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High-voltage Direct Current Transmission Technology

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Abstract – HIGH VOLTAGE DIRECT CURRENT(HVDC) TECHNOLOGY has characteristicsthat make it especially attractive for certain transmission applications. HVDC transmission is widely recognized as being advantageous for long distance bulk power delivery, asynchronous interconnections, and long submarine cable crossings. The number of HVDC projects committed or under consideration globally has increased in recent years reflecting a renewed interest in this mature technology. New converter designs have broadened the potential range of HVDC transmission to include applications for underground, offshore, economic replacement of reliability-must-run generation, and voltage stabilization. This broader range of applications has contributed to the recent growth of HVDC transmission. There are approximately ten new HVDC projects under construction along with many more projects underway globally.

Keywords: Interconnection of HVDC across the globe , New Technologies in HVDC, World Wide Projects on HVDC.

I. INTRODUCTION

AC system is used in the transmission of bulk power, instead of DC (Direct Current), because of its ability to transform voltage to various levels using a transformer. The voltage transformation follows the faradays Law which states; the emf induced in a circuit is directly proportional to the time rate of change of magnetic flux through the circuit.
Ability to transform voltage and to flow power in two opposite directions (bidirectional) are the only major advantages of AC system over DC system. DC transmission system on the other hand has more advantages over AC transmission system.
The industrial growth of a nation requires increased consumption energy, particularly electrical energy. This has lead to increase in the generation and transmission facilities to meet the increasing demand. The generation can be increased to the required level but the problem is in transmission due to the thermal limit, because the transmission line loadability is fixed up to 60% of the power to be transmitted.

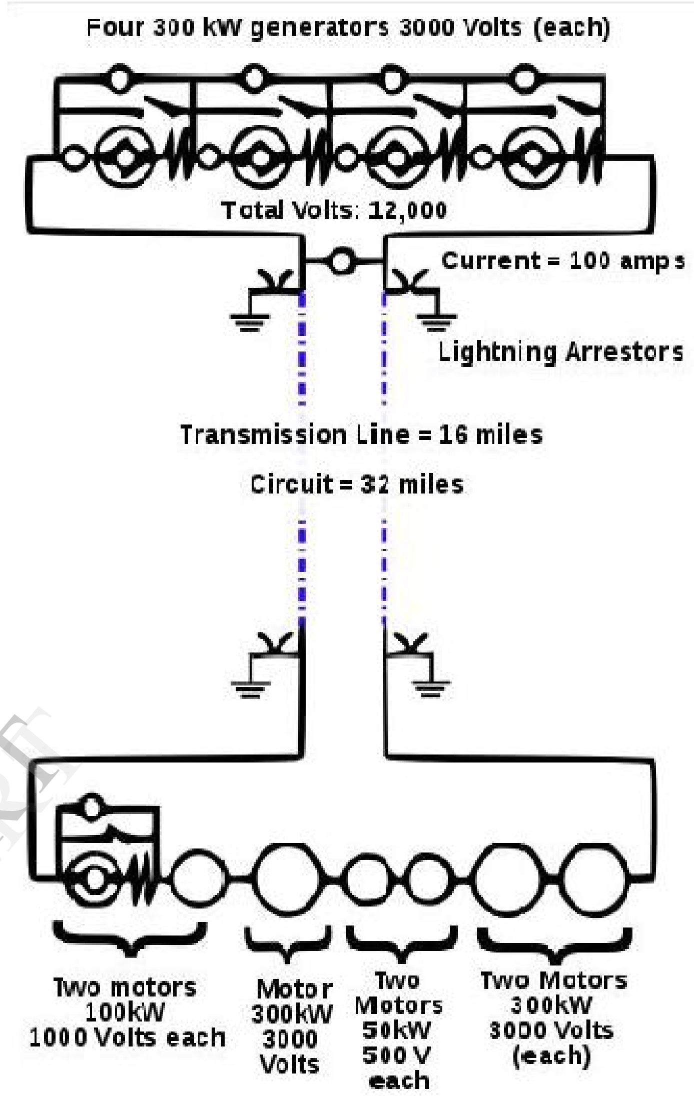
II. HISTORY

The first transmission of direct current was in 1882, distance was 50 km long (distance between Miesbach-Munichbut) and voltage level was only 2 kV. DC transmission was developed by Rene Thury. This scientist created own method, which based on series-connected generator and was used in practice by 1889 in Italy. System based on Thury's idea transmitted 630 kV at 14 kV over project distance 120 km. The next important was line Mountiers-Lyon in France which was working between 1906 until 1936. Mountiers power plant had eight generators which was connected in series. Line of

Mountiers-Lyon connected hydroelectric power plant, transmitted 8600 kW, had 200 long kilometers and voltage between two poles was 150 kV. In sum was built fiftee similar systems. Other systems worked at up to 100 kV DC, and was using to 30s'. Economical and technical low efficiency caused that Thury's systems was withdrawal, but despite those reasons – it was little commercial success.

The next era, was attempts with mercury arc valve. The first such technology was put in 1932 by General Electric, which tested mercury-vapor valves in 12 kV DC line. System could convert current from 40 Hz to 60 Hz frequency. This installation worked in Mechanicwille, New York. In 1941 existed underground DC (with mercury arc valves) connection in Berlin, but due to war project was never completed.

Crucial moment in development of HVDC was in 1954. This moment began era of static mercury arc valve. This system was created by ASEA and connected Sweden with island Gotland. Up to 1975 had used technology based on solid-state devices. From this time to 2000 had been lasting era of thyristor valves. Future probably will belong to commutated converters.



III. COMPOTENTS AND RECTYFING/INVERTINGSYSTEMS

HVDC using mercury arc rectifiers but the most modern way are thyristors. Thyristor is a solid- state semiconductor, similar to the diode, but has particular property in control of AC cycle. The insulated-gate bipolar transistor (IGBT) is simpler and cheaper way of control.

Rectifying and inverting systems usually use the same devices. *At the AC end a set of transformers, often three physically separate single-phase transformers, isolate the station from the AC supply, to provide a local earth, and to ensure the correct eventual DC voltage. The output of these transformers is then connected to a bridge rectifier formed by a number of valves. The basic configuration uses six valves, connecting each of the three phases to each of the two DC rails. However, with a phase change only every sixty degrees, considerable harmonics remain on the DC rails. An enhancement of this configuration uses 12 valves (often known as a twelve-pulse system). The AC is split into two separate three phase supplies before transformation. One of the sets of supplies is then configured to have a star (wye) secondary, the other a delta secondary, establishing a thirty degree phase difference between the two sets of three phases. With twelve valves connecting each of the two sets of three phases to the two DC rails, there is a phase change every 30 degrees, and harmonics are considerably reduced.[1].* In elements which take share in conversion, are applied filterswhich limit harmonic in DC cycle.

IV. ADVANTAGES AND DISADVANTAGES

The advantage of HVDC than AC is ability to transmission big amount of power on long distances with lower wastes. DC technology is better in such situations:

- undersea connections
- power transmission and stabilization between unsynchronized AC distribution system
- connection generating plants remote from power grid
- stabilizing AC grid
- connection between countries with different current frequency/voltage
- synchronize AC produced by renewable energy sources Long underwater lines have a high capacitance. In AC transmission is required process of charging and discharging,

what is causes of power losses. HVDC has minimize this effect. In AC lines occurs also dielectric losses.

To disadvantages of HVDC we can include conversion, switching and control. Static converters are expensive. In short distances losses in static inverter may be even bigger than in AC transmission. In the future static converters will be replaced by thirystors.

In DC system controlling of multiterminal configuration is quite hard, because required good communication between terminals.

Also circuit-breakers are difficult than AC.

V. ECONOMICAL ASPECTS

Is not simple estimate a cost of buildings HVDC transmission line and operations unit. Cost are very different and depends on power of line, length connection, environment of track wires (air or water) and so on. Usually the biggest producers of high-voltage direct current transmission as Areva, Siemens or ABB don't reveal financial information about investments. Despite narrow basement of information, we can estimate some costs of builtDC line, which is show on Fig.

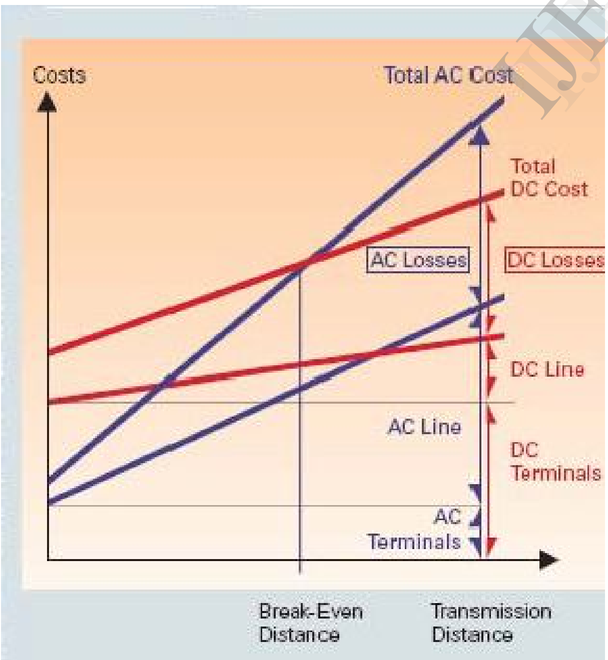


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Fig.3 Relation between length of line and costs in AC and DC line

About 50% cost of DC structure are converter transformers, valves and infrastructure as buildings.

VI. APPLICATIONS

HVDC system can connected unsynchronized grids, therefore such lines very often are natural boundaries between countries. DC line is also meeting in places where is require undersea transmission (e.g. wind farm) and between two long distant points. From such reasons was built grids e.g. in Siberia, Canada, Australia or Scandinavia. Problem of synchronized AC because of different frequency system occur e.g. in Japan, North America, South American (enormous hydroelectric power plant) – between Brazil and
Paraguay In Europe the most lines are between UK, Scandinavia and continental Europe.

*Fi*g 4. Nicolet convert station in transmission line Québec - New England

VII. CONCLUSIONS

Today HVDC is very important issue in transmission energy. In near future this technology probably will be develop very intensive. Influence on future may have intensive spread of renewable energy source, also wind farm which need undersea connections. Also problem of cascade blackout, can be reduced by application of HVDC. Intensive, very large investments in e.g in China and India shows that high-voltage direct current will very important in the future, especially in big, new-industries countries.

VIII. REFERENCES

[1] http://en.wikipedia.org/wiki/HVDC
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3]www.areva.com