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# Integration of HVDC System with Renewable Energy

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**Abstract:** Metro cities needs bulk amount of electricity to function. This need is fulfill by transmission of power from generated sites located in remote areas hundred or even thousands of kilometers away. Now the question is how to transfer large amount of power from renewable energy sites like wind parks, hydro plant and solar parks without affecting the power network balance. The answer to this question is integration of HVDC with renewable energy. HVDC Transmission plays an important role in transmitting bulk amount of power over a long distance using different HVDC links. This paper discusses the integration of HVDC with Renewable energy, different DC link configuration and different HVDC projects in the world.

**Keywords:** HVDC (High Voltage Direct Current), Renewable energy.

## I. INTRODUCTION

One of the challenges of renewable power generation like wind and solar power is that it can be interrupted, and this variability affects the stability of the power produced. FACTS devices address network capacity and stability as more renewable energy is brought online. Power grids are facing a major transformation, driven by the need to integrate renewable energy, improve energy efficiency and allow consumers more control over their energy consumption. As it evolves, the “smart grid” will combine established power technologies with advanced analytics, smart devices and automation technologies to create a power system that is more reliable, flexible, secure and efficient, and has a lower impact on the environment. FACTS technologies such as Static VAR Compensators and Series Capacitors enable more power to flow through existing power lines while improving voltage stability, and also make a power network more resilient to ‘system swings’ and disturbances.

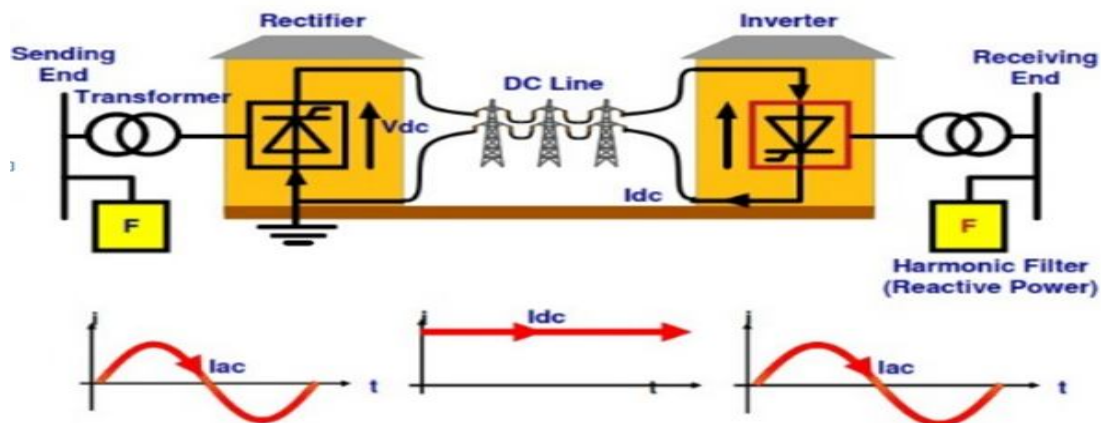


Figure1. Basic HVDC Transmission system point to point

Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits. The results of a recent review of the literature concluded that as greenhouse gas (GHG) emitters begin to be held liable for damages resulting from GHG emissions resulting in climate change, a high value for liability mitigation would provide powerful incentives for deployment of renewable energy technologies. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power. At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. Some places and at least two countries, Iceland and Norway generate all their electricity using renewable energy already,

and many other countries have the set a goal to reach 100% renewable energy in the future. For example, in Denmark the government decided to switch the total energy supply (electricity, mobility and heating/cooling) to 100% renewable energy by 2050.

## II. TECHNOLOGY OF CHOICE

Offshore wind generation - particularly far out at sea where the wind is strong and steady - is an enormous potential power resource. For distances of more than 100 km or for large power levels, HVDC Light transmission has emerged as the technology of choice to link it to the grid. FACTS is a good option for shorter distances and lower power levels. For example, ABB has just built a 400-megawatt transmission link using HVDC Light technology for a wind park 130 kilometers off the German coast. When commissioned in 2010, wind-generated electricity from Borkum is expected to displace 1.5 million tons of CO<sub>2</sub> emissions each year by replacing electric power generated from fossil fuel on the mainland. With HVDC Light, high power levels generated offshore can be fed into the network without destabilizing it. Nor will intermittent offshore electricity generation disrupt the grid. HVDC Light transmission systems are also extremely efficient, with very low transmission losses, even over long distances. 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.

## III. INTEGRATION OF RENEWABLE ENERGY SOURCES WITH HVDC SYSTEM

The integration of large amounts of renewable energy sources poses several challenges to system planners.

However, the benefits of this generation, combined with government incentives and mandates, demand that system planners embrace these developments and overcome these challenges. The major challenges related to the integration of large amounts of renewable energy sources are:

- A. Conventional long range planning generally starts with a reasonably well defined generation development plan. Long range development of renewable energy has a much larger degree of uncertainty in terms of amount, location, and technology.
- B. Large generating stations are generally sited with transmission access in mind. Renewable energy sources are, of course, sited where their energy supply is plentiful, for example the siting of wind farms in areas where there is strong and consistent wind. These areas tend to be distant from major load centers and often are areas with weak transmission systems.
- C. The electrical characteristics of conventional generation technology have seen improvements in materials and efficiency, but the basic characteristics have remained the same and are expected to be similar in the future. The electrical characteristics of renewable generation technologies are undergoing rapid development and will likely be significantly different in the future. Thus the planning process must be adjusted to accommodate these uncertainties.

## IV. DIFFERENT DC LINK CONFIGURATION

A. HVDC links can be broadly classified into

- 1) Monopolar links
- 2) Bipolar links
- 3) Homopolar links
- 4) Back-to-back links
- 5) Monopolar Links:

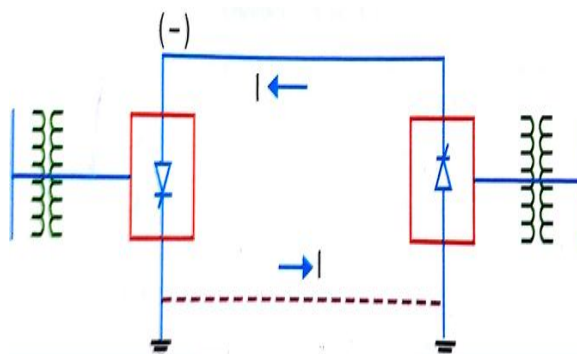


Figure2. Bipolar link

- 6) It uses one conductor
- 7) The return path is provided by ground or water
- 8) Use of this system is mainly due to cost considerations
- 9) A metallic return may be used where earth resistivity is too high
- 10) This configuration type is the first step towards a bipolar link.

**B. Bipolar links**

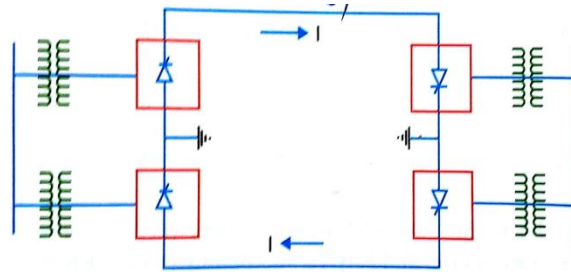


Figure3. Bipolar link

- 1) It uses two conductors, one positive and the other negative
- 2) Each terminal has two converters of equal rated voltage, connected in series on the DC side
- 3) The junctions between the converters is grounded

**C. Homopolar links**

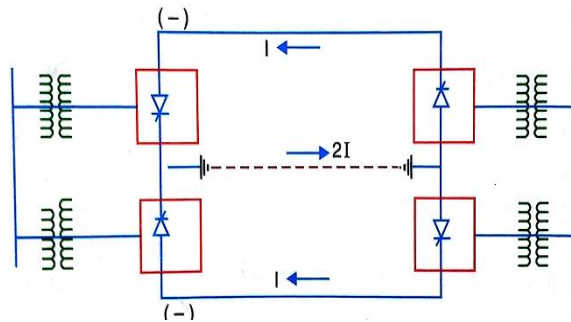


Figure4. Homopolar link

- 1) transmission lines is less for negative It has two or more conductors all having the same polarity, usually negative
- 2) Since the corona effect in DC polarity, Homopolar link is usually operated with negative polarity
- 3) The return path for such a system is through ground

**D. Back-to-Back Links**

- 1) Used to connect asynchronous system with different frequency.
- 2) The length of back to back connection is kept very small
- 3) Heps to achieve the connection between any asynchronous system

**V. HVDC PROJECTS IN INDIA.**

India's first high-voltage, direct-current (HVDC) transmission line, connecting the northern states with the north-eastern ones, will be operational on August 31. The 800-kv, 6,000-MW line was built by Power Grid Corporation of India at an investment of R12,000 crore. "The high-capacity (800-kV, 6,000-MW) HVDC bipole line is being implemented from Bishwanath Chariali in Assam to Agra in Uttar Pradesh through Alipurduar in West Bengal. The high-voltage corridor would facilitate transfer of 24,000 MW from future generation projects in the north-eastern region and Bhutan," said a senior Power Grid official. M The corridor shall integrate the north-eastern region with other regions of the country to facilitate smooth and reliable power transfer, giving rise to a stable national grid. The nature of control of power flow of the HVDC interconnection provides additional flexibility in grid

operation, thereby improving various grid parameters. The link will act as a highway from the north-eastern region to the rest of the country and shall play a significant role in the hydro potential in the north-eastern region. The transmission project, connecting 1,728 km, was started in September 2013 and is nearly complete. Currently, only China has such a high-voltage transmission corridor. Two more such corridors are likely to come up in India, which include Champa-Kurukshetra (1,350 km) and Raigarh-Pugalur-New Trichur (1,600 km). “There was a need to interconnect the north-eastern grid with a strong, reliable and secure interconnection with the rest of the Indian grid, which would also take care of the large potential of hydro power in the region,” the Power Grid official explained. Currently, the north-eastern states are generating about 2,000 MW, while demand is around 1,610 MW. In the future, the HVDC line could help to evacuate electricity to the tune of 50,000 MW and supply to power-deficit northern states. Government-owned BHEL and Switzerland-based ABB have supplied equipment for the project. The line has overcome a major hurdle by passing through the chicken-neck area in Siliguri district of West Bengal. The HVDC interconnector will facilitate bidirectional control flow of power, which means it can transfer power from the north-eastern region when it is in surplus during the high hydro period of the year. On the other hand, the north-eastern region can also import power from other regions, particularly in the lean hydro period of the year.

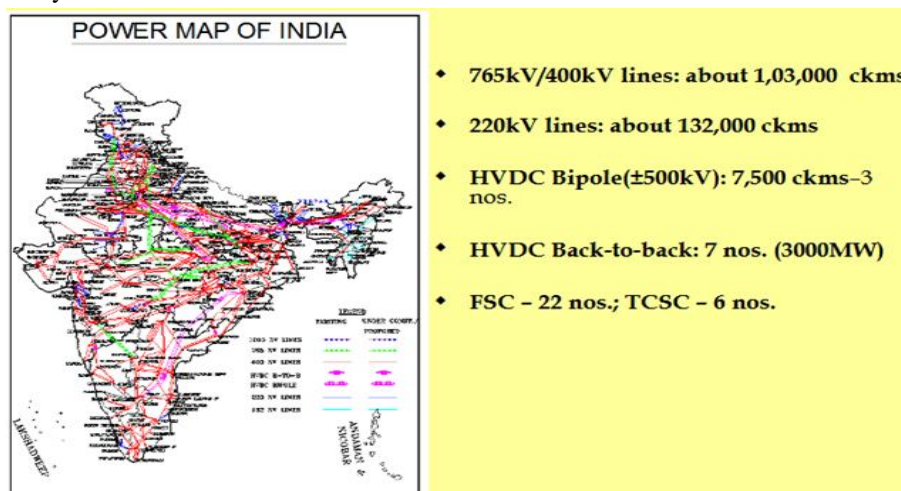


Figure5. Power Map of India

## VI. CONCLUSION

In this paper the integration of HVDC with Renewable energy is discussed, different DC link configuration and different HVDC projects in the India.

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