HVDC (High Voltage Direct Current) Transmission System

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Abstract - **The development of HVDC (High Voltage Direct Current) transmission system dates back to the 1930s when mercury arc rectifiers were invented. Since the 1960s, HVDC transmission system is now a mature technology and has played a vital part in both long distance transmission and in the interconnection of systems. 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. HVDC transmission systems, when installed, often form the backbone of an electric power system. They combine high reliability with a long useful life. An HVDC link avoids some of the disadvantages and limitations of AC transmission. HVDC transmission refers to that the AC power generated at a power plant is transformed into DC power before its transmission. At the inverter (receiving side), it is then transformed back into its original AC power and then supplied to each household. Such power transmission method makes it possible to transmit electric power in an economic way.**

Keywords: ***HVDC Links, Bipolar Transmission, Transmission***

1. INTRODUCTION

The development of HVDC (High Voltage Direct Current) transmission system dates back to the 1930s when mercury arc rectifiers were invented. In 1941, the first HVDC transmission system contract for a commercial HVDC system was placed: 60MWwere to be supplied to the city of Berlin through an underground cable of 115 km in length. It was only in 1954 that the first HVDC (10MW) transmission system was commissioned in Gotland. Since the 1960s, HVDC transmission system is now a mature technology and has played a vital part in both long distance transmission and in the interconnection of systems. HVDC transmission systems, when installed, often form the backbone of an electric power system. They combine high reliability with a long useful life. Their core component is the power converter, which serves as the interface to the AC transmission system. The conversion from AC to DC, and vice versa, is achieved by controllable electronic switches (valves) in a 3-phase bridge configuration. A new transmission and distribution technology, HVDC Light, makes it economically feasible to connect small scale, renewable power generation plants to the main AC grid. Vice versa, using the very same technology, remote locations as islands, mining districts and drilling platforms can be supplied with power from the main grid, thereby eliminating the need for inefficient, polluting local generation such as diesel units. The voltage, frequency, active and reactive power can be controlled precisely and independently of each other. This technology also relies on a new type of underground cable which can replace overhead lines at no cost penalty. Equally important, HVDC Light has control capabilities that are not present or possible even in the most sophisticated AC.

2.Why Choose HVDC Over HVAC?

This is an exciting question that why we prefer HVDC over HVAC Because most electricity transmissions use three-phase alternating current. So how HVDC transmission fit into the present power transmission network? The fascinating question is that why we choose HVDC transmission system compare to HVAC whereas most of the three phase electricity transmission uses AC. How will HVDC transmission get success in the present transmission network?

We answer that AC has been preferred for electrical transmission anywhere, i.e. home, business, in the world, But AC has been some limitation, i.e. it's transmission capacity, long distances, SKIN effect and can never connect between two different frequencies electricity transmission network. The skin effect & Corona effect tends to less significant for DC & AC conductors. HVDC transmission is most helpful especially for the interconnection of different frequencies AC grids, also provides high efficiency and control capability. It can be our choice that we go for HVDC power transmission system because DC can able to carry a significant amount of electricity with shallow losses.

3.HVDC Transmission network component

The main components of the HVDC system are mentioned below Converting Station, Converting Units, Converting Valves, Converting T/Fs, Filters, High-Frequency Filters, Power Source (Reactive), Levelling Reactor, Poles

3.1 Converting Station:

At the substation, Rectifier terminal converts an AC to DC whereas Inverter substation line converts DC Every terminal is designed in such a way that they work in both mode (Rectifier & Inverter), so then each terminal is known as converter terminal. A two-terminal HVDC transmission system is having two terminals and one HVDC.

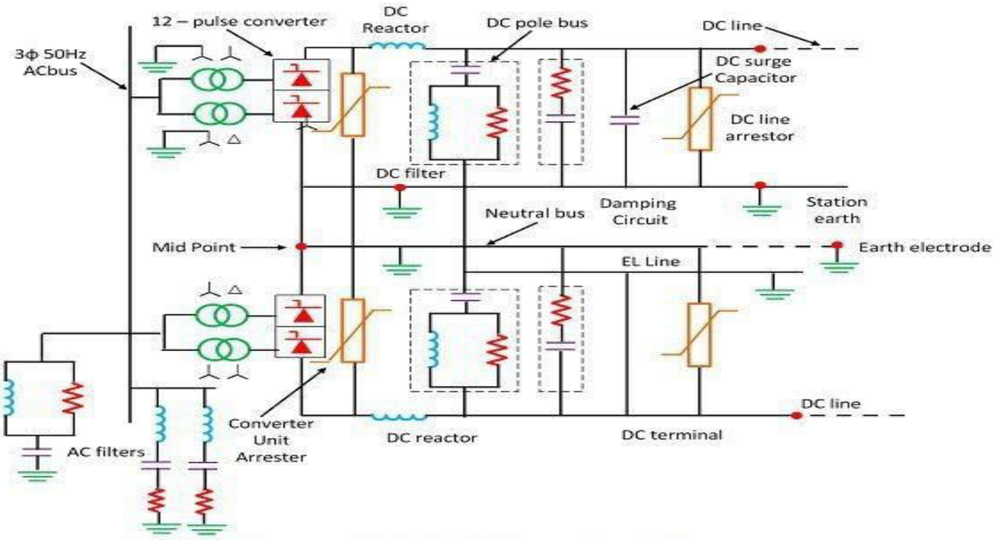


Fig (1): Schematic Diagram of a Typical HVDC Converter Station.

3.2 Converting unit: This usually consists of 2-3phase converter bridges connected in series to form a twelve pulse converter unit as shown in fig (2). The total no of valves in such a unit are twelve. The valves can be packaged a single valve, double valve or quadrivalve arrangements. Each valve is used to switch in a segment of an AC voltage waveform.

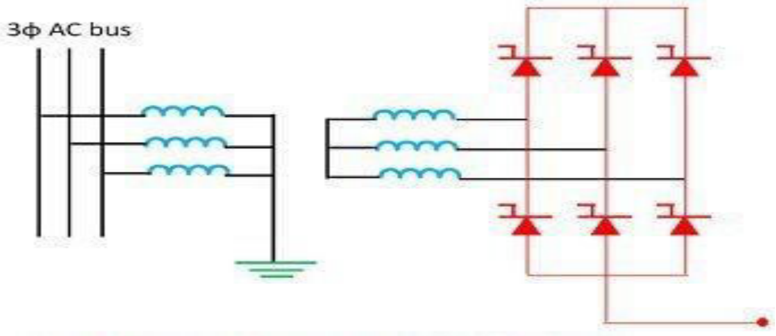
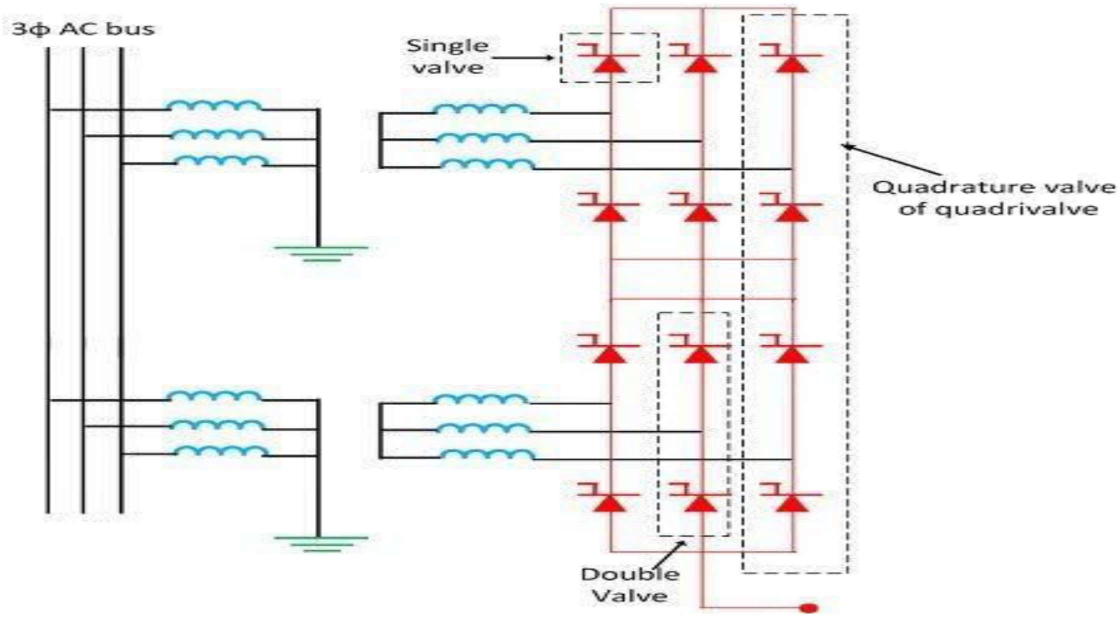


Fig (2): 6- Pulse Converter Unit.

3.3 Converting Valves:

However new HVDC converter uses 12-pulse converter units and the total number of valves in each group shown in figure 3. Thyristor based modules are used to make series connection valves. The amount of thyristor valve depends upon the required voltage across the



valve.

Fig (3): 12-Pulse Converter unit.

3.4 Converting T/Fs:

The converter transformers are designed to withstand DC voltage stress and increased eddy current losses due to harmonic currents. One problem that can arise is due to the magnetization of the core due to un symmetric firing of valves.

In back to back links, which are designed for low DC voltage levels, and extended delta configuration can result in identical transformers being used in twelve pulse converter units. This results in the reduction of the spare capacity required. However, the performance of extended delta Transformer in practice is still to be tested.

3.5 Filters:

Filtration of Harmonics is exceptionally essential and furthermore for generation of receptive power at line cumulative converter station. The AC and DC sound music is infused into AC and DC lines separately. The music has the accompanying focal points. Filtration is almost obligatory for generation of reactive power at range expanding converter station. The AC and DC sounds are infused at AC and DC line separately.

4.Designing, Constructing, Operating, Maintenance& cost structure considerations

Generally, it can differ from three years for vast HVDC frameworks given one-year thyristor to HVDC VSC based frameworks running from contract date to dispatching as far as development.

Since the term task alludes to progressing exercises to keep up framework accessibility at composed levels. At present day, HVDC connections can be worked remotely, given the included semiconductor and chip-based control frameworks. There are existing offices without staff. What's more, present-day HVDC frameworks are intended for the unmanned task. This component is especially vital in circumstances or nations where there are few qualified individuals, and these individuals can work various HVDC joins from a focal area. Upkeep of HVDC frameworks is practically identical to that of high voltage AC frameworks. The HV gear at change stations is equivalent to the relating hardware in the AC substations, and the support can be performed similarly. Upkeep will centre around: AC and DC channels, smoothing reactors, divider infiltrations, valve cooling gear, thyristors valves. In the majority of the over, the time of establishment, start-up and start-up of the task gives satisfactory preparing and support.

A) Cost Structure:

The cost of an HVDC framework relies on different elements, for example, transmitted power limit, ecological conditions, kinds of transmission media and other administrative and wellbeing prerequisites, and so forth. Figure 4 demonstrates the cost structure.

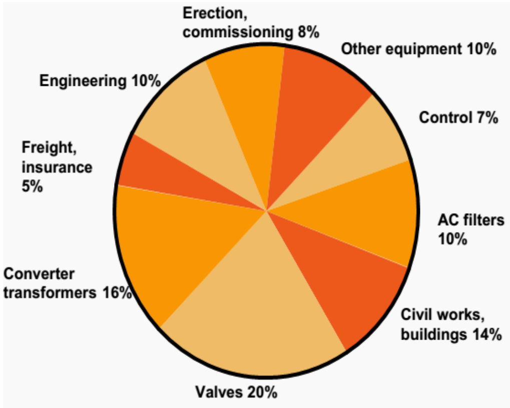


Fig (4): Cost Structure

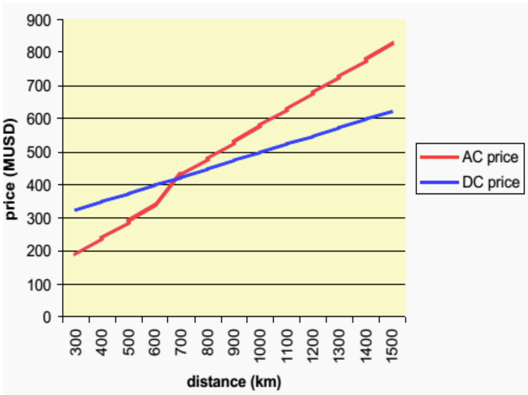


Fig (5): price variation of an AC transmission Compared with an HVDC transmission

The price variation for an AC transmission & an HVDC transmission for 2000 MW is shown below in Fig (5). For the AC transmission, a two circuit is expected with a cost for each km of 250 USD/km (every), AC substations and arrangement remuneration (over 600 km) are assessed to 80

MUSD. Bipolar OH line was accepted with a cost for every km of 250 USD/km; converter stations are evaluated to 250 MUSD.

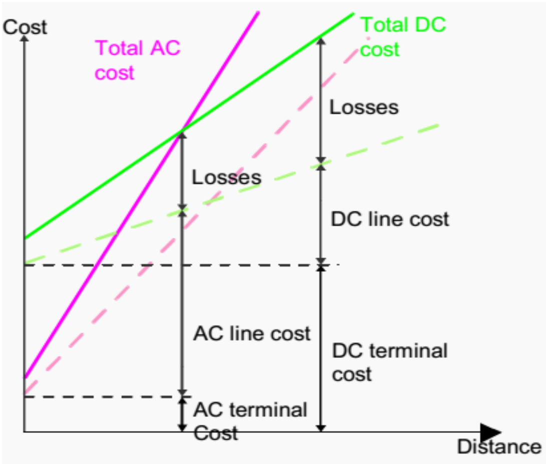
B) Two different examinations are indicating correlation amongst AC and HVDC high voltage frameworks, one is HVDC frameworks and high voltage AC transmission framework, and other is an HVDC framework given VSC and an AC framework and a nearby age source.

1) THYRISTOR based HVDC system versus high voltage AC system:

HVDC converter stations costs are high when compare with high voltage AC substations. Likewise, working and support costs are brought down in HVDC. Introductory misfortune levels are higher in the HVDC framework, yet don't shift with remove.

2) VSC based HVDC system versus an AC system:

VSC HVDC-based frameworks serve low power applications (up to 200 MW) and generally short range sections (many km) of the power transmission range. The accompanying diagram demonstrates that the VSC-based HVDC framework is the best practical other option to a high voltage AC framework as appeared in Figure (7).



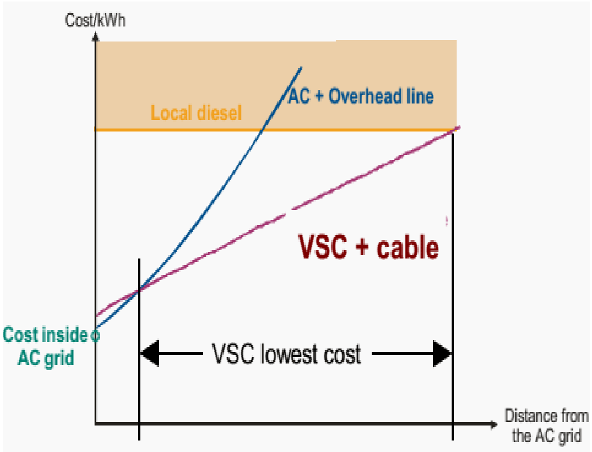


Fig (6): THYRISTOR based HVDC System

Fig (7): VSC based HVDC system

4.Planning for HVDC Transmission

The system planner must consider DC alternative in transmission expansion. The factors to be considered are (1) cost, (2) technical performance, and (3) reliability.

Generally, the last two factors are considered as constraints to be met and the minimum cost option is selected among various alternatives that meet the specifications on technical performance and reliability.

The considerations in the planning for DC depends on the application. Two applications can be considered as representative. These are:

1.Long distance bulk power transmission.

2.Interconnection between two adjacent systems.

In the first application, the DC and AC alternatives for the same level of system security and reliability are likely to have the same power carrying capability. Thus the cost comparisons would from the basis for the selection of the DC (or AC) alternative, if the requirements regarding technical performance are not critical.

5.Types of DC links

a) Mono polar Link: The converter O/P terminal are reversed related to one another with ground return the system requires just one transmission cable and earth is used as the return path.
The earth electrodes are design for continuous full current operation and for any overload capacity required in specific case. Mono polar HVDC scheme is used only for low power rated link.

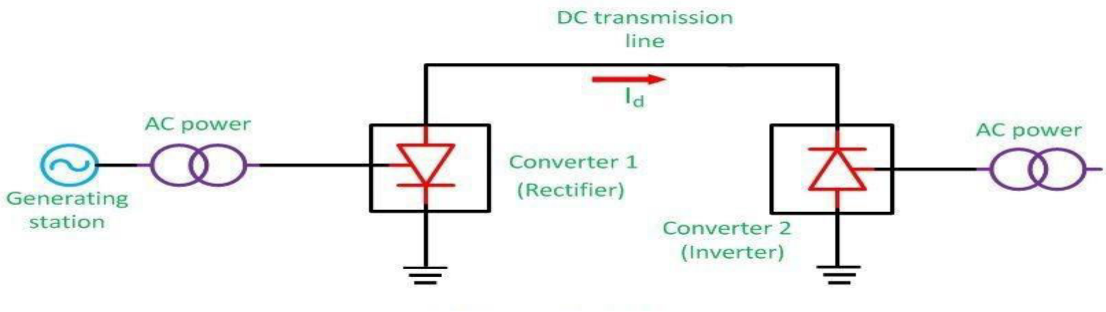


Fig (8): Mono polar link

b) Bipolar Link : The bipolar system with ground return has the power flow in oe direction i.e one pole has positive(+) polarity to ground and the other pole has negative(-)polarity to ground.
For the power flow in other direction the two poles reverse their polarity.when both poles are in operation the embalance current flow in the ground.

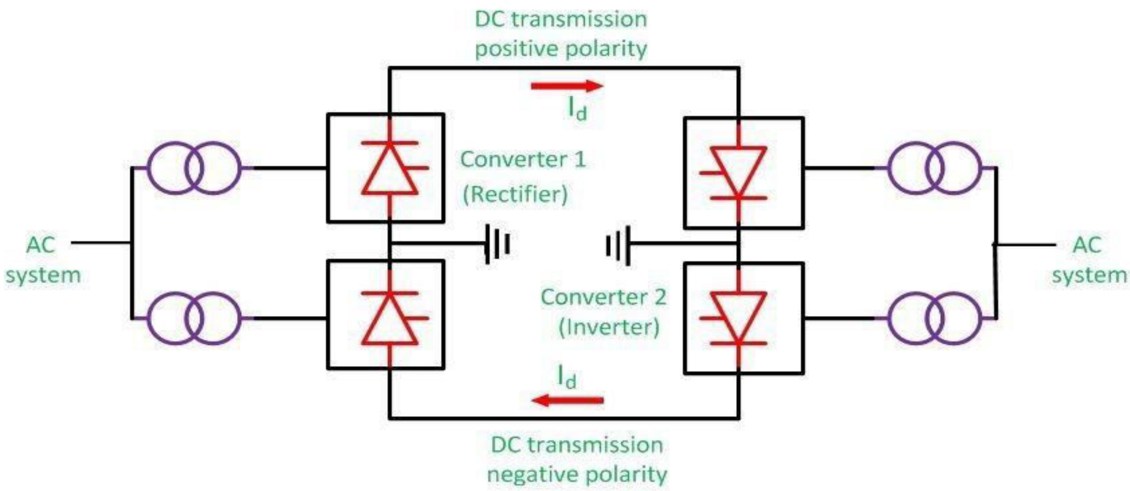


Fig (9): Bipolar Link

c) Homo polar Link: A homo polar link has two conductors or having the same polarity and always operate with ground return, if a fault develops on one conductor, then the converter equipment can be reconnected. So that healthy conductor can supply more than half the rated power. such reconnection is very complicated in a bipolar scheme and therefore a homo polar scheme is preferable to a bipolar scheme provided continuous ground return.

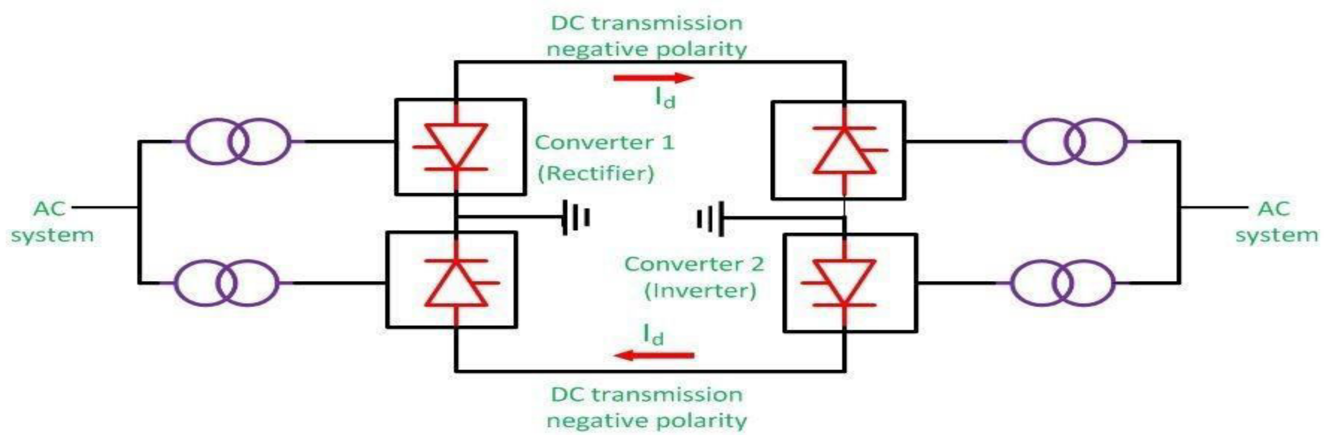


Fig (10): Homo polar Link

<u>6. HVDC Transmission in INDIA:</u> Following fig.11 is showing Transmission Existing in India.

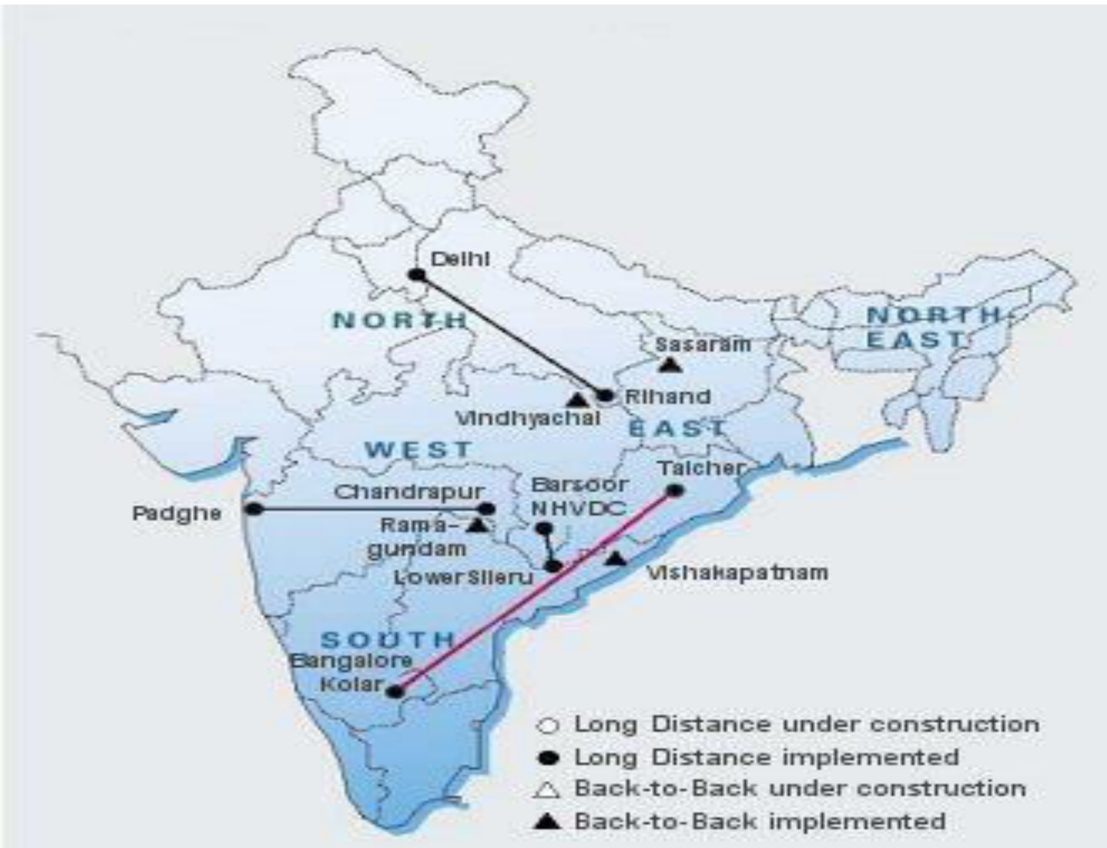


Fig (11): HVDC Transmission in India

(1) DADRI HVDC Project: Below figure 12 is showing details of this project.

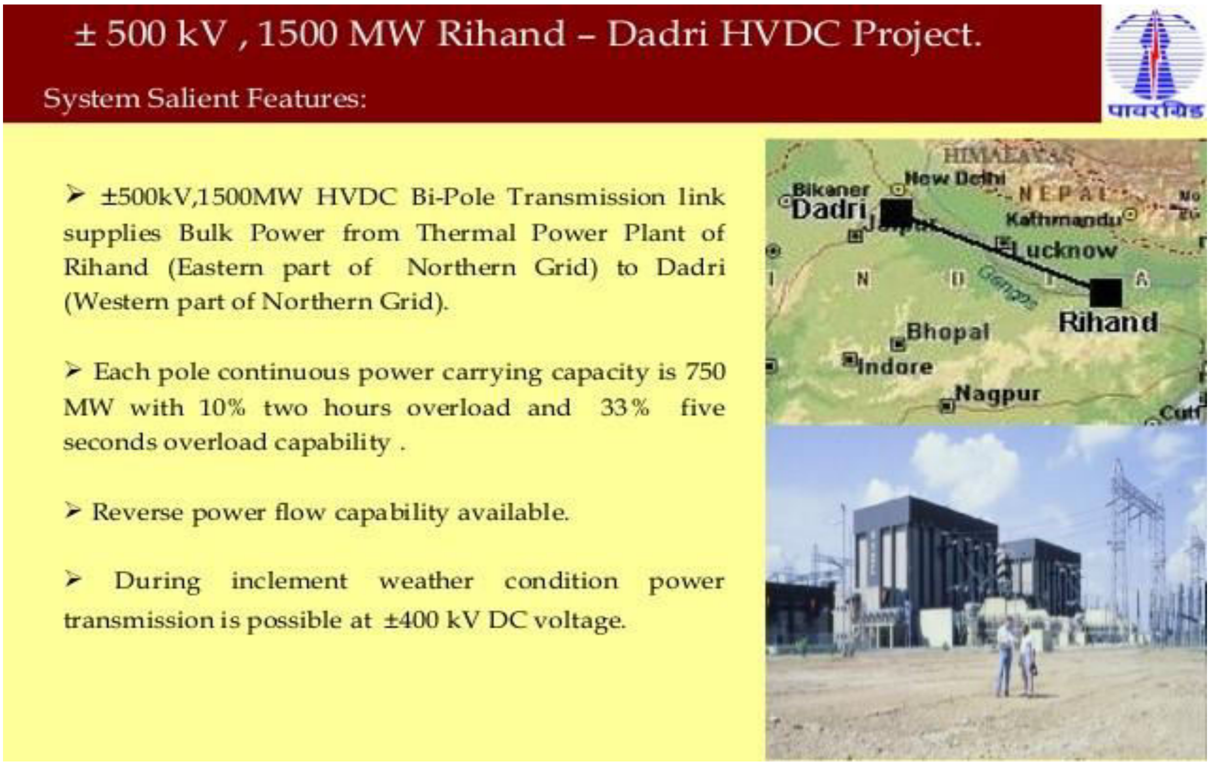


Fig12: DADRI-HVDC Bi-pole Transmission link.

(2) VINDHYACHAL Back to Back Station:

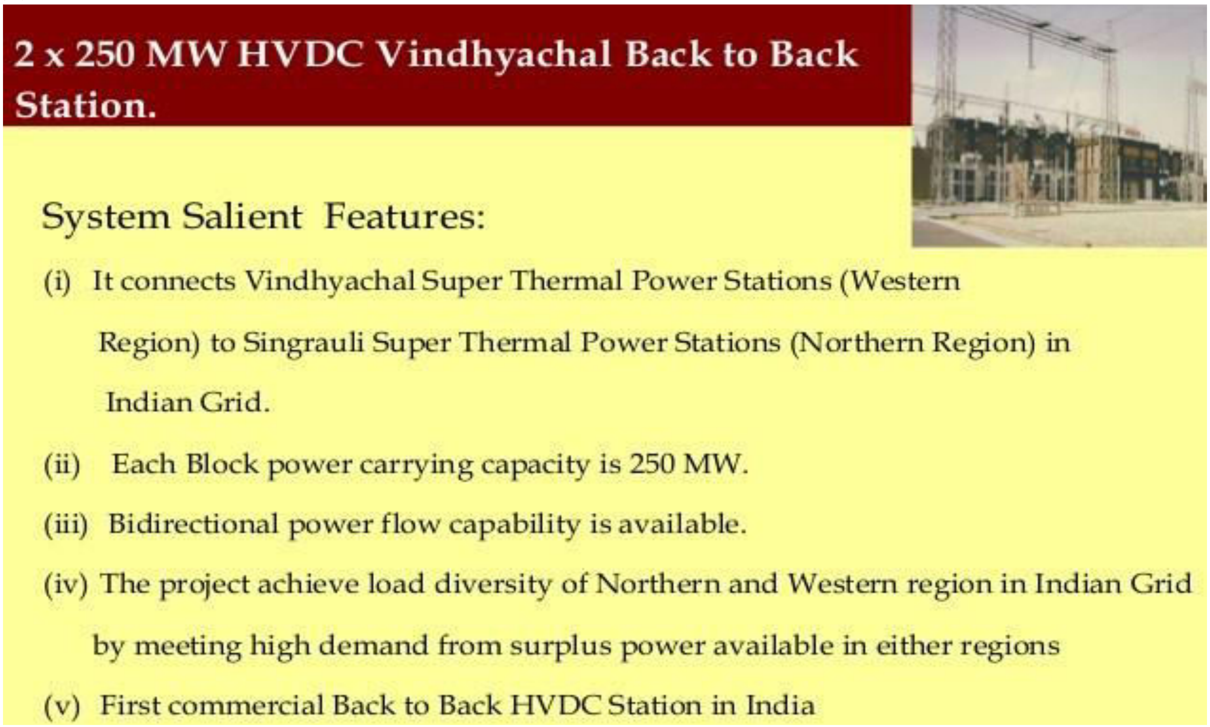


Fig 13: VINDHYACHAL Back to Back Station

7. Advantage of HVDC Transmission

a) cost of transmission is less, since only the conductor used for transmission.
b) There is no reactive power, so transmission losses are reduced.
c)Installation cost is less.

8. Disadvantage of HVDC Transmission

a) High cost converting and inverting equipment are required for HVDC transmission.
b) Converter control is quite complex.
c)Additional filters are required at various stage of HVDC transmission system. So, its lead to high installation cost.

9. Application of DC Transmission

a) Long distance bulk power transmission.
b) Underground or underwater cables.
c) Control and stabilization of power flows in AC ties in an integrated power supply system.

10.HVDC Technology in Electricity Industry

1. Broad measures of intensity (>500 MW) should have been transmitted over long distances (>500 km);
2. Transmitting force submerged;
3. Interconnecting two AC arranges in a non-concurrent manner.
4. HVDC frameworks remain the best sparing and naturally benevolent choice for the above customary applications. Be that as it may, three unique elements - innovation improvement, deregulation of power industry around the globe, and a quantum jump in endeavours to moderate the earth - are requesting an adjustment in believing that could make HVDC frameworks the favoured different option to high voltage AC frameworks in numerous different circumstances also. To expound:
5. Innovations, for example, the VSC based HVDC frameworks, and the new expelled polythene DC links have made it workable for HVDC to end up financial at bringing down power levels (up to 200 MW) and over a transmission separation of only 60 km.
6. Liberalization has expedited different requests the power foundation generally. Transmission is presently a contracted administration, and there is next to no space for deviation from contracted specific and financial standards. HVDC gives much better control of the power interface and is accordingly a preferred path for giving legally binding transmission administrations.
7. Liberalization has expedited the wonder of exchanging to the power area, which would mean bi-directional power exchanges, contingent upon economic situations. HVDC frameworks empower the bi-directional power streams, which isn't conceivable with AC frameworks (two parallel structures would be required).

10. Conclusion

So what is the fate of HVDC? HVDC innovation is (or will be) able to do such establishment, be that as it may, more sides from substantial modern and open spectra should be included to get genuine and most extreme benefit both for the organisations and the general public. In the nearby future, the states will proceed in associating with their neighbours. Then again, more new or present substantial power plants will be at some point or another associated with HVDC (as observed today in India, China, Brazil...). At last, I trust that entire EU will be „interlaced" with HVDC lines, and afterwards, the subsequent stage will happen – an association of these different lines in a single complex framework.

And if the question is when will this happen? Then my answer is I don't have the foggiest idea. An excessive number of variables are included, and when I see the excruciating procedure which goes with relatively every choice and arrangement inside the EU, it won't be easy...however, I am persuaded, that at some point or another the methods will be made, on the grounds that there are issues which should be tackled and HVDC control framework is one (and possibly the just a single) of the arrangements.

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