HVDC and Green Power Corridor: A Review

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Abstract: ***High Voltage Direct Current transmission system can turn out to be the ideal power transmission system for bulk power and transferring clean power from remotely locatedhydroelectric dams to distant load centers. Therefore, the solution to the sudden increased demand for electricity can be found by evacuating remotely located bulk renewable energy and transmitting the clean power to load centers located at a significant distance away via HVDC link.***

Keywords: Bulk power transmission, Green power, HVDC, Renewable energy.

1. Introduction

With the increasing population, big cities need large amounts of electricity to function. The required power is transferred from remotely located generating stations. However, due to deteriorating environmental conditions and increased stress on clean power, the question is how to transfer power from renewable energy generation sites like hydro plants and wind grid parks to distant load centers. HVDC (high-voltage direct current) power transmission can be the solution. The major challenge of renewable energy generation is the intermittent nature of the renewable energy source. If harnessed properly, the HVDC transmission link can prove to be beneficial for bulk renewable power transmission.

2. HVDC Basics

HVDC power transmission started in the second half of the last century and provided a new way of power transmission. The initial power transmission level was very low; however with the change of technology, the power transmission level has increased significantly. Transmission of thousands of MW is being done currently via HVDC link in monopolar and bipolar mode of operation. India has also joined the HVDC membership by starting the world's first multi-terminal HVDC link from Biswanath Chariali (Assam) to Agra with Alipurduar in between. Majority of the power transmitted via the HVDC link is remotely located hydro power which is green power. HVDC links pave the way for harnessing of untapped clean and green hydro potential.

HVDC interconnections require a conversion from AC to DC and vice versa at each connection point with the AC system. This collection of equipment at each AC connection point is referred to as a converter station. The converter station requires a higher capital outlay than would be required for an AC substation; however, HVDC transmission towers are simpler and smaller than AC towers. For a monopolar HVDC link (equivalent to a single AC circuit), only one high voltage conductor is required, as opposed to three in the equivalent conventional 3-phase AC system. In some locations, electrodes can even be inserted into the earth to provide the low voltage return path. With DC transmission the DC voltage remains fixed, thus the insulation levels and the equivalent outside conductor radius required for the transmission conductor are proportional to the continuous voltage applied to the conductor.

Though ac power transmission mode is widely used, HVDC power transmission has the following advantages:

1) Bulk power transmission with reduced losses.
2) Increasing the power transmission capacity and short circuit capacity of a grid.
3) Allowing power transmission between two asynchronously connected grids.
4) Reducing the Right of Way for transmission towers.
5) Connecting a remote hydro generating plant to the load centers.
6) Reduced Corona losses.
7) Reduced conductor cost for same amount of power transmission via ac network.
8) Fast and accurate control.

2.1 Modes of HVDC Operation

The various modes of operation in HVDC are as follows [1] :

a) Monopolar operation with ground return :
In this mode of operation, only one pole is in operation and the return path for the circuit is via ground. At times, there are limitations in operating the monopole in ground return mode. The limitations may arise due to environmental impact.

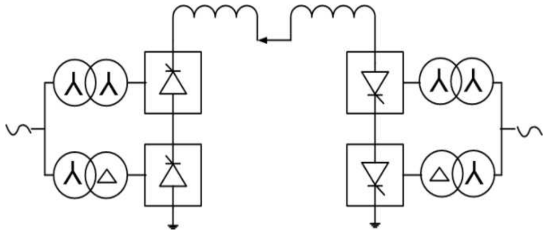

Figure 1: Monopolar HVDC with ground return

b) Monopolar operation with metallic return :
In this mode of operation, only one pole is in operation and the return path is via the conductor of the other pole or via dedicated metallic return path. Upcoming HVDC projects shall have only Dedicated Metallic Return path and the ground return mode shall not be utilized. Provision of electrode station for ground return shall be replaced by dedicated metallic return path.

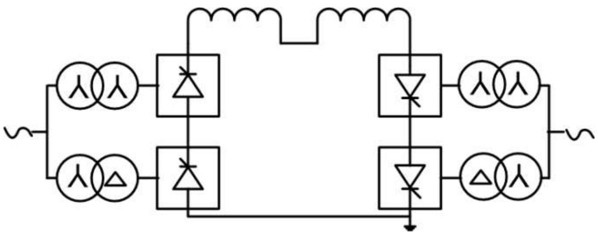

Figure 2: Monopolar HVDC with metallic return

c) Bipolar operation :
In this mode of operation, both the poles of a station are in operation. The circuit is completed via the conductor of both the poles. In case of any unbalance, the unbalance current is grounded in the electrode station.

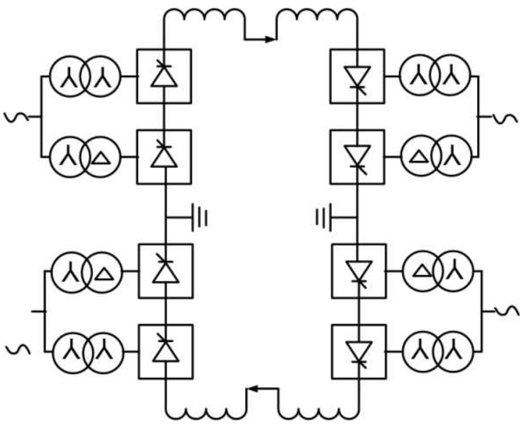

Figure 3: Bipolar HVDC system

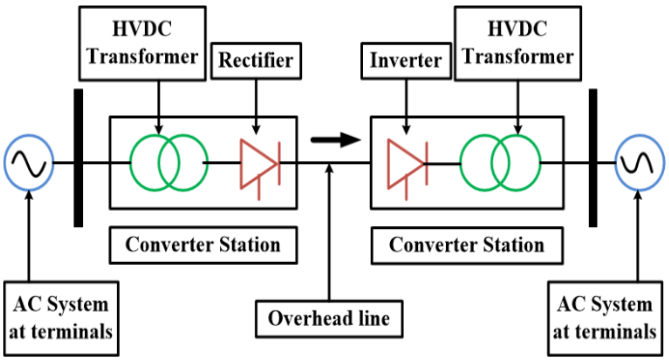

Figure 4: Typical layout of a HVDC link

3. CSC and VSC based HVDC

3.1 CSC (Current Source Converter) mode

CSC uses thyristor valves as switching devices. The thyristors can be turned off only when the current flowing through it falls to zero. The thyristors help in building stable high dc voltage. CSC-HVDC is suitable for high voltage bulk power and long distance transmission projects. CSC based stations can be used for reverse power flow by changing the polarity of the thyristor valves. The current direct direction shall remain unchanged[2].

3.2 VSC (Voltage Source Converter) mode

Insulated Gate Bipolar Transistor (IGBT) is used in VSC-HVDC projects. A new VSC topology, Modular Multilevel Converter (MMC) is bearing used for effective dc voltage build up in VSC based HVDC stations. Being a forced-commutated voltage source converter, it does not need the ac voltage support from grid side for commutation. The major advantage of VSC based HVDC stations is that these stations can be utilized as first station to charge during black start in case of grid failure.

4. HVDC and Green Power Corridor

The utility of HVDC can be seen in the case of integrating with renewable energy sources which are intermittent in nature. Due to the non-sinusoidal input to the grid by the renewable energy sources at times, the renewable energy can bring in harmonics to the grid. However, if it is integrated to the HVDC link, the AC filters will eliminate the harmonics and allow only sinusoidal voltage to enter the HVDC system. Thus, HVDC will prevent harmonics from entering the grid.

Wind generation –particularly in the coastal areas and in the seas where the wind is strong can be an ideal energy source[3].The renewable energy sources can be intermittent in nature and because of this unwanted oscillation in the availability of power, it might be a very good idea to combine renewable energy sources directly with HVDC stations. The controllers and power oscillation dampers will eliminate any harmonics in the incoming ac power from renewable energy sources before it enters the HVDC valves. Thus, the ac grid is prevented from unwanted oscillations and harmonics by the HVDC station. The incoming ac power can be cleaned of any harmonics and sent to distant load centers by converting it to dc. ABB has recently constructed a 400-MW transmission link using HVDC Light technology for a wind park 130 kilometers off the German coast. HVDC Light is also attractive for its simple-to-handle cable design and modularized, factory-assembled voltage converter, which means the network links essential to receiving power from offshore wind parks can be quickly installed and commissioned. HVDC VSC is the technology preferred for connecting renewable energy sources, such as offshore wind farms, to the power system [4].

India's first green energy corridor project links Pugalur in Karur district in western Tamil Nadu with Raigarh in Chhattisgarh which will enable the southern State to transmit excess wind energy generated to central India. This link shall play the role of a key element of integrating renewable energy with the main grid. It will link thermal and wind energy from Tamil Nadu for transmission of power to load centers located far away, The Raigarh Pugalur project is owned by Power Grid Corporation of India (POWERGRID) and is being executed by ABB along with BHEL. This HVDC transmission line will support investments in wind energy in the state. The maximum power transmission capacity will be of 6,000 MW, and it will integrate thermal and wind energy transmission to high consumption centers. When wind energy generation in Tamil Nadu is in excess it will be transmitted to central India, and when electricity demand is high in Tamil Nadu, thermal energy can be transmitted from central India to the south [5].

In normal ac transmission systems, the losses during transmission are two to three times higher when compared to HVDC. This means that HVDC system will keep around 700,000 tons of CO_2 per year out of the atmosphere. In October 2011, HVDC facilities were certified as green technology by the United Nations Framework Convention on Climate Change (UNFCCC) [6].

5. Sources of clean power in India

There are many renewable energy sources that are presently being harnessed by the power generation companies with an eye to meet the clean power requirements [7]. However, the few renewable energy resources that are being directly connected to HVDC transmission lines for transmitting the clean power to distant load centers are as follows:

I. Hydro Power: India is a significant producer of hydroelectric power in the world. Many rivers and tributaries are found in the North Eastern part of the India. The North East India is high in hydro potential. This aspect has been aptly identified and the hydro power will be sent via HVDC link to power deficit regions in the Northern part of India. India's hydroelectric power potential is increasing significantly and it is estimated at 84,000 MW at 60% load factor [8].

II. Wind Power: The progress of wind power in India began in the 1990s, and has escalated in the last few years. As of 2017 the installed capacity of wind power in India was 29151.29 MW. Though wind is easily available but the particular wind speed required to drive a turbine and convert it into electrical energy is not found easily. Adequate wind speed which can be harnessed successfully is found in coastal areas and sea shore areas. Wind power accounts for 14% of India's total installed power capacity.

III. Solar Power: Solar power can be harnessed anywhere where the level of solar insolation is adequate. In India, most of the states receive sufficient solar insolation level and thus solar power can be utilised easily. In rural areas, one of the first applications of solar power has been for water pumping, to begin replacing diesel powered water pumps. Desert areas can be used to harness the solar power significantly. Some large projects have been proposed in the Thar Desert, which has been set aside for solar power projects, sufficient to generate bulk power.

6. Conclusion

The availability of electric power at all times is the paramount requirement from an electrical utility. However, with the growing adverse impact on the environment and climate, the power evacuation technique needs to keep an eye for reduced impact on the climate. The aspect of sustainability is gradually gaining in importance in view of such challenges as the global climate protection and economical use of power resources. With the advent of newer technology for harnessing renewable energy resources, the electrical transmission utilities in all parts of the world should be ready to transmit the clean and green power available to distant load centers. HVDC transmission lines shall pave the way for transmitting bulk power from remotely located renewable energy sources to the required load centers located far away from the point of generation. In the growing competitive market, all electrical utilities should pay significant attention for harnessing the untapped potential of renewable energy and deliver green power to the load centers. Proper measures should be taken by all the utilities so as to prevent undue stress to the global climate by reducing the dependency on fossil fuels, reducing the expulsion of CO_2 gas and also reducing the damage on the global climate. HVDC transmission lines along with FACTS technology can reduce a lot of stress on global environment by providing a proper channel for long distance green power transmission to the required load centers. A sustainable green power transmission will be required in the near future to cater to the increasing demand for green power which can be aptly provided by HVDC power transmission technology.

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