HVDC LIGHT TECHNOLOGY

ABSTRACT

Transmitting power at high voltage and in DC form instead of AC is a new technology proven to be economic and simple in operation which is HVDC transmission. The HVDC (High Voltage Direct Current) technology is used to transmit electricity over long distances by overhead transmission lines or submarine cables. It is also used to interconnect separate power systems. A further development in this technology is HVDC light where HVDC light converters are used for faster and efficient conversion of power.

HVDC Light is a fundamentally new power transmission technology developed recently. It is particularly suitable for medium to small-scale power transmission applications. This new transmission and distribution technology, HVDC Light provides an important role to today’s requirements on our network systems and opens up new opportunities for both investors and environmentalist alike.

HVDC light technology for transmission of electric power is introduced in this paper. Its features, advantages and applications are pointed out. HVDC cables, their design, under ground laying, their advantages and applications are also added. The paper also gives a note on the advantages of HDVC light cables over AC underground cables.
INTRODUCTION:

Competition in the electricity power industry, coupled with continued load growth requires that the existing transmission system assets are utilised more effectively and some times closer to their technical limits. As the existing AC lines become loaded closer to their thermal capacity with increasing losses and reduced power quality we face the risk of declining network stability. One solution would be to simply build new, more powerful AC lines.

But, it is getting increasingly difficult to obtain permits to build new high voltage Overhead transmission lines, the right-of-way occupies valuable land. Overhead lines change the landscape, causes public resentment and is often met by political resistance. People are increasingly concerned about the possible health hazards of living close to overhead lines.

There are many examples today of public agitation against overhead power lines and the call for them to be buried. Media reports which link living close to power lines with higher cancer risks and leukaemia in children don’t help the situation. On the other hand laying an underground cable is an easier process than building an overhead line. A cable doesn't change the landscape and it doesn't need a wide right-of-way. Cables rarely meet with public opposition. There are technical constraints, which limit the distance of traditional AC underground cables to around 80km.

And, even though the cost of laying AC cables is rapidly reducing it still costs more than equivalent over head lines.

Currently there is little incentive for putting high voltage lines underground particularly when the Network Service provider is predominantly driven by cost to provide performance-based transmission services at a competitive price. So what is the solution?

HVDC Light technology has the potential to play an important role in achieving this solution. It provides improved power quality and power flow control as well as Introducing extruded DC-cables which have no technical limit to distance which can be installed, and can provide an alternative to overhead lines particularly when the total capital and environmental costs are considered.
In Australia, at Direct Link and Murraylink, we have two such examples where HVDC Light technology with underground DC-cables has been implemented in a competitive, market-oriented network service.

**HVDC Light Technology:**

As its name implies, HVDC Light is a high voltage, direct current transmission technology and is well suited to meet the demands of competitive power market for transmission up to 330MW and for DC voltage in the ±150kV range. Traditional HVDC, or if you like HVDC Heavy, is designed for high voltage, direct current transmission above 300MW and for DC voltage up to ±600kV.

HVDC Light design is based on modular concept build up from standardised designs with compact transportable modules, which are factory assembled and pre-tested to provide short delivery and a fast response to the competitive market demands. These standardised modular designs allow for delivery times as short as 12 months. It consists of two AC to DC converter stations and a pair of underground cables interconnecting
The converter stations are designed to be unmanned and virtually maintenance-free. Operation can be carried out remotely or automatically based on the requirements of the Network Service contract.

The AC to DC converters employ the latest in power semiconductor technology, the IGBT (Insulated Gate Bipolar Transistor). This technology provides the HVDC Light converter with a switching speed 27 times faster than a traditional HVDC, thyristor controlled converter.

This fast control makes it possible to create any phase angle or amplitude which can be done almost instantaneously providing independent control of both active and reactive power. From a system point of view it acts as a motor or a generator without mass.

While the transmitted active power is kept constant the HVDC Light converter can
automatically control the voltage of the connected AC network by compensating the generation and consumption of reactive power within the capacity of its rating. In the presence of a fault on the existing AC system the HVDC Light converter can rapidly assist with voltage support to avoid severe disturbances in the local grid. The response time for a change in voltage can be as quick as 50ms. With this speed of response HVDC Light will be able to control transients up to around 3Hz, thereby helping to keep the AC bus voltage constant.

HDVC light is a transmission system including cables, converters, transformers, etc.

**Technical Features:**

- Advantageous for long distance cable transmission.
- Power reversal without interruption.
- Can start up dead A.C network.
- No increase of short circuit current.
- Equal or longer service life than XLPE AC cables.

In summary, HVDC Light combines the operational features of traditional HVDC
converters with those of static var compensators to provide new levels of performance in terms of power quality during both steady state and transient operation.

**HVDC Light Cable:**

The HVDC Light cable is a new design triple extruded, polymeric insulated DC-cable, which has been successfully type tested to 150kV DC, following a comprehensive R & D program. It is a new lightweight cable similar in appearance and characteristics to a standard AC, XLPE cable except that the problem associated with space charges which breakdown the insulation when using AC, XLPE cables on DC has been overcome with this new design.

DC underground cables provide significant advantages, compared with overhead power lines. The cable system is complete with cables, accessories and installation services. The cables are operated in bipolar mode. One cable with positive polarity and one cable with negative polarity. The cables have polymeric insulating material which is very strong and robust. This strength and flexibility make the HDVC light cables perfect for severe installation conditions.

- The sub marine cables can be laid in deeper waters and on rough bottoms.
- The rough cables can be installed less costly with ploughing technique.
- HDVC cables can now also go overhead with Aerial cables.

**Environmentally friendly:**

- Magnetic fields are eliminated since HVDC light cables are laid in pairs with anti-parallel dc currents.
- Risk of oil spill, as in paper-oil-insulated cables, is eliminated.

**Advantages:**

- Reduced environmental impact, an underground cable has no visual impact on the landscape. Once it's installed the cable route can be replanted with Native vegetation.
- Faster and easier issue of permits using DC underground cables. Underground
cables rarely meet with public opposition and often receive political support.

- The system reliability is enhanced with reduced risk of damage from natural causes such as storms, wind, earthquakes and fire. You simply bury it and forget it.

- Operation and maintenance costs of the transmission easement are virtually eliminated as there is no need for long term contracts to maintain the easement with suitable access roads, thermographic checks of conductors joints, insulator replacements, constant trimming and removal of regrowth vegetation and public safety and security.

- The width of the corridor to install the underground cable can be as narrow as 4 metres, which will give greater flexibility with the selection of a transmission route.

- There are considerable cost savings to the community in terms of amenity, property values and possible health risks. The installation of a DC cable has no environmental impact, the land can continue to be used and there is virtually no magnetic radiation associated with the bi-polar DC cable.
Compared with AC underground cables the HVDC Light cable also has some significant advantages to be considered:

- DC cables require only two cables between each converter station.
- Unlike AC cables, which generally have a technical limit of around 100km due to reactive power and losses, DC-cables have no technical limit to distance.
- DC cables can carry up to 50% more power than the equivalent AC cable.
  - There is no need to install groups of cables to achieve the required power rating.
  - As there is no need to maintain wide distances between groups of cables, DC cables can be ploughed direct in the ground or laid together in narrow trenches.
- DC cables have a longer life expectancy than AC cables due to its lower operational stress level of around 20kV/mm.

In summary, when considering the cost of installing an HVDC Light underground transmission it is important to consider the total life cost benefits and not just the initial up front capital costs.

Applications:
HVDC Light technology has been well proven since the first successful pilot installation in March 1977 with a number of commercial projects undertaken and in operation.

Applications to date include connecting wind power generation to the grid. This includes Gotland, off the Swedish mainland, transmitting 50MW back onto the grid. The link has been transmitting power since November 1999.

Wind generation is often placed in remote locations where the grid is weak and short circuit power capability is quite low. They often require expansion within a few years and wind generators absorb reactive power from the grid for magnetisation.

**Advantages**

- Flexibility to be expanded
- Limits the short circuit power contribution
- Supplies reactive power to wind generator, independently to active power it receives.
- A meshed DC grid can be built which connects the wind farms

Another application for HVDC Light is interconnecting different Networks. In this application the advantages provided include:

- The flow of energy over the link can be precisely defined and controlled, thereby capacity rights for fully commercial network are readily defined.
- The converter stations at each end can act independently of each other to provide ancillary, reactive power support into the network.
- Underground cables facilitate the issuing of permits. Unlike Government Utilities there are no rights of acquisition for a private developer.
- Rapid construction of the HVDC Light allows a fast response to market conditions of market-driven network services.
- The cable route requires no easements over private land for installation, and the overall impact on vegetation is absolute minimum. Once the cable is installed the cable route can be replanted with native vegetation providing a net gain in native vegetation.

**Typical Layout Of HVDC SubStation:**
Two identical parallel systems each feed one drive system on the platform from the existing 132kv network through a converter station and a 70km long HVDC Light subsea cable.

**Conclusions:**

HVDC Light is a new technology that has been specifically developed to match the requirements of the new competitive electricity markets. It provides the ability to connect renewable generation to the AC grid. It allows us to supply power to remote locations and islands replacing local diesel generation. It is an ideal vehicle for privately funded developers to link different regions and trade energy. The technical merits are that by virtue of its standardised prefabricated modular construction which lead to short delivery times, it is relocatable and can be expanded to meet growing demand. Moreover, a key advantage is that it provides accurate control of the transmitted active power and independent control of the reactive power in the connected AC networks. A pair of lightweight DC cables can be laid direct in the ground in a cost-effective way which is comparable to or less than a corresponding total life cycle cost of AC overhead line. As opposed to an overhead line, an underground cable pair has no visual impact on the landscape. Usually it’s much easier to obtain permission and public approval for an underground cable transmission compared with an overhead line, especially in residential areas. For these reasons HVDC Light provides an important role as a business concept and opens up new opportunities for both investors and environmentalist.
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