressure inevitably decreases. In order to maintain (and expand) production capacity, offshore precompression of the gas has become necessary.

If the electrical power for all this equipment can be supplied onshore, the CO_2 emissions of offshore installations are eliminated, saving operators a considerable sum of money. In addition, transmitting electrical energy from shore is also more efficient in terms of equipment maintenance, lifetime and availability.

Therefore, using HVDC Light and another innovative technology, Very High Voltage

6 From the rectifier station at Kollsnes, subsea HVDC cables transmit power to the Troll A Platform, where the inverter station and VHV cable wound motor are located. Two identical systems are to be installed.



(VHV) cable wound motor technology, ABB has developed a system which uses power from the on-shore electrical grid (some 70 km away) to drive the compressors on the platform.

Two identical parallel systems each feed one drive system on the platform from an existing 132 kV network through a converter station and a 70 km long HVDC Light sub sea cable 6. One advantage with VHV cable wound motor technology is that no large heavy step-down transformer is required to connect the VHV cable wound motor to the HVDC Light converter on the platform. Apart from this, VHV cable wound motor technology reduces the total system losses by as much as 25%. Being epoxy-free, it also has important environmental benefits, including easy recyclability.

HVDC Light technology is an excellent example of ABB's commitment to a sustainable and enjoyable environment.

Case five: Interconnecting different power grids

The fifth and final example could take place anywhere in the world. Several HVDC Light transmission systems have been built to interconnect different power grids. By means of these links, the existing generating plants in the power network now work more effectively meaning the building of new power stations can be deferred. Not alone does this make economical sense, but it is also very good for the environment.

The greatest environmental benefit is obtained by linking a grid transmitting hydro generated energy with one carrying predominantly thermally generated energy. The advantage here is that thermal generation (mainly at peak demand) is saved by hydro generation. Also thermal generation can be run more efficiently at constant output and does not have to follow various load variations. These can be easily handled through hydro generation. Similar attractive solutions are realized by combining powerful wind energy sources, ie, from offshore windfarms with grids mainly fed by hydro energy.

ABB 'walks the talk'

Commitment to a sustainable environment begins at home and is realized at every level of the company. 'Walking the talk' means: caring about the environment at each and every step in the product development and manufacturing process and working in close cooperation with customers and suppliers. HVDC Light technology is an excellent example of ABB's commitment to a sustainable and enjoyable environment.

Gunnar Bennstam
ABB AB
Ludvika, Sweden
gunnar.bennstam@se.abb.com

Lennart Carlsson
ABB Power Technologies AB
Power Systems
Ludvika, Sweden
lennart.k.carlsson@se.abb.com