

# HIGH VOLTAGE DIRECT CURRENT (HVDC) AND FACTS

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**Abstract:** Electricity is an essential source of energy for modern life, and High Voltage Direct Current (HVDC) & Flexible AC Transmission Systems (FACTS) represent advanced technologies that are shaping the new age electrical power transmission & distribution. The benefits of HVDC technology over its HVAC counterpart in long-distance and high-capacity power transmission are obvious, as it offers lower transmission losses, increased stability and possibility to interconnect systems operating on different frequencies. HVDC helps to reduce these energy losses by changing AC to DC before sending it long distances, switching it back to AC and only converting the power once, for example when receiving power from remote renewable energy sources. In general, Flexible AC Transmission Systems (FACTS) are utilized to reduce power losses, increase the loading of transmission lines so that it will provide more security and control gives makes the system flexible. The FACTS devices for the AC systems enhance control and damp out power quality issues, to level of optimization in the performance of an existing system such as Static VAR Compensators (SVC), the Unified Power Flow Controllers (UPFC). AC/DC hybrid technologies: These are the key to controlling power flow, maintaining voltage stability and increasing AC network transmission capacity substantially without major new transmission lines. In the absence of it, HVDC and FACTS works together to meet growing needs for reliable, efficient and sustainable energy transmission. They support the integration of renewable energies, provide benefits for grid stabilisation and facilitate security of supply thanks to a networked configuration of resilient controls. This article presents the benefits, application and impact of HVDC & FACTS technology on global power transmission view..

**Keywords:** Power Transmission, AC Transmission, Flexible AC. HVDC Tech, Power Flow, Advanced Tech, Network

## I. INTRODUCTION

In the world of growth, we know that growth required humanity, respect and much more, but in the growth of a nation or world a major part under-consideration is electricity. A nation or the world is said to be in growth by saying amount of electricity development has happened. The major part of the electricity production is not about generation or utilization it is also about transmission of the power. This transmission is either done in HVAC or HVDC. HVDC (high-voltage direct current) technology is changing the electricity transmission landscape across large distances by providing a more efficient and reliable solution as compared to traditional AC systems.

HVDC is widely used in sending renewable energy because AC power generation comes from turbines and some alternative sources (Wind, Solar etc.) where it suits to convert into DC for long distance to avoid system losses as well as grid stability. In today's energy landscape, HVDC systems loom large as key enablers to the widespread transport of vast quantities of electricity without the very high losses that using AC would involve. This is especially useful in conjunction with the main power grid (for example when coupling energy from offshore wind farms or distant solar arrays) where the grid will still be needed as a major backup - just like before. Secondly, HVDC technology enables the interconnection of regional or national grids which provides an efficient exchange of energy and contributes to the resilience of the grid.

With sustainable and dependable energy increasingly required, HVDC technology is essential for the future of power transmission to transport clean power in an efficient manner to support the growing global need for electricity.



HVDC Power Line



FACTS Power Line

**II. HISTORY OF HIGH VOLTAGE DIRECT CURRENT**

In the year of 1831, we had come across a law named “Law of Induction” which was discovered by Michael Faraday in England. Later in 1880, Thomas Alva Edison using the law introduced first substation of DC supply in New York City. In the following years AC system was introduced by Nikola Tesla and the era was called as the “War of Currents.” Later in the future many invocation was taking place such as microcomputer based control equipment for HVDC in 1979, Then highest DC transmission voltage in brazil around 1984. One of the pillars HVDC is that it have the ability converts AC electricity to DC electricity at one end of transmission line and transmit power over a long distance with easier and less loss and then reconvert DC into AC at the receiving end. This technology allows long-distance transfer of bulk power between regions connecting remote renewable energy sources to heavy-duty population centres and large industrial areas.

Some of the benefits that HVDC offers compared to traditional AC transmission are outlined above (i.e., reduced transmission losses, improved control over power flow, and ability to connect asynchronous AC grids.) In addition, HVDC helps integrating renewables such as wind or solar by providing an efficient way of sending their energy from vast and remote locations to areas of high demand. With the economic and environmental advantages, the evolving technology of HVDC has further to offer with continual advances in converter technology, control systems as well as grid integration solutions. As demand for global supremely reliable and sustainable energy grows, HVDC remains central to the narrative of shaping a future of efficient electricity transmission and distribution.

**III. Difference between HVDC and FACTS**

HVDC	FACTS
Lower Transmission losses	High initial cost
Efficient long-distance Transmission	Complex Technology
Improved Grid Stability	Limited applicability for short distance

**IV. High voltage Direct current also called as HVDC**

1. **Pioneering Technology:** The first commercial HVDC transmission system, originally built in 1954 and in operation continuously for more than 60 years was developed by ASEA between the Swedish mainland and the island Gotland. This early system proved that HVDC could work well for long distance power transmission.
2. **Power Electronic-based DC Transmission-** HVDC technology is being used globally, some of the projects are to mention Europe, North America, Asia And Africa. It is used to interconnect renewable energy sources, such as wind farms and hydroelectric plants with the main grid.
3. **Record-Breaking Projects:** The world's largest HVDC transmission range 2071 km is Xiangjiaba-Shanghai project-China One of the most powerful HVDC links in the world with a capacity of 6,400 MW

4. Space efficient Subsea Transmission: HVDC is the most preferred technology for subsea power cables, e.g., the North Sea Link connecting Norway to UK. These projects are a demonstration of the long-range underwater power transmission capabilities of HVDC with minimal losses.

5. Renewable Energy Integration -> HVDC systems are very critical for the integration of renewable (solar, wind) to the power Grid. The DoIWin3 project in Germany is an interesting example, connecting offshore wind farms in the North Sea to the German grid through HVDC instead of running high voltage AC transmission cables (HVAC) over long distances to ensure efficient power transmission.

## **V. Flexible Alternating current Transmission also called as FACTS**

FACTS fact

1. Provides grid stability by improving dynamic control of voltage and reactive power. This helps maintain system stability under varying operating conditions.
2. Transmission capacity increases by the technologies as they optimize power flow and voltage control.
3. The major role that FACTS plays is to stable the power quality, where there are major fluctuations in the power quality the FACTS provide Grid unity.
4. Where DC moves in liner way and has late response time to the outcome here in FACTS the response time is busted up by 100X which help to protect and enhance the grid safety.
5. One of the major importance is the cost-effective sector, where the DC is highly costly whereas AC is economical and widely used in all kind on machineries.

## **CONCLUSION**

In conclusion, both High Voltage Direct Current (HVDC) and Flexible AC Transmission Systems (FACTS) are two side of the coin, both being the part of growth plays important role in the society. HVDC is the side where the transmission is allowed or preferred to be for long distance and offers a high efficiency in cost cutting and ecofriendly. Its ability to convert AC to DC for transmission and back to AC for distribution enhances grid stability and facilitates the integration of renewable energy into existing power networks. On the other hand, FACTS provide dynamic control of voltage and reactive power, enhancing grid stability, increasing transmission capacity, and improving power quality.

Together, HVDC and FACTS plays a major role in the society and offer major advantage in the growth of the nation and working conditions.

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