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Comparative Analysis of HVAC and HVDC Transmission System

ANKIT KUMAR BARNWAL[1], AKSHAY KUMAR[2], DR. NEERAJ TIWARI[3]
[1,2,3] *Department of electrical engineering, Poornima College of engineering, Jaipur, India*

Abstract -- High Voltage Direct Current (HVDC) technology has characteristics which make it especially attractive in certain transmission applications. Alternating current (AC) is the main driving force in the industries and other areas and because of several properties alternating current is considered very reliable as compared to direct current (DC). But for the long transmission lines AC transmission is more expansive than the direct transmission. It is very complicated in case of AC because of frequency. DC transmission doesn't have these drawbacks and because of this we have been using this technology since 40 years. This paper represents the analysis of both HVAC and HVDC transmission systems along with the advantages and disadvantages.

Index Terms: HVDC and HVAC transmission, transmission cost

I. INTRODUCTION

A high voltage direct current (HVDC) electric power transmission system is also known as the power super highway or an electrical superhighway uses direct current for the bulk transmission of electrical power. HVDC is an established technology that has been in commercial use for 60 years. During the first 30 years it was a niche technology with a limited number of installations per year. HVDC transmission is widely recognized as being advantageous for long distance, bulk power delivery, etc. HVDC transmission system has three basic components which are a rectifier station, dc line and an inverter station.

The technology can use overhead lines or underground and underwater cables. There are two types of HVDC transmission systems. The first is the 1) Classic technology using thyristor for conversion and 2) Voltage Source Converter (VSC) technology.

II. HVDC SYSTEM

The basic components of HVDC system are given as Converter, Smoothing reactor, Harmonic filters, Reactive power supplies, Electrodes, DC lines, AC circuit breakers.

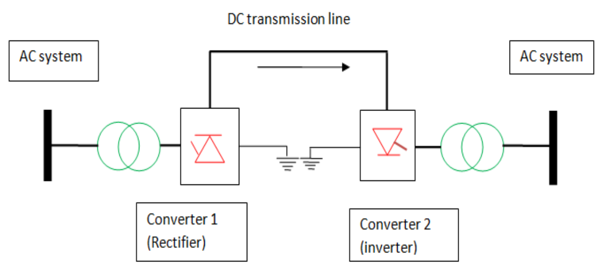


Figure 3: Mono Polar Link

Two AC systems are interconnected by a DC line say A and B. From system A three phase supply is first passed through AC filter. The AC filters reduce the current harmonics generated by the converter. The supply is stepped up through step up transformer. The high AC voltage is converted into high DC voltage by the converter (rectifier).The DC output of the converter is filtered by DC filters and smoothing inductors to eliminate DC ripples. Thus ripple free high DC voltage is obtained. The high dc Voltage is then transmitted through DC transmission line. The DC line has +kV and –kV with respect to ground. This is done in purpose to balance the voltage of two transmission lines with respect to earth. The center line between A and B is earthed. At receiving station, the DC voltage is again filtered and passed through converter (inverter). The inverter output is stepped down and passed through the AC filters. Thus the three phase AC supply is obtained at the receiver side finally.

III. COMPARISON OF HVAC AND HVDC

A long distance point to point HVDC transmission scheme generally has lower overall investment cost and lower losses than an equivalent AC transmission scheme. HVDC conversion equipment at the terminal stations is costly, but the total DC transmission line costs over long distances are lower than AC line of the same distance. HVDC requires fewer conductors per unit distance than an AC line, as there is no need to support three phases and there is no skin effect.

Depending on voltage level and construction details, HVDC transmission losses are quoted as less than 3% per 1,000 km, which are 30 to 40% less than with AC lines, at the same voltage levels. This is because direct current transfers only active power and thus causes lower losses than alternating current, which transfers both active and reactive power.

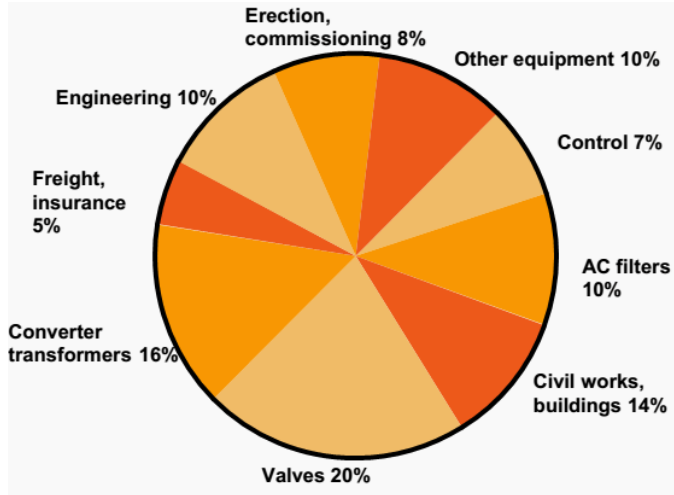
HVDC transmission may also be selected for other technical benefits. HVDC can transfer power between separate AC networks. HVDC power flow between separate AC systems can be automatically controlled to support either network during transient conditions, but without the risk that a major power system collapse in one network will lead to a collapse in the second. HVDC improves on system controllability, with at least one HVDC link embedded in an AC grid—in the deregulated environment, the controllability feature is particularly useful where control of energy trading is needed.

IV. COST STRUCTURE OF HVDC

As we know that the highest cost in constructing HVDC transmission is spent on power electronics and converter transformers.

The cost of an HVDC transmission system depends on many factors, such as:

1. Power capacity to be transmitted,
2. Type of transmission medium,
3. Environmental conditions and
4. Other safety, regulatory requirements etc.



To build a converter station is much more expansive than an ordinary ac substation of similar rating because a better technical performance of a HVDC system needs many more components.

V. COMPARATIVE COST INFORMATION

However the breakeven distance and power transfer level criteria and the comparative cost information should be taken in proper perspective, because of the following reasons

1. Conserve the environment
   In the present industry environment of liberalized competitive markets and heightened efforts to conserve the environment. In such an environment, the alternative for a transmission system is an in-situ gas-fired combined cycle power plant, not necessarily an option between an AC transmission and a HVDC one.

2. System prices
   Second, the framework costs for both AC and HVDC have differed generally notwithstanding for a given level of energy exchange. For instance, a few distinct levels of undertaking costs have been brought about for a HVDC framework with a power exchange limit of 600 MW.

3. Technological developments
   Third, innovative advancements have tended to push HVDC framework costs descending,

while the natural contemplations have brought about pushing up the high voltage AC framework costs.

VI. ADVANTAGES AND DISADVANTAGES

A. ADVANTAGES

- Simpler line construction
- No charging current
- No skin effect
- Cables can be worked at high voltage gradient
- Low short circuit current on DC line
- Low corona loss
- Low radio interference
- Line power factor is always unity

B. DISADVANTAGES

- Converters are expansive
- Multi-terminal operation is not easy
- Harmonics is generated in this system so it requires filters
- DC circuit breakers are not easy to manufacture

VII. CONCLUSION

Long distances are technically unreachable by HVAC line without intermediate reactive compensations. The frequency and the intermediate reactive components cause stability problems in AC line. On the other hand HVDC transmission doesn't have the stability problem because of absence of the frequency and thus no distance limitation. The cost per unit length of a HVDC line is lower than that of HVAC line of the same power capability and comparable reliability, but the cost of the terminal equipment of a HVDC line is much higher than that of the HVAC line. The breakeven distance of overhead lines between AC and DC line is range from 500km to 800km. The HVDC has less effect on the human and the natural environment in general, which makes the HVDC friendlier to environment.

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