

J. Basic. Appl. Sci. Res., 3(8)840-843, 2013 © 2013, TextRoad Publication

# To Investigate Environmental effects of HVDC versus HVAC Transmission Systems

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# ABSTRACT

Alternating current (AC) has few drawbacks which have increased the demand of Direct current (DC) Transmission. The normal HVAC range is between 220-800 kV .This high voltage has to pass different types of terrains including settled area, mountains and water. It is quite clear that human beings and environment will be effected from this huge voltage. The common effects of these huge voltages are magnetic fields, electric fields, corona effects, RF interference, acoustic noise, and electromagnetic interference. This paper discusses the technical details of high voltage DC (HVDC) transmission versus high voltage AC (HVAC) transmission in terms of environmental effectson people and surrounding.

KEYWORDS:HVDC Transmission, High Voltage transmission, Corona effects, Electric fields.

# I. INTRODUCTION

Due to generation of electricity, Electric and magnetic fields (EMF) are created. Magnetic fields and Electric fields are formed due to motion and presence of electric charges .These time varying fields are influenced by number of parameters such as magnitude, phase frequency and direction. Electric transmission is basically the transfer of electrical power in bulk form from generating units to substations located near to Load centers. The interconnection of Transmission lines forms together HVAC transmission networks. The transmission Network is named as "power grids" in the USA, while in the UK these networks is called "national grid." It is a usual practice to step up voltage above 110 kV in order to reduce the loss in energy during far away transmission.

An electromagnetic field consists of electric and the magnetic fields. The electric field does not depends on the amount of current flowing through conductors but depends on potential difference between charge-carrying bodies where as magnetic field has a relation with the amount of electric current passing through the conductor irrespective of the presence of voltage.

Electric field strength is normally measured in (Volt/meter) or in kv per meter (1 kilovolt/meter = 1000 V/m). Magnetic fields are normally represented by magnetic flux density (B) or magnetic field strength (H); both have a direct proportion to the magnitude of the current. B is calculated in the centimeter-gram-second unit, the gauss (G), or the unit of the System International

(SI), the tesla (T); 1 mG = 1 x 10  $G = 0.1 \mu$ T. H is calculated in SI units of (Amperes/meter). B and

H forms a relationship:  $B = \mu 0H$ , where  $\mu 0 = 1.26 \times 10^{\circ}$  H/meter is the magnetic permeability of a vacuum. Normally,  $\mu 0$  remains the same for air and human tissues, and only one of the variables, B or H, need to be calculated. Magnetic field refers to the magnetic flux density in microtesla ( $\mu$ T; 1  $\mu$ T =  $\frac{-6}{10}$ 

1 x 10 T), current voltage, and magnetic flux are taken in (root mean square value) as shown in eqt (A).

$$B_{rms} = \sqrt{1/T} \int_{t=0}^{t=T} B(t)^2 dt$$
 (A)

Where B(t) refers magnetic flux density and T is the time for an integral over a number of periods of the fundamental frequency.

Typical 60 Hz or 50 Hz electric fields are less than 100 V/m in homes and are not greater than 10 kV/m beneath a high voltage Power line i.e. 500 Kv. However the Line staff and those people who work very close to high power line can experience internal electric fields in the range of  $10^{-3}$  V/m [1].

Corresponding Author: Ahmed Bilal Awan, COMSATS Institute of IT, Islamabad. ahmed.bilal@comsats.edu.pk, Tel: +92-345-8554471 This research paper examines the effects of HVDC versus HVAC Transmission systems on environment and people.

# II. PROBLEM STATEMENT

Nancy Wertheimer and ED Leeper were the first authors to show a possible relation between childhood cancer and High Electric lines (HVAC) when they published their paper in 1979 [9]. They observed that due to high power lines childhood cancer might increases. After that other authors from different countries including USA, Canada, New Zealand, have investigated the effects of Low Frequency Magnetic Fields (ELF - MF) on childhood diseases. Although difference diseases' like central nervous system tumor, Leukemia in children were deeply investigated but acute lymphoblast leukemia (ALL) in children was their main focus.

In order to estimate the intensity of Electromagnetic fields Scandinavian authors Feychting and Ahlbom (1993) [10], Olsen et al (1993) [11], Verkasallo et al (1993) [12], and Tynes and Haldorsen (1997) [13], used calculations based methods. As according to early findings which indicated an increased danger of childhood diseases (Wertheimer 1979) and other Authors concluded that there is a decreased risk of Cancer related diseases' among children exposed to Magnetic field generated by Low Electric lines inside homes (Olsen 1993, Verkasalo 1993, Tynes 1997).However Children living in developing countries in industrial cities are directly exposed to High voltage Power lines due to negligence in housing safety precautions is very dangerous to their health. [2].

In Paper [2-3] it is clearly investigated that there is increased danger of ALL (acute lymphocytic leukemia) due to residing near high voltage overhead Electric lines. Risk factor has a direct relationship with the magnitude of voltage of the Electric lines i.e 132 KV, 230 KV,400 KV and 800 KV. Normally Distance of 600 m away from Electric lines lower the danger of ALL (acute lymphocytic leukemia) by 0.61folds. Draper investigates that distance of 600 meter is the thresh hold value for measuring risk factor (Draper et al., 2005) [14]. It is clear that distances  $\leq$  500 meter and Magnetic Fields > 0.45  $\mu$ T are two important threshold limits specially for the risk of acute leukemia's in children.

Table 1, shows number of cases of Leukemia and central nervous system tumor among people living close to (220- 400) kV electric lines in Sweden is shown [4].

Diagnosis	Number
Leukemia	325
AML	72
CML	57
ALL	14
CLL	132
Other	50
CNS Tumor	223

Table 1.Number of cases
in Sweden 1960-1985.

\*AML = acute myeloid,CML=chronic myeloid leukemia, ALL =acute lymphocytic leukemia, CLL= chronic lymphocytic leukemia.

# III. HIGH VOLTAGE DC VERSUS HIGH VOLTAGE AC IN TERMS OF ENVIRONMENTAL EFFECTS

High Voltage Direct Current (HVDC) technology is suitable for certain applications due to its certain advantages. It is mostly suitable for long-distance, weak link interconnections and underwater crossings. Due to availability of polyphase circuits and Induction Motors in 1880s and 1890s DC lost its initial supremacy and alternating current (AC) defeated the DC due to its greater use. The HVDC projects implemented or under consideration around the world have raised showing interest in the ability of this modern technology

HVDC transmission systems uses two technologies one is voltage sourced converters (VSC). And other is current source converters (CSC).

High voltage Transmission line has two important parameters Current and voltage .Due to skin effect phenomena the conductor DC resistance is less than conductor AC resistance which results in greater loss for AC transmission [5-6].

The combine effects of high voltage transmission systems which include acoustic noise, magnetic fields, corona effects, RF interference, electric fields, and electromagnetic interference, is compared with respect to AC and DC transmissionin the following section.

## A. MAGNETIC FIELD:

The magnetic flux density is in inverse proportion to the distance from the conductor. For  $\pm$  450 kVDC transmissions line the flux density is about 25 µT, whereas the magnetic field strength of an AC Electric line changes from 10 to 50 µT.

#### B. ELECTRIC FIELD:

The AC Conductor has its peak electric field beneath the conductor around 20 kV/meter for a  $\pm$  450 kV Electric line. The electric field normally changes according to weather and also increases and decreases with humid temperature. DC has fewer electric field problems compare with that of AC because of the constant current phenomena; thus HVDC needs less right-of way (ROW) than horizontal HVAC apparatus and lower Tower height compare with HVAC Electric line of similar rating. To find the ionic current passing through a human being standing beneath an HVDC line at voltage level of  $\pm 1000$  kV (kilo-Volts) and the capacitive current beneath an HVAC line at a voltage 1150 kV measurements were calculated. These tests concluded that difference in current between the two systems was approximately 100-fold (2-3  $\mu$ A for the HVDC line and 0.2 mA for the HVAC line) [6-7].

#### C. CORONA:

Corona effects generated on the surface of Electric power lines produces radiated noise. Corona process depends on the magnitude of the electric field strength, its surface characteristics, the diameter of the line, and weather conditions. Corona effect is produced only by conductors having positive poles in HVDC Systems whereas in an HVAC transmission systems Corona is produced by three phases of A.

### D. RADIO, TV, AND TELEPHONE INTERFERENCE:

Parasitic current which is produced due to fast switching process of Thyristor valves (High voltage DC Converters) involving voltage changes and commutation process produces harmonics in the kilohertz and megahertz area of the radio-frequency spectrum. Due to Converter Transformers these high frequencies transfer to the Electric lines. Radio interference is normally lowered by electromagnetic shielding of the Thyristor valves. The radio-interference level of an HVDC over head Electric line is less compare with HVAC overhead Electric line. The value is 40 dB ( $\mu$ V/m) for 0.5MHz, 300 meter away from a conductor for HVDC, and it is 50 dB ( $\mu$ V/m) for 380 kV HVAC overhead Electric line [6-7].

#### E. ACOUSTIC NOISE:

The allowable limit of the acoustic noise is generally between 35 and 45 dB (A) but it depends on the local atmosphere for any industrial plant .The HVDC transmission system is composed of many equipments and parts which can create noise. Transformer is the main source for the production of noise, and this noise is due to the core flux density. Due to converter transformers, sum of load noises is approximately 10 dB (A) higher than the no load noises, and the frequency content of the emitted noise is evenly spread over 300 to 3000 Hz. The noise problem can be solved with the help of best quality standard equipments, to shield a room or separate the noise producing equipment by a distance. A common HVDC system has a noise intensity less than 10 dB (A) at a distance around 350 m .Bad weather can decrease the Noise levels in a HVDC Electric lines, unlike the noise levels on HVAC Electric lines [8].

## IV. CONCLUSION AND FUTURE WORK

This paper clearly shows that there is little risk of magnetic fields by ordinary domestic electric lines but high voltage Electric power lines is a great danger in this regard. High Electric lines above 132Kv can be potential hazards to human beings and children if proper safety distance and

precautions are not maintained. The HVDC and HVAC comparison shows that former has fewer effects on the human beings and environment, thus making HVDC systems friendlier and less hazards to environmen.

In future, we are interrested to inverstigate the hazards discussed in this work using sensors [15] and [16].

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